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REMOTE STORAGE

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Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

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Editorial Notices.

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Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

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THE

PRACTICAL ENGINEER.

JANUARY 4TH, 1889.

ENGINEERS IN THE NAVY.

THE unfair and anomalous position occupied by the engineer officers in Her Majesty's Navy, as compared with that held by those in other branches of the service, has constituted a grievance that has loudly called for redress for a long time past, though the requests for something like consideration that have frequently been made to the authorities have hitherto received but scant attention.

The invidious distinction that is drawn between the engineers and the executive officers is very forcibly brought out in the report of the cross-examination by Sir Edward Reed of Vice-Admiral Sir Anthony Hoskins, before the Committee on the Navy Estimates, which has been prepared by the engineer officers of the Navy for the information of members of Parliament and others.

It appears from this document that the number of engineer officers in the Navy is about 700, including a chief inspector of machinery and the junior acting assistant engineer. In addition to the officers there are about 8,000 artificers and stokers, so that the total engine-room staff of the Navy may be set down roughly at 8,700 officers and men. Contrasting this total with the 2,500 officers of the executive class, 202 midshipmen, 282 naval cadets, 14 second mates, and the 9,000 seamen, Sir Edward Reed was desirous to impress the committee with the fact that in these days of a steam Navy, when nearly all operations are performed by machinery, the engineer branch is miserably starved and depressed.

On the other hand, Vice-Admiral Hoskins maintained that no trustworthy comparison could be established between the functions performed by the executive and engineer branches of the service, and that the existing engine-room complements were quite adequate to the requirements of a fleet comprising 550 ships.

The snobbery and ignorance that prevail amongst the executive officers with regard to their views of an engineer's duties were well illustrated in the reply given by Vice-Admiral Hoskins to a question pressed upon him in committee. Referring to the duties of an engineer, he thought that a very exaggerated view prevailed in the mind of the public with regard to their importance. The multiplicity of the engines and the duties connected with them, he said, impressed the public mind very much when they went on board vessels; but he regarded "an engine as a very simple thing in itself generally, and he had himself seen, on board a Peninsular and Oriental steamer, a Lascar lubricate some machinery on deck with a bottle of oil, start a lever, and hoist the cargo himself, and he was driving an engine."

Comment on the opinion implied by such an answer is needless, and had it not been made by the Junior Sea Lord of the Admiralty before a committee of the House of Commons, it would have been utterly unworthy of notice. The fact that the management of the complex steam machinery on board a modern man-of-war should be considered by an Admiralty Lord as equivalent to that of a Lascar driving a winch engine, will serve to illustrate more forcibly than anything we can say the extent of the ignorance and prejudice that prevail in certain quarters, and how great is the barrier of crass ignorance that requires to be broken down before the Navy can be placed upon the efficient and satisfactory footing which the demands of the nation require.

Some little satisfaction and some little hope of reform is afforded by the knowledge that the line of argument pursued by Sir Anthony Hoskins is opposed to the convictions of such officers as Admiral Colomb and Lord Charles Beresford, but it furnishes unquestionable evidence of the prejudice which prevails in certain influential quarters with regard to the claims of what they are pleased to consider the democratic element of the naval service. The fact that there is no royal road to the acquirement of engineering knowledge, and that the experience necessary to qualify a man to manage such complex pieces of machinery cannot be acquired by strutting about in peacocks' feathers on a quarter-deck, but must be slowly and hardly gained by actual contact with laborious and often dirty work, may account for the supercilious airs affected by officers of the type of Vice-Admiral Hoskins. The objectionable comparison made by him between engineer officers and a Lascar winch driver suggests an equally absurd and invidious one that might be drawn with regard to those who promenade the quarter-deck; but as such a comparison would be equally wanting in taste, we refrain from making it, and trust in future Sir Anthony and those who think with him, when giving expression to their opinion, will display an equal amount of regard for good manners. For the benefit of our friends on the upper deck we would point out that the functions of an engineer officer in the Navy are not confined simply to the filling of a tallow cup or the opening of a valve, but demand for their adequate discharge quite as severe, and in many respects a more thorough training than that necessary for the executive officer. An engineer officer must be capable of commanding large bodies of men in critical as well as upon ordinary occasions, and the mere fact that the students are entered after a severe mathematical competitive examination, and that they are subsequently required to pass through a severe scientific course of education at Greenwich, in addition to the professional training they receive at the dockyards, goes far to prove that the engineer branch of our steam Navy demands other and higher qualifications than mere mechanical dexterity and rule of thumb.

Perhaps a no more adequate statement of the engineers' case can be given than that contained in the presentment by the engineers themselves.

When steam was first introduced into the Navy, the principal, and practically the only, duties of the engine-room staff consisted in working the propelling machinery of the ship, maintaining it in a state of efficiency, and keeping watch when under steam. The engines were of the simplest description, worked under a pressure of 30lb. to the square inch, and confined to the turning of a single screw. Such auxiliary engines as existed were adjuncts of the main engines. Now steam is used at a pressure of 120lb.; the simple engines have developed into the triple-expansion type; open stokeholds have given place to forced draught, necessitating the employment of a number of fans; while in a battle-ship of the first class the auxiliary engines have increased to about 50. In 1862 the Black Prince and Warrior, with their engines of 5,770 indicated horse power, were probably the most powerful fighting ships afloat. At the present day we have vessels of the Victoria and Nile types, fitted with engines capable of developing 14,000 I.H.P., while in the new fast cruisers, Blake and Blenheim, the propelling machinery alone is to indicate the stupendous power of 20,000 horses. As has been stated, in the early armour-clads the application of steam was limited to the propulsion of the ships; but as engineering science advanced, and the employment of machinery for various purposes became more general, the responsibilities of the naval engineer increased, until at the present day manual gear has become wellnigh obsolete, and there is scarcely a single function on board a war vessel in which the engineer does not play an indispensable part. Steam is applied to weigh the anchor and to steer the ship; machinery is employed to rotate the turrets and to load, elevate, and run out the heavy guns; and steam-produced electricity is requisitioned for search lights and domestic illumination. Steam, again, is used to charge the torpedoes and to shoot them from the side of the ship by means of compressed air; for purposes of ventilation; for boat hoisting; for pumping, ejecting, and fire service; and for the production of potable water at sea. Then, in addition to the care and superintendence of this universal agent, to the engineer is committed the supervision of the water-tight doors, the iron masts, and the double bottoms; so that practically, with the exception of the discipline, navigation, and fighting of a battle-ship, he may be said to have almost entire control.

The invidious distinction that is drawn between the Engineer-in-Chief and the heads of the other branches of the service was well brought out in the examination of Vice-Admiral Hoskins with regard to his status. It was admitted that there was no Engineer Lord of the Admiralty; that the Engineer-in-Chief holds a subordinate position in the Controller's Department; and the witness was unable to say whether he ever attended a meeting of the board, or, as a matter of fact, was ever consulted. At present it appears that the head of the engineer service is not considered worthy of ranking with the heads of other departments, such as, for instance, the Medical Department, Admiral Hoskins regarding such a suggestion as a disputatious matter. But, if the engineer officers are to be credited, the matter scarcely admits of any dispute. At the present time there is under construction machinery for about 50 ships of 193,000 collective indicated horse power, and representing an aggregate expenditure of £1,332,000, and the officer who is personally responsible for the efficiency of all this machinery receives a salary of £1,000 per year, rising to £1,200 per year after five years, and ranks with a captain under three years' seniority. Now, in the Medical Department there are no fewer than three Inspector-Generals of Hospitals and Fleets, under the Director-General, each of whom has relative rank with a rear-admiral, and receives as salary £1,003 15s. per annum. The Director of Naval Construction, who is also Assistant Controller, receives £2,000, and the Director of Dockyards £1,500 a year; and, as if to make the anomaly still more glaring, it remains to be mentioned that each of the Civil Assistants to the Admiral Superintendents at Portsmouth, Chatham, and Devonport, whose services are confined to a single dockyard, receives precisely the same amount of remuneration as the Engineer-in-Chief, who is responsible for the whole of the machinery of the British Navy.

Although the officers of the Engineer Department have been reduced by 50 per cent since 1862, the engine-room staff over which the engineer exercises supervision has during the last ten years increased by over 60 per cent, with the probability that in the near future it will attain to even greater magnitude. Notwithstanding, however, the consequent growth of their responsibilities, subordination from the highest to the lowest continues to be the badge of their calling. As regards relative rank, for instance, the executive officer can attain lieutenant's rank as early as 19 years of age, provided he be successful in his examinations, while the medical officer receives it from the moment of entering the service. But the engineer does not obtain *bona-fide* lieutenant's rank until he has served his period of service, first as an assistant engineer, and subsequently as an engineer, by which time he has reached the mature age of 33 years. On promotion to the grade of engineer he ranks for six years "with, but after" lieutenants, and is thus junior to every lieutenant and to every officer of lieutenant's relative rank in the Navy, although in the majority of cases the engineer is much senior in age and service as a commissioned officer. When, again, he attains to the rank of chief engineer, he ranks "with, but after lieutenants of eight years' seniority." This peculiar and subordinate distinction fails to carry with it the proper uniform of the rank it confers, and is only adopted in the case of engineer and accountant officers. As this difference touches the *amour propre* of the department on board ship, it is naturally productive of great dissatisfaction. Then, as to the matter of pay, while the engineers have largely benefited since 1862, they are still behind every other class of commissioned officers, with the single exception of the accountant branch, of corresponding age and service. While, for example, the executive and medical officers realise their *maximum* rate of pay of 33s. per day at a fairly early age, the engineer officers can only attain their *maximum* pay of 22s. per day (or 11s. per day less than either the medical or accountant officers) at an age when they are just on the point of retiring from the service. In fact, we learn that at the present time there are not half a dozen fleet engineers who are in receipt of the *maximum* pay of 22s., all the others receiving 18s. or less per day. There are other grievances complained of, with reference to extra pay, length of service for promotion, store allowance, &c., but we think enough has been said to show that there are many anomalies and hardships affecting the engine-room staff of the Navy which loudly call for immediate redress.

ALLOYS: THEIR CONSTITUTION AND PROPERTIES.—VIII.

(*Continued from page 651, vol. ii.*)

Let us now examine some effects of uniting metals by fusing them together into what are called alloys; and, second, the direct influence of a minute quantity of one metal in changing the mass of another in which it is hidden, and causing it to behave in a different way in relation to light, and consequently to possess a colour different from that which is natural to it; or the added metal may so change the chemical nature of the metallic mass that varied effects of colour may be produced by the chemical combinations which result from the action of certain "pickling" solutions. This portion of the subject is so large that I can only hope to set before you certain prominent facts.

First, with reference to the colour produced by the union of metals. Here is a mass of red copper, and here one of grey antimony; the union of the two by fusion produces a beautiful violet alloy when the proportions are so arranged that there is 51 per cent of copper and 49 per cent of antimony in the mixture. This alloy was well known to the early chemists, but, unfortunately, it is brittle and difficult to work, so that its beautiful colour can hardly be utilised in art. The addition of a small quantity of tin to copper hardens it, and converts it, from a physical and mechanical point of view, into a different metal. The addition of zinc and a certain amount of lead to tin and copper confers upon the metal copper the property of receiving, when exposed to the atmosphere, varying shades of deep velvety brown, characteristic of the bronze which has from remote antiquity been used for artistic purposes. But by far the most interesting copper alloys, from the point of view of colour, are those produced by its union with zinc, namely, brass. Their preparation demands much care in the selection of the materials, and I might have borrowed from the manufacture of brass instance after instance of the influence of traces of impurity in affecting the properties of the alloy, for I have many inducements in this place to speak about this beautiful alloy. I am proud to be a namesake of the craftsman, William Austin, who, in 1460, made that magnificent monument in brass which covers the remains and commemorates the greatness of Richard Beauchamp, Earl of Warwick, and I am glad to remember that Queen Elizabeth granted the first patent for the manufacture of brass in England to William Humfrey, Assay Master of the Mint, a predecessor in the office it is my privilege to hold.

I want, however, to direct your attention to-night to some alloys of copper with which you are probably less familiar than with brass. In this direction Japanese art affords a richer source of information than any other. Of the very varied series of alloys the Japanese employ for art metal-work, the following may be considered the most important and typical. The first is called "shaku-do;" it contains, as you will observe from Analyses I. and II.,

Shaku-do.
I.

Copper	94·50
Silver	1·55
Gold	3·73
Lead	·11
Iron and Arsenic	traces
	99·89

II.

Copper	95·77
Silver	0·08
Gold	4·16
	100·01

in addition to about 95 per cent of copper, as much as 4 per cent of gold. It has been used for very large works. Colossal statues are made of it, one cast at Nara in the 7th century being specially remarkable. The quantity of gold is, however, very variable; specimens I have analysed contained only 1·5 per cent of the precious metal. The next alloy to which I would direct your attention is called "shibu-ichi."

Shibu-ichi.
III.

Copper	67·31
Silver	32·07
Gold	traces
Iron	·52
	99·90

IV.

Copper	51·10
Silver	48·93
Gold	·12
	100·15

There are numerous varieties of it, but in both these alloys, shaku-do and shibu-ichi, the point of interest is that the precious metals are, as it were, sacrificed in order to produce definite results, gold and silver when used pure being employed very sparingly to heighten the effect. In the case of the shaku-do, we shall see presently that the gold appears to enable the metal to receive a beautiful rich purple coat or patina, as it is called, when treated with certain pickling solutions; while shibu-ichi possesses a peculiar silver-grey tint of its own, which, under ordinary atmospheric influences, becomes very beautiful, and to which the Japanese artists are very partial. These are the principal alloys, but there are several varieties of them, as well as combinations of shaku-do, and shibu-ichi in various proportions, as, for instance, in the case of kiu-shibu-ichi, the composition of which would correspond to one part of shaku-do rich in gold, and two parts of shibu-ichi rich in silver.

Now, as to the action of pickling solutions. Many of you will be familiar with the mysteries of the treatment of brass by "dipping" and "dead dipping," so as to produce certain definite surfaces; but the Japanese art metal workers are far ahead of their European brothers in the use of such solutions.

The South Kensington Museum contains a very valuable series of fifty-seven oblong plates, some plain and others richly ornamented, which were specially prepared as samples of the various metals and alloys used by the Japanese. The Geological Museum, in Jermyn Street, has a smaller but very instructive series of 24 plates, presented by an eminent metallurgist, the late Mr. Hochstatter-Godfrey. From descriptions accompanying the latter, and from information I have gathered from certain Japanese artificers now in London, it would appear that there are three solutions generally in use. They are made up respectively in the following proportions, and are used boiling:—

	I.	II.	III.
Verdigris	438 grains	87 grains	220 grains.
Sulphate of copper	292 „	437 „	540 „
Nitre	—	87 „	—
Common salt	—	146 „	—
Sulphur	—	233 „	—
Water	1 gallon	—	1 gallon.
Vinegar	—	1 gallon	5 fluid drachms.

That most widely employed is No. I. When boiled in No. III. solution, pure copper will turn a brownish red, and shaku-do, which, you will remember, contains a little gold, becomes purple. And now you will be able to appreciate the effect of small quantities of metallic impurity as affecting the colour resulting from the action of the pickle. Copper containing a small quantity of antimony gives a shade very different from that resulting from the pickling of pure copper. But the copper produced in Japan is often the result of smelting complex ores, and the methods of purification are not so perfectly understood as in the West. The result is that the so-called "antimony" of the Japanese art metal workers, which is present in the variety of copper called "kusomi," is really a complex mixture containing tin, cobalt, and many other metals, so that a metal worker has an infinite series of materials at command with which to secure any particular shade, and these are used with much judgment, although the scientific reasons for the adoption of any particular sample may be hidden from him. It is strictly accurate to say that each particular shade of colour is the result of minute quantities of metallic impurity, and these specimens and diagrams will, I trust, make this clear, and will prove that the Japanese arrange true pictures in coloured metals and alloys.

[This portion of the subject was illustrated with much care by coloured diagrams representing specimens of Japanese art metal work, by photographs projected on the screen, as well as by the reflected images of small ornaments made of the alloys which had been specially referred to. There was also a trophy of large leaves of copper of varying degrees of purity, coloured brilliantly by one or other of the "pickles" above described.]

There is one other art material to the production of which I hope art workmen in this country will soon direct their attention, as its applications are endless. It is called in Japanese "mokumè," which signifies "wood-grain." It is now very rare, even in Japan, but formerly the best specimens appear to have been made in Nagoya by retainers of the Daimio of Owari. I have only seen six examples, and only possess a single specimen of native work, and have therefore had to prepare a few illustrations for you in soldered layers of gold, silver, shibu-ichi, shaku-do, and kuromi.

This diagram (fig. 3) shows the method of manufacture. Take thin sheets of almost any of the alloys I have mentioned, and solder them together layer upon layer, care being taken that the metals which will present diversity of colour come together. Then drill conical holes of varying depth, A, in the mass, or devices in trench-like cuts of V section, B, and hammer the mass until the holes disappear; the holes will thus be replaced by banded circles, and the trenches by banded lines. A Japanese artificer taught me to produce similar effects by taking the soldered layers of the alloy, and, by the aid of blunted tools, making depressions on the back of the mass, so as to produce prominences on the front, C. These prominences are filed down until the sheet is again flat; the banded alloys will then appear on the surface in complicated sections, and a very remarkable effect is produced, especially when the colours of the alloys are developed by suitable "pickles." In this way any device may be produced. In principle, the method is the same as that which produces the damascening of a sword-blade or gun-barrel, and depends on the fact that under certain conditions metals behave like viscous solids, and as truly "flow" as pitch or honey does, and in the case of mokumè the art workman has a wide range of tinted metals at command.

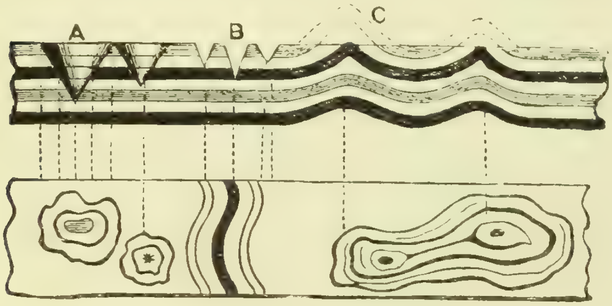


Fig. 3.

Since this lecture was delivered I have succeeded in preparing some elaborate specimens of mokumè, and the artistic merits of the material have been recognised by Mr. Alfred Gilbert, A.R.A., who is employing it in the exquisite repoussé metal work which he alone can produce.

(To be continued.)

LESSONS IN MECHANICAL DRAWING.—XXV.

By Prof. A. MacLay, B.Sc., C.E.

Geometrical Loci and Point Paths.—*Continued.*

Inverse Curves.

In the last lesson we drew several curves representing the path of a point moving along a straight line at various rates, while the line turned about a fixed point on it, as centre.

In this lesson we shall consider a few cases in which there are two moving points on the turning line. Several types of curves could be drawn in this way, representing various fixed relations between the positions of the moving points and the fixed point or pole. Thus, we might have the sum, the difference, the ratio, or the product of the distances constant, in a similar manner to that worked out in a previous case, viz., the case of the path of a point moving with reference to two fixed points.

In both these classes of curves, then, there are three points whose relative positions and changes of position are represented. But whereas in the former case two of the points were fixed and *one* was in motion, in the present class one of them is fixed and *two* are in motion. The present series, of which we shall give three examples, may be said then to form a continuation of those in Lesson XVIII., only, being of a more advanced character, could not very conveniently be discussed then. The following examples are those representing the condition of constant product (of the distances of the moving point from the fixed point).

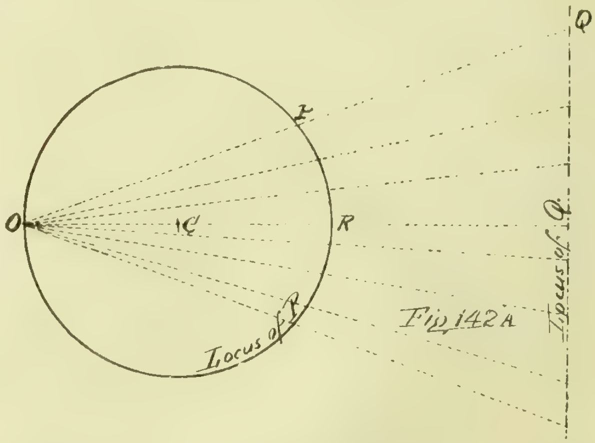
Definition: *If on any radius vector* OP *a second point* Q *be taken, such that the product* OP × OQ *is constant, while* P *describes some curve; then the locus of* Q *is said to be the "inverse" of that curve, the point* O *being the pole.*

EXAMPLES.

Curve described by P.	Position of Fixed Point at	Locus of Q. Name of Curve.	Illustrated by
(*a*) Circle	The Centre	Circle	
(*b*) Parabola	The Focus	Cardioid	Fig. 142
(*c*) Ellipse, or Hyperbola	A Focus	Limaçon	,, 143
(*d*) Rectangular Hyperbola	The Centre	Lemniscate	,, 144
a) Circle	Point on Circumference	Straight Line	,, 142A
(*b*) Circle, &c.	The Centre, &c.	Circle, &c.	

Exercises.

Ex. 159, Fig. 142.—Let a line FL turn about a point F on it, as a fixed centre. Suppose a point Q on FL to trace out a given parabola, find the locus of a point P, also on FL, such that FQ × FP = c, a given constant. Take, for example, the distance from focus to vertex of the parabola, FV = $\frac{3}{4}$ and $c = 2$. (FL is shown in middle position in the figure. Q is then at V and P at R.)



Draw any line YY, and at any point A on it set off AF perpendicular to it. Make AF = 2 × $\frac{3}{4}$in. = 1$\frac{1}{2}$in. Then with F as focus and YY as directrix, construct a parabola by Ex. 77, page 248. Next construct a rectangle of two square inches in area. In fig. 142*a* make FW = 2in. and FV = 1in. – FV being ⊥ FW. Complete the rectangle FVWX. Now, by the same principle as was shown in fig. 79, and explained at page 212, construct a set of equivalent rectangles, for a series of pairs of lengths of constant product. For example, make Fv = FV in fig. 142. Draw vx ∥ VX, cutting WX at z. Then a line from F through z cuts VX produced at Z. Zw drawn ∥ VF cuts FW produced at w. Then Fvwx is a rectangle equal in area to FVWX. Make FL in fig. 142 equal to Fw in fig. 142*a*. Then L is a point on the curve described by P. Next, using Fvwz as a base, draw lines from F, intersecting vx at points 1^1, 2^1, 3^1, &c., and wx produced at 1, 2, 3, &c. Pairs of sides are thus obtained. Example: With $w5$ as radius, and F in fig. 142 as centre, cut parabola at point 5. Through F5, fig. 142, draw a line, and on it cut off $F5^1 = v5^1$ in fig. 142*a*. Then 5^1 is another point on the curve. In a similar manner find a series of points, and trace a curve through them.

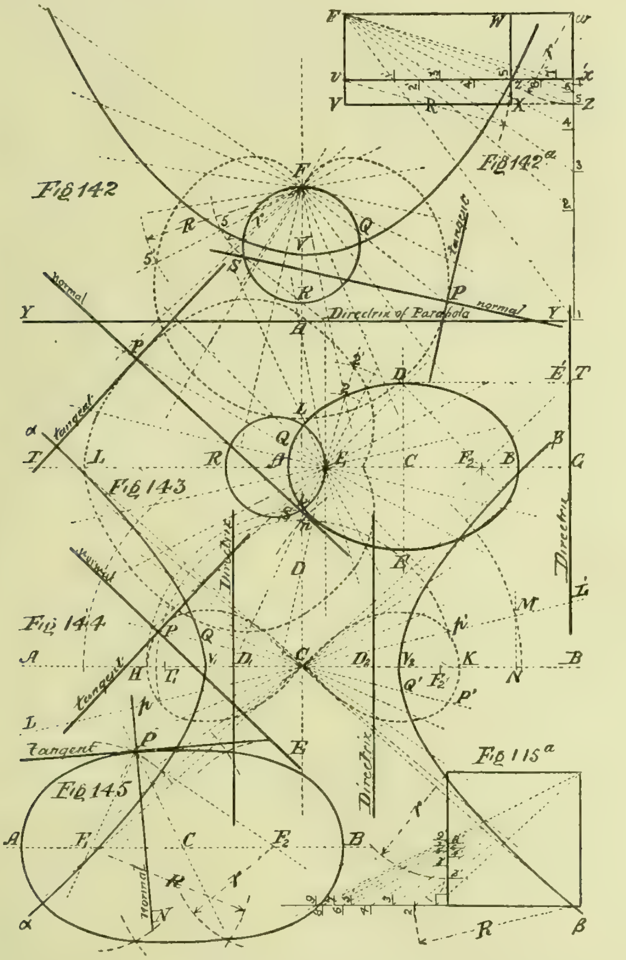
Ex. 160, Fig. 143.—Let F, the fixed point in the previous question, be now placed at a focus of an ellipse traced out by Q. Find the path of P if FQ × FP = c, a given constant. Let the given ellipse be 3in. by 2in. in size, and let $c = 3$.

First, for the ellipse, draw two lines AB and DE, intersecting at right angles at the point C. Make $CA = CB = 1\frac{1}{2}$in., and $CD = CE = 1$in. AB and DE are the major and minor axes respectively of the given ellipse. With centre D, radius CA or CB, describe arcs intersecting AB at F_1 and F_2. F_1 and F_2 are the foci. Then draw the ellipse as the path of the point D, with reference to the fixed points F_1 and F_2, by Ex. 85, p. 307; or, if preferred, describe circles upon AB and DE as diameters, and draw the ellipse as in Ex. 114, p. 437.

Draw next a rectangle of 3 sq. in. area, as in fig. 142a. In this case make $FW = 3$in. and $FV = 1$in. Then, as in the last problem, with any one of a pair of sides (*e.g.*, $v2^1$, fig. 142a) as radius, F_1, in fig. 143, as centre, describe an arc, cutting the ellipse at 2. And with same centre, radius $w2$ (fig. 142a), find point 2^1 on $F_1 2$ produced. Then 2^1 is a point on the locus of P, and other points may be found in a similar manner.

Ex. 161, Fig. 144.—Draw the two branches of a rectangular hyperbola, and let a line LL^1 turn round the centre C as pole. If Q and Q^1, two points on the turning line, be constrained to move along the hyperbolic curves, find the paths of two points P and P^1, also on the line, if the conditions are that $CP \times CQ = CP^1 \times CQ^1 = c$, a given constant.

Given the distance F_1F_2 between the foci at 5·41in., V_1V_2 between the vertices at 4in., and D_1D_2 between the directrices at 3in., and $c = 4$.



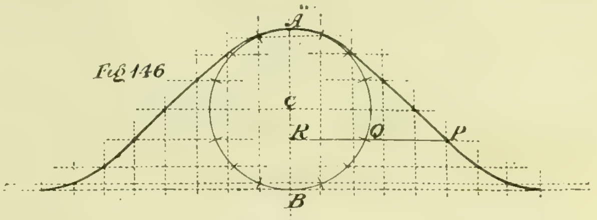
By Ex. 90, p. 308, trace the two curves $\alpha\alpha$ and $\beta\beta$, as shown in fig. 144. These are the two branches of the hyperbola, and they are symmetrical about the lines AB and DE. When the ratio of the distance of any point on the curve from the focus, to its perpendicular distance from its directrix, has the particular value of $\sqrt{2} : 1$, the curve is then known as the *rectangular* hyperbola. If straight lines be drawn through C at 45° to AB and DE, and therefore at right angles to one another, it will be found that these lines and the curves get nearer and nearer to each other the farther they are carried out, but that they never touch. Lines so situated with reference to a curve are called its *asymptotes*. The *rectangular* hyperbola is so called because its asymptotes are at *right angles* to one another.

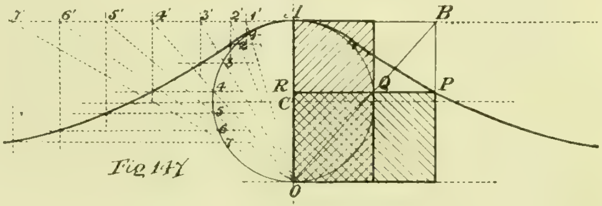
Having drawn the curves, as shown in fig. 144, next construct a rectangle of 4 sq. in. area, and find a series of pairs of sides of equivalent rectangles, as in fig. 142a. With these as radii, find points on the inverse curve, as in previous constructions. Example: Draw any line such as PP^1 through C, intersecting the two branches at Q and Q^1. Cut off a distance CQ on vx of the auxiliary diagram. Then a line from F through the point on vx will cut off on wx produced, the desired length of CP or CP^1.

OTHER METHODS.

Ex. 162, Fig. 142.—Draw any given line FL, and bisect it at R. On FR as diameter describe a circle. Suppose a line to turn about F as a centre, and R a point on it, to move along the circumference of the circle, trace the locus of L, a second point on the line if RL remains of constant length. Take FL of the same length as in Ex. 159.

The locus of L is the same curve as was obtained in Ex. 159, viz., the *Cardioid*. By taking FL of the same length as in that problem, comparison of the two curves will be made easy.

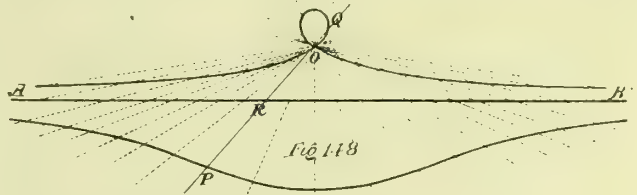


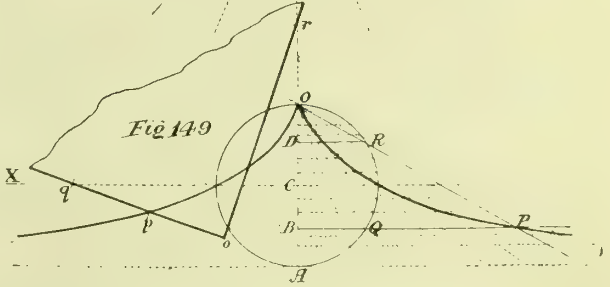


Ex. 162A, Fig. 142A.—Draw a circle of say 3in. diameter. Take any point O on the circumference as pole. From O draw any line OQ, cutting the circle at P. Find the locus of Q if $OQ \times OP = c$ a constant. Let $c = 12$.

The inverse of the circle is in this case a straight line. This is the principle upon which the Peaucellier cell is built—famous as the first exact linkwork parallel motion.

Ex. 163, Fig. 143.—Draw any given line F_1L, and divide it into any two parts F_1R and RL, such that the ratio $\frac{F_1R}{RL} < 1$. On F_1R describe a circle. Find the locus of L if R be constrained to move in the circle, and RL remains of constant length, while F_1L turns round F_1 as a centre, as in the last problem.





The curve traced out by L is the same as that found in Ex. 160 and if we take the ratio $\frac{F_1R}{RL} = e$, the *eccentricity* of the given ellipse in that problem, we shall be able to compare results, and find that the locus is again the *Limaçon*.

Firstly then, to find e. The eccentricity of a conic section is the ratio of the focal distance of any point on the curve, to its perpendicular distance from the directrix. Or, if we represent these distances by r and p, as in Exs. 88, 89, and 90, p. 308, then $e = \frac{r}{p}$. In the parabola $e = 1$, in the ellipse < 1, and in the hyperbola > 1.

In the ellipse (fig. 143), at any point D on the curve, draw the tangent DT. Join DF_2, and draw from F_2 a perpendicular to DF_2, intersecting DT at E^1. E^1 as the point of intersection of the tangent, and a perpendicular to the focal line to any point on the ellipse, is a point on the directrix. Then $\frac{DF_2}{DE^1} = e$. Take now a length F_1L, equal to that obtained in Ex. 160, and divide it at R in the ratio $DF_2 : DE^1$; *i.e.*, make $\frac{F_1R}{RL} = \frac{DF_2}{DE^1}$. On F_1R describe a circle; then draw rays from F_1 in all directions, and make the length beyond the circle always equal to RL.

Ex. 164, Fig. 144.—Draw two lines, AB and DE, intersecting each other at right angles at CNS, on CA, CB, and CD, mark off CH = CK = C*k* respectively. With centre C, radius H*k* or K*k*, describe a circle. Draw any radial line CL^1, cutting this circle at M. From M draw MN ⊥ AB. With centre K, radius CN, cut CD in *n*. Then with centre C, radius C*n*, cut CL^1 in p^1 and CL in *p*. Find the locus of *p* and p^1, while LL^1 turns about C as a fixed centre.

Another method of drawing the *Lemniscate of Bernoullé*, and by taking CH of the same length as found in Ex. 161, the results will be comparable.

Tangents and Normals.

Ex. 165.—To draw the tangent and normal at any point on the cardioid.

On the curve obtained in Ex. 162, take any point P. Join PF. Through R draw RS ∥ PF, cutting the circle on FR at S. Then NS PS is the normal, and PT the tangent at P.

Ex. 166.—To draw the tangent and normal at any point on the limaçon.

On the curve obtained in Ex. 163 take any point P. Join F_1P. Through R draw RS ∥ F_1P, cutting the circle on RF_1 at S. PS is the normal, and PT the tangent at P.

Ex. 167.—To draw the tangent and normal at any point on the lemniscate.

On the curve obtained in either of the Exs. 161 or 164, take any point P. Join PC. Draw a line PE, making an angle with PC twice that between PC and CA. PE is the normal, and PT the tangent at P.

Miscellaneous Curves.

Ex. 168, Fig. 145.—Trace the path of a point which moves in such a manner that the product of its distances from two fixed points is constant.

The condition implied in the problem gives the series of curves known as *Cassini's Ovals*, of which the two fixed points are the foci. About any given pair of fixed points as many curves may be drawn as we choose to take values for the constant. Suppose *c*, the constant, to be 4, and the distance F_1F_2 between the foci to be 2·5in. Having drawn any line AB, and taken two points on it 2½in. apart, obtain next a square or rectangle of 4 square inches area, from which, as a base, to find a number of pairs of sides of equivalent rectangles, as in Ex. 159.

With F_1 as centre, with the one side of any pair as radius, draw an arc, and with F_2 as centre, radius the other side, draw an arc intersecting the first. The intersection will be a point in the curve.

For the normal PN at any point P on the curve, make $\angle F_2PN = \angle F_1PC$, C being a point midway between F_1 and F_2.

Ex. 169, Fig. 146.—AB is a fixed diameter of a given circle. At R, a point on it, draw a perpendicular RP, cutting the circle at Q. Suppose R to slide along AB, and Q to move along the circumference of the circle, RQ being always perpendicular to AB, find the locus of P if QP is always equal to the length of arc QA. Take AB, 3in. long.

The locus determined by the conditions is the curve known as the *Companion to the Cycloid.* The construction will be obvious from the statement of the problem. For example, point P is found by stepping round the arc QA, with the points of the spring dividers set at a short distance, say a distance ≯ ¼in. Then step off the same length along QP.

N.B.—In stepping off distances in this way students often waste time trying to find a unit distance, such as may be contained in the arc to be measured an exact number of times. This is not necessary. If there happens to be a fractional remainder in the arc length QA, it can be added by itself to make out the exact length of QP.

Ex. 170, Fig. 147.—A point Q moves round the circumference of a circle. A line PQ passes through Q, and is perpendicular to a fixed diameter OA, R being a point on the latter. Trace the path of P, when the length PR is found by the condition that PR : OA : : QR : OR. Make circle 3in. diameter.

The above condition gives the curve known as the *Witch of Agnesi.* For the construction we fall back once more upon the principle of equivalent rectangles, explained in fig. 79, page 211, and applied in figs. 80 and 81, also in Ex. 159 of this lesson.

For PR : OA : : QR : OR may be written $\frac{PR}{OA} = \frac{QR}{OR}$ *i.e.*, $PR \times OR = QR \times OA$, as illustrated by the shaded rectangles in fig. 147.

Construction: To find a series of positions of P, corresponding to a series of assumed positions of Q, draw from O rays through the points 1, 2, 3, &c., on the circle, meeting the tangent to the circle at the point A in the points 1^1, 2^1, 3^1, &c. The intersections of verticals through 1^1, 2^1, 3^1, &c., with horizontals through 1, 2, 3, &c., are points on the curve.

Ex. 171, Fig. 148.—A line PQ, of fixed length, passes through a point O, about which it turns as a fixed centre. A point R, midway between P and Q, is constrained to move along a fixed straight line AB. Trace the paths of P and Q. Take O at 1·2in. distant from AB, and let PQ = 3·8in.

These curves are known as the *Conchoid of Nicomedes.*

The construction is very simple. Through O, as a pole, draw a number of rays, *e.g.*, OP, cutting AB at R. Make RP one-half the given length PQ; also, cut off RQ of the same length on RO produced, if necessary. Through the double series of points so found draw curves

Ex. 172, Fig. 149.—OA is a fixed diameter of a circle. Suppose a point B to travel uniformly from A to O in the same time that a point D travels uniformly in the opposite direction from O to A. Further, let perpendiculars to OA from B and D be drawn, cutting the circle at Q and R respectively. Find the locus of the intersection of a line through OR with the perpendicular BQ. Take OA = 3in. long.

The locus is the curve known as the *Cissoid of Diocles.*

To find points on the curve make AB = OD. At D draw DR ⊥ OA, cutting the circle at R. Join OR and produce it indefinitely. At B draw BQ ⊥ OA and produce, to intersect OR produced, at P, which is a point on the curve.

Ex. 173, Fig. 149.—Another method of describing the Cissoid is as follows: Draw two lines CX, CY at right angles to each other. On CY mark off CO = O*r* = CA, the radius of the circle in the last exercise. Take now a piece of stiff paper with two straight edges *oq*, or at right angles. Mark two points *p* and *q* on one edge, making *op* = *oq* = O*r*. Then if one edge be made to pass through *r*, and the point *q* on the other edge be made to travel along the line CX, the point P will trace the cissoid.

Ex. 174, Fig. 115, page 436.—*ab* represents on plan the door of a railway carriage, moving 15 miles an hour. The door is opened with a uniform angular motion into the position shown in ¼ of a second. Draw the curve which would be traced by the point *b*. Scale, ¼in. = 1ft. (1884.)

Ex. 175.—Trace the path of a point on the circumference of a paddle wheel of a steamer. Its diameter is 16ft., the number of revolutions per minute is 45, and the speed of the ship is 15 miles per hour. Show the curve traced in three revolutions of the wheel. Scale, $\frac{1}{96}$.

Ex. 176.—Describe any mechanical methods of drawing the ellipse, parabola, and hyperbola. (1879.)

Ex. 177, Fig. 120, page 436.—Two lines, including a given angle, touch two given circles, as shown. Trace the locus of the intersection of the lines. (1887.)

A problem similar to Ex. 117. The dotted lines in the figure show how to find a second point, p^1, on the locus. Other points can be found in the same way.

Telegraphic Cable Extension.—In consequence of the interruptions of telegraphic communication with Australia, owing to volcanic eruptions and other causes, the Eastern Extension Telegraph Company have determined to lay a third cable from Bangoewanzie to a point in Western Australia, probably somewhere in Beagle Bay. The length of the new cable will be over 1,000 miles. The Telegraph Construction Company are working night and day loading their ship, the Seine, which is to leave the Thames on Wednesday next to lay the cable. Another great cable is now being laid by the Silvertown Company for connecting London with Mossemedes, on the West Coast of Africa, while the Telegraph Construction Company are making a cable 1,500 miles in length to connect Mossemedes with Capetown. This work will be completed in March, and thus there will be two telegraphic routes to South Africa, one *vid* the east and another *vid* the west coast, an important boon in the event of any grave crisis again arising in that quarter of the world.

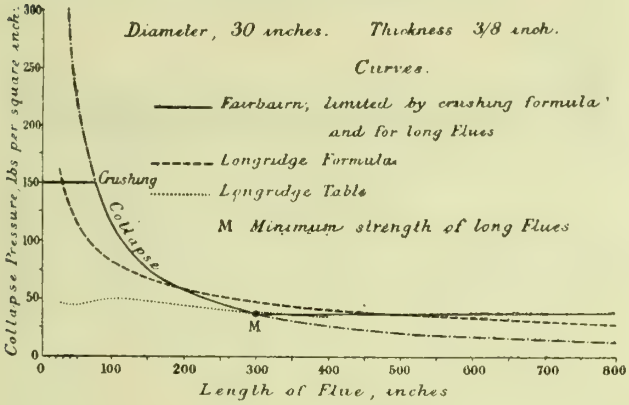
either the rivets shear, or more probably the joint crushes out of form, and lets the water through. No engineer would like, I think, on a single riveted joint, to have a working pressure greater than 12,000lb. per square inch* on the net section of metal, which comes to about 6,000lb. per square inch on the gross section before the holes are punched. We can determine, therefore, the pressure at which collapse will practically cease, and a totally different mode of giving way will enter in. For short flues the working pressure must not exceed

$$\text{Working pressure} \;=\; 12{,}000\;\frac{t}{d} \qquad (5)$$

Now, the next stage in the collapse problem I may take some credit for myself. I had originally assisted Fairbairn in the collapse experiments, and I recurred to them again and again with a view of accounting rationally for the singular form of the collapse formula. Obviously enough, giving way by collapse is related to the mode of giving way of long thin columns. But it was long before I discovered how the collapse formula and the long column formula were related. At last I noticed that the number of segments into which a tube collapsed followed a perfectly simple law. It depended only on the ratio of diameter to length. Assuming the experimentally ascertained number of collapse segments, and using then the pillar formula, I got by a rational process, a formula for collapse which is very nearly identical with Fairbairn's. †

Now, my formula fits such experimental and practical data as we have a trifle better than Fairbairn's. But I don't attach much importance to that. A point of more importance arises out of the fact that we have reached a true conception of how collapse occurs.

FIG. 1. BOILER FLUES.



It was obvious that any formula of Fairbairn's form must be inapplicable not only to very short flues, but also to very long ones. It leads to the result that a very long flue has no collapsing pressure at all, which is nonsense. But if the collapsing pressure depends on the number of segments into which a flue collapses, then a flue cannot collapse into less than four segments. When the length is reached at which the influence of the ends so far vanishes that the flue collapses into four segments, the minimum collapsing pressure is reached. Beyond that length, all flues of the same diameter and thickness are of equal strength, just as in the case of very short flues. We can exhibit these results by a diagram. Suppose we take a flue 30in. diameter and $\frac{3}{8}$in. thick, then p and l are the remaining variables. Plotting the collapsing pressures for different lengths, we get the curve shown in fig. 1, and marked "collapse." For flues so short that crushing begins before collapse, the strength is independent of the length, and the crushing pressure for such flues is given by the horizontal line which is marked "crushing." For a ratio of length to diameter not yet very well determined, but generally beyond ordinary practical limits, the tube collapsing in four segments, the strength again becomes independent of the length. This point is taken at M on the diagram. For greater lengths the strength is given by the horizontal through M.

Recently, Mr. Michael Longridge, whose experience with boilers is enormous, has attempted to find a practical solution of the collapse problem in quite a new way. He has tabulated the dimensions and working pressure of the flues of no less than 8,000 actual boilers. Classifying the flues into groups, with small variation of dimension, he has found the value of c in Fairbairn's formula, and tabulated these values in order of diameter and length. If flues of all dimensions were really constructed to agree with Fairbairn's formula, with a constant factor of safety, the values so found ought to be constant; actually they are very far from being so. Excluding one or two cases, however, in flues over 20ft. in length, the variation of the constant in Mr. Longridge's table is not very great. There are flues actually working, 36ft. long, which give the same constant as flues 18ft. long, which so far confirms the application of Fairbairn's formula to long flues. With flues less than 18ft. long, as we might expect, the constant deduced from actual flues differs greatly from the constant for long flues, and that for two reasons. In the first place, it would be practically impossible to make short flues thin enough to agree with Fairbairn's formula. Hence, even if that formula applied, we should find short flues made with an excessive factor of safety merely for practical convenience. But, as we have seen, Fairbairn's formula does not apply to very short flues. Another rule comes in requiring a greater thickness. If, as is no doubt true, we may assume that the thickness of Mr. Longridge's flues did not greatly differ, then it can be shown that his numbers for flues from 5ft. to 10ft. in length agree as well with the formula for short flues (5) as with any other which has been proposed. There are erratic exceptions in Mr. Longridge's table showing that some flues are working with an exceptionally large factor of safety, but there is no consistent variation in the constant, either for change of diameter or change of the length.*

So far, then, Mr. Longridge's table is perfectly consistent with the adoption of Fairbairn's rule for long flues, and the crushing rule for short flues, and it is a very interesting and valuable table, for it enables us to determine the limiting values of the constants which have been found safe in practical working, though, of course, it gives no direct information as to the real crushing or collapsing pressure of the flues.

Mr. Longridge has, however, taken another way of dealing with his results, which seems to me less satisfactory. Without stopping to consider whether all flues fail in the same way, or can possibly be designed by a simple rule, he has attempted to find an empirical rule applicable to all cases. His table contains records of flues from 3ft. to 36ft. in length, and from 14in. to 50in. in diameter; and he tries to find a single rule fitting this enormous range of cases. Even in doing so, his method is extremely unsatisfactory, for his formula does not agree with his own table, except in two selected cases. He assumes, from an inspection of the table, that a flue 30ft. long and 32in. to 36in. in diameter is safe when it gives a Fairbairn constant = 3,540,000, in which case the factor of safety, I believe, is about 3. With this assumption I see no reason to quarrel. Next, he assumes that a very short flue—3ft. 6in. long—is safe with a constant of 1,229,000. Mr. Longridge candidly admits that he does not take this number from his table, and, in fact, it is a nearly pure guess. Now, taking these two results, Mr. Longridge finds he can squeeze them into a single formula, by assuming that the strength varies, not as in Fairbairn's formula, inversely as the length, but inversely as the square root of the length, and he thus obtains the expression—

$$p \;=\; 174{,}000\;\frac{t^2}{d\sqrt{l}} \qquad (6)$$

A small additional empirical correction, which Mr. Longridge gives for 5ft. flues, I need not notice, as it is quite unimportant.

Now, on the diagram Plate I., I have plotted pressures calculated from Mr. Longridge's formula and those found in his table for 30in. flues. You will see, I think, that there is no obvious relation between the pressures on actual flues, which he has tabulated, and the pressures which, according to his formula, should be allowed. The run of the results is not at all similar.

I have shown that Mr. Longridge's formula rests on a pretty well established result for a long flue, and a mere guess as to a short flue. But what is worse still, is what I believe to be a totally erroneous assumption, that these two flues fail in the same way, and are subject to the same law of collapse. I believe we shall go much more safely, and find much closer agreement with Mr. Longridge's table by adopting two rules—one for long flues and one for short flues, one for collapse and one for crushing, and Mr. Longridge's very valuable table will help us to fix what the proper factors of safety in the two cases are. Mr. Longridge's formula is open to exactly the same objection as Fairbairn's, that it gives collapsing pressures necessarily too small for long flues, and too high for short flues.

(To be continued.)

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* Probably even this pressure is too high.

† The Resistance of Boiler Flues to Collapse. Proc. Inst. of Civil Engineers, vol. xlvi.

* I have not, at present, examined exactly what the constant in formula (5) should be. I only argue, at present, that the form of the expression agrees with the results in Mr. Longridge's table.

THE NEW PROTECTED CRUISER MEDEA.

The following records of the trial of the new protected cruiser, the Medea, at Portsmouth, on Thursday, the 20th ultimo, which has been built at Chatham, and engineered by Messrs. Humphrys and Tennant, are of special interest, as the vessel is the first of her type that has yet been tried under steam. Considerable importance attached to the results of the trial, as the vessel's behaviour under various conditions required to be carefully noted, in order to ascertain whether any and what modifications were desirable in the class of vessel to which she belongs, to secure the maximum efficiency of the engines and speed of the vessel.

A large number of experts were attracted to Portsmouth to witness the result of the trials, among whom may be mentioned, in addition to the local professional officers, Rear-Admiral Hopkins, Controller of the Navy; Mr. W. H. White, Director of Naval Construction; Mr. Richard Sennett, Engineer-in-Chief; Mr. Froude, Superintendent of the Experimental Establishment at Gosport; Mr. Thomas Soper, Admiralty Inspector of Machinery; and Mr. Andrews, from Chatham Yard.

The ship was in charge of Commander Hay, and the trials were conducted by Mr. Robert H. Humphrys, belonging to the manufacturers' firm. The other ships of the same type are the Medusa, like the Medea, unsheated, and the Melpomene, Marathon, and Magicienne (sheathed and coppered.) They are 265ft. long, 42ft. in beam, with a depth of hold of 23ft., and are defended against projectiles by a steel turtle-back deck 2in. thick on the slope, and 1in. in the horizontal parts, besides being protected in other respects by a great number of compartments and water-tight spaces. They are designed to realise speeds of 20 knots and 19¾ knots respectively; and for the purpose of showing at what an enormous expenditure of energy these high speeds are attained, it may be mentioned that the Medea, with a displacement of 2,800 tons, is fitted with engines of substantially the same indicated horse power as the 16½ knot armour-clad Collingwood, with a displacement of 9,500 tons, or between three or four times the weight.

The armament of the cruisers consists of six 6in. 5-ton breechloaders and ten quick-firing guns, in addition to machine guns and torpedoes. They are intended for independent service at sea, and are almost destitute of sails.

The engines are of the twin-screw triple-expansion type, with cylinders of 33½in., 47in., and 74in. respectively, and a stroke of 3ft. 3in., and are under the protection of the sloping armour deck. The engines were first tried for endurance under natural draught, the continuous full-power run extending over 12 hours.

Under the new regulations, whereby the steam trials of a new ship are made to afford a practical test of her performances under actual conditions of service, the Medea was brought down by ballast to her designed load-line, the draught forward being 15ft. 3in., and that aft 17ft. 9in., giving a mean immersion of 16ft. 6in.

The result of the long steaming gave a mean collective indicated horse power of 6,099, and a speed, as measured by log, of from 17 to 18 knots.

The crucial run of four hours under forced draught was made on Thursday, under favourable conditions of weather. This might also be regarded as a test of endurance, for, besides determining the *maximum* resources of the engines, it may be fairly assumed that, except in action or under circumstances of emergency, they are not likely to be pressed for so long a period at their full power.

The mean results of the trial were: Steam in boilers, 149lb.; vacuum, 26in.; revolutions, 140; and collective indicated power, 9,183 horses. Though the power developed was in excess of the contract, and the trial was thus satisfactory from the point of view of the engineers, the speed obtained on the occasion was less than what the ship may be expected to realise when she is finally completed for commission.

The trials were in a large measure experimental, and from the few intermediate runs that were made on the measured mile, under different rates of speed, it was obvious that the present form of propeller, in consequence of the great amount of slip noticed, was not exactly suited to the ship. The result was that much of the power developed by the engines was wasted in churning the water. It has been decided to fit the Medea with new screws, after which she will be subjected to a series of progressive mile trials.

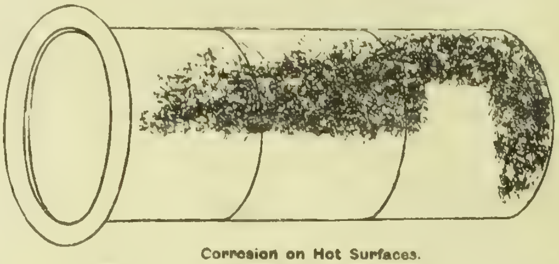
CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

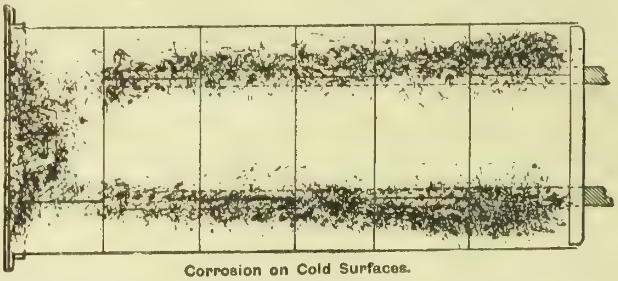
CORROSION IN RASTRICK BOILERS.

To the Editor of "The Practical Engineer."

Sir,—"Works Manager" does not stand alone in his peculiar experience of corrosion. I have often seen similar instances, and I have also seen instances of corrosion quite the reverse. The somewhat erratic forms taken by corrosion are very difficult to account for. It is occasionally found deepest on the coldest parts, which leads one to think the cold plates are the only places where the corrosion is effective, or where acids can settle. In other cases it will be found most seriously to affect the heat-giving surfaces, suggesting decomposition at a very high temperature. In "Works Manager's" case the parts not affected are those where water is never still, so that concentrated acids scarcely have an opportunity of becoming effective, and they are carried swiftly past, by the severe circulation set up in this class of boiler. I enclose two sketches, one showing corrosion on heat-giving surfaces, and the other showing corrosion on cold surfaces and over brickwork.



Corrosion on Hot Surfaces.



Corrosion on Cold Surfaces.

I have often asked for an engineering chemist's opinion in this matter, but all "fight shy." Volumes might be written, and hundreds of different peculiar cases cited; but the question is, "What governs these peculiarities?"

Chalkline.

COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—I do not see anything in my remarks which appeared in your issue of the 7th, on the paper read by Mr. James Bolas, of Patricroft, on "Modern Locomotives," before the Manchester Association of Engineers, to rouse his ire to the extent his letter would indicate, though I can make considerable allowance for his feelings after reading my remarks, especially those that upset his pet theory. I do not think it worth while going into all the details of his letter, but there are one or two to which I may refer. My statement that in nine cases out of ten the piston speed of a goods engine is as great, if not greater, than a passenger engine, was made purely from observation, which I admit was rather reckless. Nevertheless, I find on looking into the North-Eastern time table that the piston speed of the fastest passenger express is 801·6ft. per minute, while that of the fastest goods is 725·76ft. per minute. On the other hand, the piston speed of the slowest passenger engine is 388·8ft. per minute, and that of the slowest through goods 483·6ft. per minute (all running between York and Newcastle). Mr. Bolas, I have no doubt, will be able to take the average for himself, as he was so quick in detecting a small clerical error in my former letter. I should like to draw your attention to his statement about one of Mr. Stroudley's expresses obtaining 1,258ft. piston speedper minute. Although they have 2in. longer stroke than the North-Eastern locomotives, the engine would have to move at the rate of 67·18 miles per hour. Against this he puts goods with the same stroke at 400ft. piston speed per minute, which only gives a rate of 16·48 miles per hour. Such ridiculous comparison needs no further comment. Mr. Bolas cannot be aware of the fact that all the important railways work their engines on the link system; that is, the week's work is divided amongst so many men and engines, so that each day's work is different. But putting all this on one side, I say the saving in fuel in compounds compared with non-compounds is practically the same both in goods and passengers.

Mr. Bolas, in his letter, admits that Mr. Worsdell's latest compound is one of the most powerful in the world, but says that is not due to the compound system, but to the boiler, "which anybody knows that knows anything at all about a locomotive." I hope for his own sake he is again "faultily reported;" if not, I cannot see how he is going to explain it.

Again, he says he does not consider a run of 125 miles in 125 minutes as good a performance as 60 miles in 60 minutes. Whether it is or not I will leave your readers to judge.

In conclusion, let me tell Mr. Bolas that I am a practical man, and have been amongst locomotive work for many years, and, though I am well aware there are no trains set to run 60 miles per hour by the time tables, yet I am satisfied Mr. Worsdell's compounds could do this, if required, without difficulty, if the load each time was limited, and, as I have already stated, just because they have less difficulty in getting rid of the exhaust.

I will not refer to the cost of building Mr. Worsdell's compounds and keeping them in repair, except to repeat that in the long run it is less than in the case of non-compounds.—Apologising for taking up so much of your space, I am, yours truly,

December 28th, 1888. PRACTICAL OBSERVER.

QUERIES AND REPLIES.

1. **Electricity and Prevention of Scale in Boilers.**—Is electricity of any use in removing scale from steam boilers? We have spare power in our dynamo, and if any subscriber would offer a feasible suggestion, I should be willing to experiment, and give the result for the benefit of your readers. I ought to say that I am entirely ignorant as to whether anything has hitherto been tried in this direction?—E. L. R.

Answer.—Various electric appliances have been used in steam boilers, but only with a very limited amount of success, while in most cases they have been decided failures. One of the latest, and perhaps the best spoken of, is the "Electrigon"; but this does not give universal satisfaction, as I believe it has been taken out in many places. Electricity may prevent the formation of dense, tenacious scale, but it cannot possibly reduce the amount of deposit, and "E. L. R." had better make sure as to the result of reducing hard scale to a deposit of another form, as before now such a process has been found most injurious, and has occasionally led to serious and even fatal results.—CHALKLINE.

2. **Varnish for Papier-Maché Goods.**—Would some reader kindly inform me how to make the black varnish that papier-maché goods are coated with? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished?—J. T. L.

3. **Slide Valve of Hydraulic Engine.**—Will some reader kindly inform me which is the best form of slide valve to adopt? The engine makes 20 strokes per minute, and the pressure is 1,000lb. per square inch. I should be glad also to learn what kind of stop valve is generally used for hydraulic cranes.

4. **Engine Piston.**—I should be glad if some fellow-reader could give me a word of advice with regard to the following: In one of the engines under my charge the junk ring is about $\frac{3}{16}$in. or $\frac{1}{4}$in. too slack for the cylinder, and the piston rod is bearing heavily on the gland. Would it be any advantage to turn the piston head upside down? as at present it is very hard to keep the asbestos packing which I use for the gland tight.

5. **Coalpit Management.**—Will some reader be good enough to favour me with the name of the best works on coalpit management, saying by whom published, and what is the price?

6. **Re-cutting and Tempering Taps and Dies.**—I should be much obliged if any reader would give me a little information as to the process of softening, re-cutting, and tempering taps and dies.—BOLTMAKER.

7. **Blacklead Pencil Making Machinery.**—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery?—B. B.

Fitter.—A small wrought-iron tank about 2ft. 6in. square would probably suit your purpose. The condensing water might either be introduced in the form of a spray, or the tank might be kept about half full of water and the steam blown in on to the face of it. In either case, however, the tank *would require to be fitted with a waste pipe*, open to the atmosphere, in order to allow any surplus steam to escape, and to prevent the accumulation of pressure.

Gondie.—We do not know where you could obtain drawings of the kind you refer to, and should think that a better and cheaper plan would be to buy some work dealing specially with the subject. An excellent little treatise is that by Messrs. Cryer and Jordan, published by John Heywood. It is furnished with a large number of capital examples, which would serve your purpose equally as well as the drawings you refer to for purpose of copying, while you would also learn the principle as well. The price of the book is 2s. 6d.

Phosphor.—We cannot answer your question, as you do not say what examinations you refer to. Any man may practise as an engineer if he can find clients. The right to do this is not restricted, as in the legal and medical professions.

MISCELLANEA.

Monster Russian Guns.—Two monster Russian guns were sent last week to Sebastopol for the purpose of being placed in the new ironclad Sinope, and although some of the details must be inaccurate, the official description is too interesting to be ignored. They are 12in. pieces, weighing 50 tons, and throwing projectiles of nearly half a ton. The powder charge is 270lb., and the initial velocity 3,000 mètres. Two men, it is stated, suffice for each gun, as they are worked by hydraulic machinery.

The Submarine Telegraphic Company.—It is stated that a contract was signed between the Treasury and the Submarine Telegraph Company last week prolonging the agreement at present existing by which all messages from France, Belgium, and Germany pass through the hands of the Submarine Telegraph Company.

A New Miners' Lamp for Gas-testing Purposes.—Mr. Patterson, of 23, Side, Newcastle, has just invented a lamp which, by a simple contrivance, the deputy or official whose duty it is to examine miners' working places for gas before the men commence working, can in a moment make the lamp as sensitive for gas testing as the old Davy, and yet at the same time have the lamp protected or shielded in a complete manner.

Hartlepool Shipbuilding in 1888.– The shipbuilding return for West Hartlepool for the past year will, it is said, be the largest in its history. The chief firm, Messrs. W. Gray and Co., in the current year have launched over 50,000 tons, whilst the total of the port in round numbers will be about 73,000 tons. The returns for some of the large Tyne yards are not fully completed, but some of the Wear statistics, duly to hand, show large additions to last year's figures.

A Japanese Floating Fort.—The Japanese Admiral, Akamatsu, is said to have invented a new floating fort for coast defence. This fort is to be built on a kind of vessel made of steel, and 150ft. in length. The armour is to be 12in. thick, and the bridge will be specially protected with a steel bulwark of 3in. It is to have a double screw and engines of 200 horse power, capable of attaining a speed of three miles an hour. On the first bridge will be placed 12 15-centimetre cannon, and on the second eight 26-centimetre. The crew will number 250 men, and each floating fort is estimated to cost £40,000.

The Gunboat Grasshopper.—The Admiralty have ordered the hull of the new fast gunboat Grasshopper to be strengthened at Sheerness Dockyard, and the ship to be prepared for her machinery trials. The Grasshopper was built last year, but has never been tested under forced draught, as from experiments made with her sister-ships it was feared her hull was not of sufficient strength to stand the strain of her machinery. This is of 3,000 horse power, being the most powerful ever fitted in a British gunboat of her tonnage. She is estimated to steam nineteen knots per hour.

Railways in China.—The merchants of Tientsin and others have petitioned Prince Chun, the Prime Minister, for leave to construct a railway to Tungchow, half way to Pekin. The great success of the line to Kaiping has doubtless prompted this step. There is an unparalleled field for railway enterprise in China, and the promises of its being opened up are on the increase. The opposition to railways has, in China, come from the Government, and in Japan from the people. The people of China and the Government of Japan have not regarded them with disfavour, a difference which is sometimes overlooked by people in Europe.

Cotton Spinning in Japan.—It is reported from Japan that the rapid growth of the cotton spinning industry of that country is beginning to direct public attention to the supply of the raw material. The total production of cotton in Japan is about 41 million pounds, and at present the mills consume 17 million. In consequence, the price of the home-grown cotton threatens to be disturbed, and the millowners are anxious to procure supplies from China, and desire the Government to reduce or abolish altogether the import duty on the raw material, which at present stands in the way of importing it from abroad.

Pilot Engines and Passenger Trains.—Major-General Hutchinson, R.E., reporting to the Secretary of the Board of Trade as to the causes of the slight collision which occurred on the 12th of November at Ryhope Station on the Sunderland and Hartlepool branch of the North-Eastern Railway, says in conclusion: "This collision would not have occurred at all but for the objectionable practice of attaching pilot engines to the back instead of to the front of passenger trains. There is now less reason, since the introduction of automatic continuous brakes, than ever for this practice being followed, and it seems most undesirable to expose the travelling public to the risks attending it."

The Hopcroft Mechanical Stoker.—A trial of a new form of mechanical stoker, which is being introduced by the Hopcroft Furnace Co., of 37, Walbrook, London, was made a few days ago on board the steamship Lotus, belonging to the Victoria Steamboat Association. In this furnace the fuel, which is of small coal, is fed into a hopper in front of the furnace, and is conducted thence through a tube, in which is an Archimedean screw, to the centre of the furnace grate, which is circular and is made to revolve slowly. The coal is thus delivered into the centre of the body of incandescent fuel, where it is slowly consumed under the influence of a forced draught supplied by a fan. The circular revolving grate is placed at a slight angle, dipping towards a set of fixed bars, on to which the clinkers fall and from which they drop into the ashpit below. During the trial the furnaces worked very satisfactorily, steam being well kept, although the fires were not over-driven. The funnel of the boat emitted no smoke during the trial, except when it was desired to show that highly bituminous, and therefore smoky coal was being used. The fuel was cheap slack or dust.

The World's Cotton Spinning.—The Austrian *Handels-Museum* gives the following interesting figures respecting the position of British cotton manufacture as compared with that of the rest of the world. The figures relate to 1887. The number of spindles in England is 42,740,000; in the rest of Europe, 23,180,000; in America, 13,500,000; in India, 2,420,000 ; total, 81,840,000. The quantity of cotton consumed is—in England, 1,514,521lb. weight ; in the rest of Europe, 1,459,119,000lb. ; in America, 944,758,000lb. ; in India, 300,000,000lb. Thus England has more than half the spindles in the world, and uses more than half the cotton worked by them, while English spinning is unrivalled in the excellence of its production and the cheapness of its price.

The Electric Light at Leamington.—It is stated that the arrangements made some time ago for lighting the streets of Leamington are likely to be brought to a termination. Hitherto the Electric Lightning Company have lighted the Parade with the incandescent light, but the effect has not been satisfactory either to the council or to the public. A short time back the company supplied four arc lights, which were erected near the Town Hall, and a number of sunbeam lights, which were placed in the top part of the Parade. The arc lights have, it is said, been far from satisfactory. They fluctuated very much in the quality of light, and occasionally one or more were extinguished. The sunbeam is admitted to be a very good light, but the cost of supplying it to the whole of the Parade will be so great as to preclude its adoption. The electric light supplied to the shops and private residences has, on the other hand, been an unqualified success.

New Steelworks at Wigan.—During the past twelve months the Wigan Coal and Iron Company Limited, who employ 10,000 workmen at their extensive collieries in the district, have been engaged in laying down extensive new steelworks at Kirkless, the headquarters of the company. Previously the company turned out a large quantity of wrought iron, but the demand for that quality of metal has of recent years fallen to a great extent, steel being utilised in its stead. It is estimated that 50,000 tons of steel blooms are consumed in Lancashire every year, and it is with the view of supplying this that the company decided to lay down new plant. This consists chiefly of four 15-ton melting furnaces, each capable of producing from 180 to 200 tons of steel per week, and it is estimated that the works will give employment to several hundred men. The works, which are illuminated by electric light, commenced operations on Saturday last.

The New German Rifle. — The new repeating-rifle adopted by the Germans is, it is stated, a slightly improved form of the Austrian repeater, the Mannlicher of eight millimetres calibre. The improvement consists chiefly in an alteration of the form of the shafts, necessitated by the system of shouldering in the German army being different from that in the Austrian. H. Mannlicher, the inventor, is a civil engineer in the service of the Austrian North-Western Railways, and has received 300,000 marks, or £15,000, for his patent, in addition to which he has been promised a small royalty. The new rifle is already being manufactured in three factories, namely, at Spandau, Danzig, and Erfurt, and is being turned out at the rate of 50,000 a month. At least two years, therefore, will be required to arm the German regular army and Landwehr. The powder which will be used is a German invention. It is said to be a highly-effective explosive, but not smokeless, like the French powder.

Proposed Harbour for Deal.—A memorial was forwarded by the Deal Town Council on the 24th ult. to the Board of Trade, in support of a proposal to construct a harbour at Deal. The memorial shows that Deal is without any harbour or shelter for ships or boats ; that for generations a large part of the population has been engaged in nautical pursuits, but from the want of a harbour they were unable to engage in deep-sea fishing, and at certain times of wind and tide were unable to carry on their occupation at all, as they could not launch from the beach ; that through the decline of their occupation the race of Deal boatmen was likely to die out unless some steps were taken ; that the harbour would open up import and export trade as well as deep-sea fishing, afford further communication with the continent, and provide a safe refuge and be of the greatest use, from its position, in connection with H.M. navy, especially in the time of war, as a rendezvous for small cruisers, and as a coaling station and victualling depôt.

Work and Wages in the Belgian Coalfields.—The recent strike in the Belgian coalfields lends particular interest to the report recently published by the Central Administration of Mines from M. Harzé, the head of that office. M. Harzé says that the number of workmen employed in the mines during the past year was 100,739, of whom 75,445 were below and only 25,294 above ground. The number of male adults was 63,292 above and 16,771 below ground ; of female adults, 3,201 below and 3,762 above ground ; of boys under 16, 7,920 below and 2,381 above ground ; of girls under 16, 1,032 below and 2,380 above ground. Clause 60 of the Code of Rules put in force in April, 1884, makes it illegal for boys under 12 or girls under 14 to be employed below ground, so that out of every thousand persons working below ground last year 839 were men, 42 women, 105 lads under 17, and 14 girls under 16, this being very different from 1883, when the proportion of boys and girls was much larger. The 100,739 workmen put out during the year 18,378,624 tons of coal, representing a total value of £5,907,000, the average price being 6s. 6d. a ton. The total amount of wages paid was £3,324,000, this giving each workman an average salary of £32 12s., or about 30s. more than in the previous year. M. Harzé calculates the daily wage at about 2s. 6d. for adults, 1s. 6d. for female adults, 1s. 2d. for boys, and 1s. for girls. The number of days during which work was provided was 289, leaving 76 without employment ; so that in a family of five persons, with, say, a father and two sons in the nine, the wages of the three would be close upon £100 ; while if the wife also worked at the mine it would reach £130. These wages, however, are at least a third lower than they were some 15 years ago.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

December 13th.

18200 Engine Packing, J. Moseley and B. Blundstone, Manchester.
18211 Metallic Alloys, G. E. Vaughan, London. (L. Weiller, France.)
18213 Circulation of Water, J. Daglish and J. E. L. Ogden, Wallsend-on-Tyne.
18214 Refrigeration, A. G. Brookes, London. (N. W. Wheeler, United States.)
18215 Stopping Leaky Tubes, S. A. Johnson, London.
18218 Coating Iron, G. Prout and D. Murry, London.
18220 Meters, E. Batault, London.
18230 Transmitting Motion, W. D. Sandwell, London.
18232 Looms, L. Boisseranc, London.
18233 Duplex Electric Telegraphs, H. A. Taylor, London.
18236 Tubes, R. Behrends, London.
18239 Cylindrical Articles, W. Ambler, London.
18241 Explosives, G. Trench, London.

December 14th.

18250 Cranes, J. W. Wailes, Liverpool.
18260 Steel or Metal Ingots, A. H. H. Bratt, Kent.
18262 Regulator, P. W. Sothmann and C. O. H. Kroll, London.
18270 Driving Chains, C. H. Brampton, Birmingham.
18273 Screws, T. S. Scarborough, Halifax. (T. Percy, New York.)
18279 Cocks, Taps, and Valves, P. Michaelis, London.
18283 Metal Pipes, E. Molles-Puyredon, London.
18284 Rock-boring Machines, J. E. Powell, R. J. Powell, and W. Whitaker, London.
18288 Turning Steel Ingots, &c., J. Neilson and J. Whitelaw, Glasgow.
18289 Valves, J. Neilson and J. Whitelaw, Glasgow.

December 15th.

18312 Furnaces, W. Booth, Manchester.
18314 Edge-setting Machines, J. M. Gimson, J. Gimson, A. J. Gimson, and S. A. Gimson, Leicester.
18324 Indicators, W. E. Heys, Manchester. (Messrs. Schaeffer and Budenberg, Germany.)—[Complete Specification.]
18332 Feed-water Heaters, D. Johnston, Glasgow.
18340 Automatic Reversing Gear, J. Jensen, Swansea.
18351 Buddle, J. Roach, London.—[Complete Specification.]
18355 Compound Engines, W. Burnell, London.
18356 Lubricating Devices, A. J. Boult, Middlesex. (C. Andersson, Denmark.)
18362 Explosive Compounds, J. W. Skoglund, London.
18363 Couplings, J. Chandler, London.
18364 Pistons, R. Hack and R. E. Plaistowe, Surrey.
18368 Motive Power, J. Stevenson, London.

December 17th.

18371 Screw Nails, H. Illingworth and S. P. Rushworth, Bradford.
18372 Milling, G. Addy, Sheffield.
18377 Gas Engines, J. F. Shaw, Manchester.
18391 Steam Engines, A. G. Brown, London.—[Complete Specification.]
18393 Packing, G. Twigden and W. H. Hick, Cardiff.
18412 Lubricators, W. L. Rawson, on behalf of the Woodhouse and Rawson Electric Manufacturing Co., Limited, and J. G. W. Fairbairn, London.
18414 Furnaces, C. A. Piat, London.

December 18th.

18431 Steam Engines, J. T. Case, London.—[Complete Specification.]
18432 Rolling Wheels, H. H. Lake, London. (H. W. Fowler, United States.) [Complete Specification.]
18433 Rails and Rail Joints, H. H. Lake, London. (W. Lowe and S. Tappen, United States.)—[Complete Specification.]
18434 Fixing Wheels on Axles, H. H. Lake, London. (A. T. Porter and A. P. Olmstead, United States.)—[Complete Specification.]
18435 Condensation, W. Burnham, London.—[Complete Specification.]
18440 Zinc, C. A. Burghardt, Manchester.
18444 Transmitting Power, G. R. Postlethwaite, Birmingham.
18449 Steam Engines, J. Williams, Caerllwyngrydd.
18464 Pumps, J. White, Glasgow.
18470 Cigarette-making Machinery, H. Brogden, Cheshire.
18472 Valves and Cocks, J. H. Ritchie, London.
18474 Husking Machines, A. J. Boult, Middlesex. (L. Paul and Co., Germany.) [Complete Specification.]
18476 Elevators, D. Steinmann-Haghe, London.
18477 Rolling Seamless Tubing, G. C. Dymond, Liverpool. (W. H. Appleton, United States.)—[Complete Specification.]
18484 Slide Valves, J. Thom, Liverpool.
18489 Belt Placer, F. Pretzel, London.—[Complete Specification.]
18492 Tap Cinder, T. H. Roberts, Middlesex.
18493 Cutting Hollow Steel, R. A. Hadfield, London.
18506 Hollow Steel Shells, R. A. Hadfield, London.
18511 Steam Pumps, P. Jensen, London. (D. B. Burnham, United States.) [Complete Specification.]
18512 Oil Cans, J. Gilchrist, Glasgow.
18513 Motors, J. F. Roseberry, London.
18514 Bilge-water Pumps, N. Richardson, London.—[Complete Specification.]
18516 Utilising Waste Heat, D. Davies, London.
18518 Cable Tramways and Railways, S. Pitt, London. (J. B. Webb, United States.)
18525 Motors, E. Wilson, London.
18527 Self-closing Buckets, C. L. Smith, London.—[Complete Specification.]

December 19th.

18537 Self-feeding Apparatus for Bronzing Machines, W. Pickersgill and E. Bush, Leeds.
18543 Governors, J. Wild and B. Wild, Chadderton.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vols. I. and II. (bound), price 6s. 6d. each, can be obtained from any Newsagent, or will be forwarded, carriage paid, from either of our offices on receipt of the amountby postal order or stamps.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office on Wednesday Morning *at the latest.*

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THE

PRACTICAL ENGINEER.

JANUARY 11TH, 1889.

FACTORS OF SAFETY.

In modern engineering practice there are probably few subjects of greater importance than that of "factors of safety" in connection with the strength of materials, and to this we propose to devote the present article.

Taken in its simplest sense, a factor of safety is a number representing the ratio of the ultimate strength of a given material to the maximum stress to which it will be submitted in the structure or machine of which it forms a part. In dealing with this question all classes of work may be divided under two heads—structural or fixed work, and machinery having moving parts. In the former the stresses generally will be of a steady and easily-determined nature, whereas in the latter they will be accompanied by vibration, and in some cases percussive action.

As soon as scientific designing began to take the place of rule-of-thumb methods, the introduction of factors of safety would necessarily follow, and the thoughtful engineer would consider upon what grounds he might determine their values so as to obtain ample security without using an extravagant quantity of material. If the materials of construction, when under stress, remained physically unaltered until upon the point of rupture, then the factor of safety might be very low. But such is by no means the case, especially in regard to the metals, and this opens up the very important question as to the datum to which our factor of safety is to be applied in order to give the safe working stress. It has been usual to apply it to the breaking or ultimate strength, but this appears illogical, as the criterion of useful resistance must be furnished by the stress at which the physical formation of the materials commences to exhibit permanent alteration —that is, the point at which its elasticity becomes impaired; for, assuming that a stress is applied capable of producing a permanent distortion, then such stress recurring will gradually cause increasing derangement, until ultimately the work fails.

In regard to the strength of iron and steel for railway structures, it is a notable fact that in the Board of Trade requirements no factor of safety is involved. There is a hard and fast line drawn; the working stress permitted is 5 tons per sectional square inch for tension and compression for iron, and 6½ tons per sectional square inch for steel. There is no restriction as to strength or elasticity of iron or steel, and therefore 5 tons is assumed to be safe whether the iron used has an ultimate strength of 19 tons or 26 tons per sectional square inch.

In this case, the Board of Trade regulations have really a nominal value, and nothing beyond that; because the engineers entrusted with the execution of important works take measures to insure the quality of the material used being such as to afford a sufficient margin of safety.

To return to the question of determining factors of safety, we will consider the elastic limit in regard to the ultimate tensile strength. It has been shown by numerous experiments that *the first stress* put upon a bar fresh from the mill will cause some permanent elongation; this, however, is not to be taken in the sense of permanent set as indicating the passing of the limit of elasticity, and for the following reasons: During the passage of the bar through the rolling mill its molecules are variously and unequally strained, both by the action of the machinery and by the variations of temperature to which it is subjected. The bar then, when it has left the mill, has its molecules in a condition of unstable equilibrium—they are not so placed as to exhibit a homo geneous structure; naturally, on the first stress being applied—which, by extending the bar, will allow the molecules to move—they will adjust themselves to normal positions, the effect being similar to that induced by the process of annealing.

Assuming now that we have a bar of wrought iron of homogeneous texture, it will be found that the elastic limit is not under one-third of the ultimate tensile strength of the metal; therefore one-third of the ultimate strength should be taken as the datum from which to determine the factor of safety, it being always borne in mind that the working resistance refers to the *maximum* strain that can be brought upon the structure. We will assume that the elastic limit is one-third of the ultimate tensile strain, and from our own practice we judge that 50 per cent margin should be left on the working stress; the factor of safety thus arrived at, expressed in terms of the ultimate strength, is 4·5. Following these lines, if we are designing under Board of Trade rules, we must specify iron having an ultimate tensile strength of not less than 22·5 tons per sectional square inch.

The matter with which we are dealing is one of such wide and varied scope that it is impossible to do more than touch upon it in the space to which we are limited, although we may have occasion to return to it again; but before concluding our present remarks we may just add a few words on factors of safety as applied to machinery and locomotives.

In the older works on mill-gearing the factor of safety commonly used was 10; the late Sir William Fairbairn gave it for spur gearing, and for steady running mill work there is no doubt that it is sufficient. For cotton and silk spinning machinery it is certainly ample, and also for ribbon looms and other machines not liable to percussive action.

To turn to locomotives, there is hardly one part of a locomotive upon which we can determine the nature of the strains; that is to say, resolve them into one resultant. The strains upon the crank axle have been treated by professional mathematicians; but their formulæ do not include the "squeeze" in going round a curve, nor the extra torsion on the axle induced. At the same time, not to dilate further than is necessary upon this point, we must remark that experience—"practical experience"—only can deal with such machines; but that experience must be exercised by one having sufficient mathematical knowledge to check his main dimensions.

There is a great deal in connection with machinery that we cannot calculate by formulæ, but which by habit can be designed by eye. One of our highest scientists, Dr. Tyndall—a man whom no one would regard as spiritualistic—admits the "scientific use of the imagination," and therefore it should be unanswerable that a man who has passed his life in the locomotive workshop is capable of judging at sight of the fitness of much of the work that comes under his notice.

THE VYRNWY WATERWORKS.

The close of the year 1888 has witnessed the practical completion of one of the largest engineering undertakings for the supply of water to towns which has yet been attempted. The artificial lake formed by impounding the waters of the river Vyrnwy, in Montgomeryshire, places at the disposal of the city of Liverpool a reservoir having a length of nearly four miles, and a stowage capacity of twelve hundred million gallons. The supply will be conveyed to Liverpool through a pipe sixty-eight miles in length. Considering the magnitude of the undertaking, the work has been executed with extraordinary rapidity. Projected in 1877, the scheme received the sanction of Parliament in 1880, but was not actually commenced until 1881, and on the 28th of November last year the valves in the masonry dam were closed, and the waters permitted to rise in the artificial lake that had been formed. It must be said that Lancashire has of late years displayed a commendable enterprise in undertaking large engineering works. The Mersey Tunnel and the Ship Canal to Manchester are works of no ordinary magnitude, while the Liverpool Waterworks, and the Thirlmere Scheme, now in process of construction, and intended eventually to supply Manchester with water from the Lake District, are both undertakings which may fairly claim to rank alongside either of the others.

MINING EXPLOSIONS IN 1888.

The number of deaths recorded from explosions in mines during the year 1888 forms a gratifying contrast to the corresponding figures of previous years. The number is the lowest registered since the year 1851, when the returns were first officially given. The lowest death-rate prior to that of last year was the one recorded in 1884, when 65 persons were killed; whilst the highest during the last thirty-eight years was in 1866, when the total number of lives lost in our mines from this cause alone reached 650, of which total upwards of 360 resulted from the terrible catastrophe at the Oaks Colliery, near Barnsley.

It is pleasant to note the marked diminution in the loss of life from mining explosions that has taken place during the last twenty years. In 1888 the loss of life from this cause only amounted to 43, as compared with the terrible total of 650 in 1866, to which we have just referred.

The stringent provisions of the Act for the better regulation of mines, which came into operation on January 1st of last year, has evidently had a good effect, and resulted in a marked decrease in the number of persons killed by mining accidents, though it would appear that a further decrease is possible, as the greater number of the explosions which occurred last year are said to have arisen from causes which were entirely preventible.

LITERATURE.

Boilers: Their Construction and Strength. A Handbook of Rules, Formulæ, and Tables. By Thomas W. Traill, F.E.R.N., M.Inst.C.E., Engineer Surveyor in Chief to the Board of Trade. London: Charles Griffin and Company.

The book before us, as its title indicates, is largely composed of rules and tables. It is hardly one that would commend itself to engineering students, for which class of readers, in fact, it has not been written. To the engineer and practical boiler-maker, however, it will prove invaluable, as its copious and carefully worked-out tables will save much of the calculating drudgery which is so frequently entailed in working out the scantlings of new boilers, or in determining the safe working pressures to be allowed for old ones.

We do not mean to imply that the book is one we should not wish to recommend to students or young engineers; on the contrary, the introductory chapter on "Material for Boilers" contains many exceedingly useful and practical hints with regard to the treatment of iron and steel which are exceedingly valuable and the outcome of a wide experience. All that we wish to point out is that the book does not treat upon the principles which determine the design of boilers for any special case, nor does it deal in any way with the evaporative performances of the various types in existence. Assuming the design and general dimensions of the boiler, however, to be determined, its construction will be very much facilitated by a reference to the pages of the book before us. The enormous increase in steam pressures that has taken place during recent years has, to a very large extent, revolutionised the science of boiler construction, so that from having in its early days formed little more than a mere tank for the reception of water, a steam boiler has, by a process of evolution, developed into a first-class piece of engineering, and to determine the dimensions of the various parts of the structure has hitherto involved a considerable amount of careful and laborious calculation. This labour, the work in question will, by its aid, enable the draughtsman and boiler-maker in future to avoid, and the book is one that certainly deserves a place on the shelf in the drawing office of every boiler shop. The introductory chapter on *material*, is followed by one on iron boilers, with a number of useful rules regarding the proportion for riveted joints of shells, receivers, domes, &c.; rules for the strength of curved ends, superheaters, furnaces, curved tops of combustion chambers, and flat surfaces generally. The rules with regard to these are, as might be expected from the position of the author, those which have been fixed by the Board of Trade. This is followed by a similar chapter on steel boilers. Following this are a series of exhaustive tables giving pressures, pitches, and areas of flat surfaces. These are supplemented with tables giving the sizes and stresses on screwed stud stays. An equally complete set of tables is given with regard to the scantlings of flat surfaces, such as combustion chamber tops, &c. A series of interesting tables, accompanied with sketches, are also given, showing the design and strength of various types of riveted joints, as well as the pressures for furnace and flue tubes. The book is furnished with the usual tables with regard to circles and circular areas generally supplied in works of this class, and the only remark that we may make with regard to this portion is that the increments of advance are much smaller than are generally given, and therefore render the tables more valuable. A reference should also be made to the tables that are supplied for enabling the proportions of spring safety valves to be readily determined. These are more complete than any we remember to have seen, and in all probability are the most exhaustive yet published.

BOOKS RECEIVED.

The Locomotive Engine. By J. A. Haswell, M.I.M.E. London: Walter Scott. Price 6d.

Construction and Use of Grinding Machines. Brown and Sharpe's Manufacturing Co., U.S.A.

Preparing for Indication. By Robert Grimshaw, M.E. Practical Publishing Co., New York.

Pumps; their History and Construction. By Philip R. Björling. Emmott and Co., London and Manchester.

A Table of the Power of Leather Belting. By C. L. Hett, Assoc.M.Inst.C.E. London: E. & L. M. Spon. Price 1s.

Questions in Applied Mechanics. By Professor Jamieson, M.Inst.C.E. Glasgow: John W. Morgan & Co. Price 8d.

Transactions of the American Society of Mechanical Engineers. Published by the Society, New York.

Calvert's Mechanic's Almanack. Manchester and London: John Heywood. Price 4d.

Yorkshire College of Science: Fourteenth Annual Report, 1887-8.

Bursting of a Cast-steel Gun.—The cast-steel gun, cast recently by the Pittsburg Steel Casting Company, and of which so much was expected, was burst at the second fire while being tested at the Government proving grounds at Annapolis, Md., on December 5th. The gun was of Bessemer steel, and was made as an experiment in connection with the proposition of adopting steel cast guns for the navy. It was rough bored at the factory, and rifled and finished at the Government works at Washington. It was 193in. long. The test was to be with a first charge of 38lb. of powder, and 48lb. for ten consecutive shots. The projectile was a 100lb. conical shot. The first fire was made with 36lb. of powder, giving a pressure of 11 tons per square inch; the second was with 48lb., giving a pressure of 14·1 tons, under which it burst; breaking from the trunnions to the breech in more than twenty pieces, between the trunnions and the muzzle it remained intact. The shot deflected about 20ft. from the spot at which it was aimed.

MARINE ENGINEERING IN 1888.

In the shipbuilding and marine engineering branch the year just closed has been one of improvement as compared with the last few years. There appear to have been launched in the United Kingdom about 500 vessels of various dimensions and designs. These include sea-going ocean single-screw steamers, twin-screw steamers, paddle steamers, tug boats, dredgers, trawlers, and sailing vessels.

Of these it is interesting to note that about 352 have been fitted with triple-expansion engines, and only about 58 with the ordinary compound, and these are all of comparatively small dimensions. The remaining steam vessels consist of those fitted with paddles, about 21 in all, of which one was on the old one-cylinder principle. Six had two cylinders, 12 had compound, and two triple-expansion engines. Twin screws also about 21, of which four had compound and 17 triple-expansion engines. Of the sailing ships, there appear to have been built about 79 altogether; of these 16 were of iron, 38 of steel, and 25 of wood, the latter being all small craft.

Among the vessels built for special purposes may be mentioned those for carrying petroleum in bulk, of which we note the Chester, the Ocean, and the Charlois vessels, 310ft. by 37ft. by 18ft., from the yard of Messrs. Russell and Co., of Port Glasgow; also the Caroline Robert de Many, a vessel 256ft. by 37ft. by 18ft., by Messrs. R. Craggs and Sons, of Middlesbrough. The Amyen and the Manlong, two light-draught vessels, 130ft. by 28ft. by 5ft. 6in., from the famous establishment of Messrs. Denny Bros., Dumbarton, are out of the ordinary; they are fitted with stern wheels, and form an addition to the enormous fleet of the Irrawaddy Flotilla Company.

Among the dredgers we note the Velez Sanfield, built by Messrs. Fleming and Ferguson, of Paisley, a twin-screw vessel 140ft. by 30ft. by 10ft., and fitted with Mr. Ferguson's improved four-cylinder quadruple engines, cylinders 10in., 14in., 20in., and 28in., by 20in. stroke.

A number of small vessels for fishing purposes, fitted with special trawling apparatus, have been built during the year, and we understand there are a number more now in hand. There is a large amount of capital being invested in this class of craft, giving an impetus to a branch of business in which there is a large number of men employed.

Of the larger vessels, say those over 350ft. long, the largest launched during the year are the City of New York and the City of Paris, which measured 527ft. by 63ft. by 22ft., having triple-expansion engines, two sets, each 45in., 71in., and 113in. cylinders by 60in. stroke and 150lb. pressure, from the yard of Messrs. J. and G. Thomson, on the Clyde.

The performances of the former of these monster ships are already known to the world, but it is anticipated that better results will yet be attained after some important improvements have been carried out. These vessels are now, since the breaking up of the Great Eastern, the largest afloat, and they are, since the days of the "Hill" boats and one or two others, the only large vessels fitted with twin screws; so that altogether they may be taken as having a combination of parts in the machinery space such as no other vessel has yet had. These may be briefly stated as consisting of separate engine-rooms divided longitudinally by a water-tight bulkhead, triple-expansion engines, independent centrifugal circulating pumps, and forced draught to the boilers. With this combination of the latest improvements, it will indeed speak volumes for the high reputation of the builders if the expectations are realised.

Tug boats form another class of vessels for special purposes, and of these there have been about a dozen. From the number that have been fitted with screws, some twin, it looks as though the old paddles were being discarded for this purpose. Three out of the number have triple-expansion engines, and the rest, with one exception, compound engines.

Engineers have had a fair amount of work in modernising old engines or fitting new engines and boilers. From the following list it will be seen that about 37 vessels were modified in this way during the course of last year. Comparing this list with that given in our issue for December 28th, there appears to be a steady continuance of work of this kind, which will no doubt exist for some time to come.

Altogether the past year may be said to have been a properous one for those engaged in shipbuilding and marine engineering generally.

LIST OF VESSELS WHOSE ENGINES WERE TRIPLED OR WHICH HAD NEW ENGINES AND BOILERS FITTED IN 1888.

Name of Ship.	Date.	Length.	Breadth.	Depth.	Old Engines. Cylinders.		Old Engines. Stroke.	Old Engines. Pressure.	New Engines or Alteration. Cylinders.			New Engines or Alteration. Stroke.	New Engines or Alteration. Pressure.	Owners.	Engineers.	Remarks.	
Adowa	1882	266	36	22	33	63	39	80	25	33	63	39	80	Fenwick & Co.	N. E. Marine Co.	Engines Tripled.	
Argo	1860	210	27	16	31	58	30	—	20½	31	55	30	—	T. Wilson & Sons	Amos & Smith	Ditto	New Boilers
Avon	1877	219	29	15	31	56½	36	65	21	33	53	36	165	W. Sloan & Co.	Cunliffe & Dunlop	Ditto	ditto
Braemar	1875	200	27	15	24½	45	30	65	15	24½	45	—	160	Grampian S.S. Co.	Hall, Russell & Co.	Ditto	ditto
Balmoral Castle	1876	344	39	21	47	75	48	60	28	47	—	48	160	Balmoral Castle S.S. Co.	D. Rowan & Son	Ditto	ditto
Circe	1874	331	35	26	37	74	48	60	25	41	68	48	160	Donaldson Bros.	Barclay, Curle & Co.	New Engines	ditto
Cristobal Colon	1880	330	36	26	40	73	48	80	24½	34	68	45	150	(Foreign owned)	W. Doxford & Sons	Ditto	ditto
Cuzco	1871	384	41	35	60	104	48	—	35	57	90	51	150	Orient Steam Nav. Co.	Fairfield S. & E. Co., Limited	Ditto	ditto
Clan Gordon	1879	305	34	24	34	63	42	80	22	34	59	42	160	Cayzer, Irvine & Co.	J. Howden & Co.	Engines Tripled	ditto
Dotterell	1878	264	32	21	32	59	36	80	20	32	52	36	150	Cork S.S. Co. Limited	D. Rollo & Sons	Ditto	ditto
Dabulamanzi	1882	260	35	21	33	64	42	90	21	33	56	42	160	J. T. Rennie & Son	Hall, Russell & Co.	Ditto	ditto
Garth Castle	1880	365	43	31	51	88	57	75	33	55	88	57	150	Donald Currie & Co.	T. Richardson & Sons	Ditto	ditto
Honfleur	1873	176	24	12	26	52	30	—	19½	31	51	33	--	L. & S.W. Railway Co.	J. & J. Thomson	New Engines	ditto
Henry	1872	221	29	20	27	50	30	-	15	23½	39	33	150	Curwen Bros.	Westgarth, English & Co.	Ditto	ditto
James Drake	1874	241	32	23	29	54	36	—	16 22½	32	45	36	170	Wilkie & Turnbull	J. Dickinson	Engines Quadrupled	ditto
Julia Weiner	1876	220	29	17	28½	53	33	45	17	28	45	33	160	R. Gordon & Co.	Black, Hawthorn & Co.	Engines Tripled	ditto
Malmo	1860	203	27	16	24	43	46	—	18	27	48	30	—	T. Wilson & Sons	Amos & Smith	New Engines	ditto
Marchesa	1877	138	25	13	21	36	24	70	9½ 9½	21	36	24	150	C. T. Kettlewell, Esq.	Fairfield S. & E. Co. Limited	Engines Tripled	ditto
Marmion	1871	249	30	18	46	82	42	--	26½	42	67	45	160	London and Edinburgh Ship Co.	S. & H. Morton	New Engines	ditto
Medway	1877	383	42	33	59	103	60	—	39	62	101	60	150	Royal Mail Steam Packet Co.	Earle's Co., Limited	Ditto	ditto
Moor	1881	365	46	28	51	90	60	85	34	56	90	60	160	Union Steamship Co.	T. Richardson & Son	Engines Tripled	ditto
Moray	1877	312	34	25	40	72	42	70	24	38	62	42	150	J. Warrack & Co.	J. & J. Thomson	Ditto	ditto
Martaban	1873	350	36	27	41	70	42	60	21½ 32	43	62½	42	180	British & Burmese S. Navigation Co.	Denny & Co.	Engines Quadrupled	ditto
Madura	1873	316	33	25	45	78	45	50	24	38	57	42	160	British India Steam Navigation Co., Ld.	A. & J. Inglis	New Engines	ditto
Naples	1875	316	35	25	36	68	45	60	22	36½	60	45	160	Nelson, Donkin & Co.	Palmer's Co., Limited	Engines Tripled	ditto
Niobe	1883	298	36	25	38	70	36	—	23	36½	59	42	165	(Foreign owned)	(Foreign Engineers)	Ditto	ditto
Pacifica	1869	340	40	33	—	—	—	—	28	44	72	54	—	H. F. Swan, Esq.	Hawthorn, Leslie & Co., Limited	Ditto	ditto
Phœnician	1864	335	34	28	39	68	42	—	19½ 27½	39	55	42	--	J. & A. Allan	Denny & Co.	Engines Quadrupled	ditto
Saltburn	1883	230	32	17	29	55	36	—	18	29½	52	36	150	J. S. Barwick, Esq.	G. Clark, Esq.	Engines Tripled	ditto
Szápáry	1877	230	30	20	30	52	36	70	19	30½	52	36	160	Adria Hungarian Sea Navigation Co.	Blair & Co.	Ditto	ditto
Waldensian	1861	322	34	29	40	68	39		20	33	54	39	160	J. & A. Allan	D. & W. Henderson	Ditto	ditto
Zanela	1871	250	28	17	30	54	36	—	19	30	48	33	150	Atlantic and Eastern S.S. Co., Ld.	Rollo & Sons	Ditto	ditto
Sakkarah	1872	240	32	23	30½	61	39	70	19	29	60	39	150	(Foreign owned)	Wigham, Richardson & Co.	Ditto	ditto
Roslin Castle	1883	380	48	31	50	90	60	80	—	—	—	—	—	—	—	—	
Nam Yong	1875	255	32	24	30	57	33	65	18	30	57	33	150	J. Wood & Co.	T. Richardson & Sons	Ditto	ditto
Poderosa	1875	250	33	20	33	62	33	70	19	33	62	33	160	J. Tully & Co.	N. E. Marine Co., Ld.	Ditto	ditto
Austrian	1867	319	38	32	45	78	45	—	23	39	64	42	160	J. & A. Allan	J. Howden & Co.	New Engines	ditto

ILLUSTRATIONS OF THE USE OF THEORY IN THE WORK OF THE ENGINEER.—IV.

(Concluded from page 9.)

THE STEAM ENGINE.

FOR no machine which the engineer constructs is a rational theory so important as for the steam engine. The whole process of conversion of heat into work lies beyond the range of simple observation, and we are entirely indebted to difficult mathematical investigations for any clear insight into the actions concerned.

The whole modern thermo-dynamical theory of the steam engine has been built up in just over 40 years, counting from Joule's first determination of the mechanical equivalent of heat. It is not surprising at all that, in the development of the theory, the complexity of the problem was underrated, and theories given as complete which failed to embrace essential conditions.

The greatest failure was that the theorists, for a long time, indeed almost till recently, having constructed a theory which would be very nearly exact if the engine cylinders were constructed of non-conducting material, did not perceive how enormous a difference in the action of the steam resulted from the conductivity of the cylinder sides. They had a certain justification in the view they took. In jacketed engines we have a measure of the whole transfer of heat through the cylinder walls. That transfer is, no doubt, not a negligeable quantity, but, at least in simple engines, it is not so large that it could not well be allowed for as a correction in results otherwise trustworthy. If the transfer of heat through the cylinder wall constituted the whole of the difference in the action of the steam in a non-conducting and conducting cylinder, then the older theory of the steam engine of ten or twenty years ago might still be accepted as a reasonable approximate rational theory.

When, however, this theory was compared with actual accurate steam-engine tests, it became apparent that in engines of good design the consumption of steam exceeded the theoretical consumption by 40 or 50, in some cases by 50 to 60 per cent. Some action had been ignored in the theory important enough to introduce errors of this large magnitude. Indeed, it is not too much to urge that the theory, apparently so exact and perfect, was not a true theory of the actual steam engine at all. Later we have come to recognise that this great discrepancy is due to the conductivity of the cylinder walls, though it is not measured by or comparable to any direct transfer of heat through the cylinder walls to the air, or the jacket surrounding them. Why the action of the sides is so obscure, and has taken so long a period to be recognised, is a point to which reference will be made presently. There are one or two singular misconceptions about the thermodynamical theory of heat engines which I should like first to clear away.

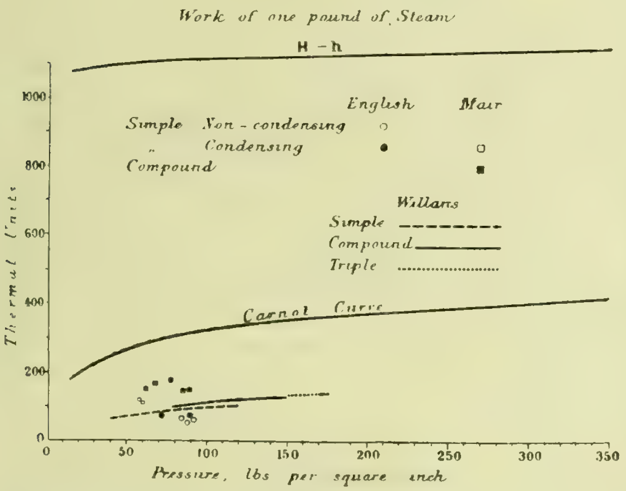
There is a remarkable principle due to Carnot, beautifully simple in its terms, and involving no algebraic complexity in its statement, which has been seized on and misapplied till it has become one of the most illused and misrepresented principles in applied mechanics.

A Carnot engine is a heat engine, in which heat is transformed into work under strictly defined conditions. The conditions secure reversibility. Under those conditions, for an engine working between the absolute temperatures t_1 and t_2, the fraction of heat converted into work is

$$\frac{t_1 - t_2}{t_1}$$

of the whole heat expended. From the conditions of reversibility, we deduce that no other engine can work more efficiently. Consequently, of a quantity of heat used in a heat engine working in given limits of temperature, the quantity available for conversion into work is given by Carnot's ratio, and in a reversible engine would be independent of the fluid employed. Whether the efficiency of any actual engine will approach this is a totally different question, for no actual engine satisfies the conditions of reversibility.

FIG. 2. STEAM-ENGINE EFFICIENCY.



For actual steam engines, the lower temperature at which the engine works is fixed by practical conditions. Say the lower temperature is 102 deg. Fahr. The upper temperature rises with the pressure, so that for a reversible engine, working down to a temperature of 102 deg., the efficiency would rise with the pressure.

In sketch fig. 2, I have shown for different steam pressures the quantity of heat H-h in a pound of steam, reckoned from 102 deg., and the portion of this which could be converted into work in a perfect reversible engine. The heat which would be so converted into work is given by the ordinates of a curve, marked "Carnot curve."

The most common misapprehension about Carnot's principle is, that it is to be taken as a practical guide to the relative efficiency of different actual engines, in which not one of Carnot's rigid restrictions is satisfied. This extraordinary notion often takes the form that two engines, working at different boiler pressures, should have efficiencies proportional to that got by putting the boiler and condenser temperature for the t_2 and t_1 in Carnot's fraction. Nothing can be less accurate or more misleading.

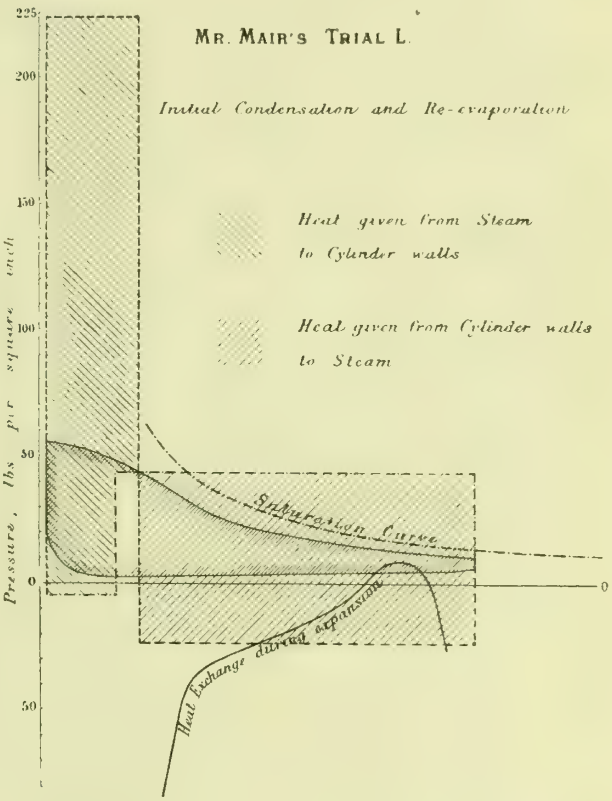
On the diagram, I have plotted the efficiencies of various engines from some of the most trustworthy experiments. Some of Mr. Mair's experiments are plotted, which represent the highest efficiency yet obtained with condensing engines. I have also shown by curves the efficiencies obtained in Mr. Willan's experiments, which represent the highest efficiencies yet obtained in non-condensing engines. Also a few of Major English's results on a less satisfactory type of steam engine. Of course these efficiencies are lower than the efficiency of the corresponding reversible engine, as they must be. But the losses in actual engines over and above the necessary and unavoidable loss in a reversible engine, generally amounting to 50 or more per cent of the available heat, totally destroy any relation between the efficiencies of actual and reversible engines.

A still stranger misconception is that in any case where heat is used, even without transformation into work, Carnot's principle may be applied. In a boiler furnace heat is generated in one fluid, and transferred to another fluid. No mechanical work is done. Carnot's principle has nothing to do with the fraction so transferred.

A case is taken where air enters a furnace at 510 deg. absolute, is raised in temperature to 2,000 deg., and finally leaves in the chimney at 510 deg. Obviously, in that case, the whole of the heat generated is transferred to the water, and the efficiency is unity. But by a misapplication of Carnot's principle the efficiency is made out to be 0·87.

In Carnot's engine the steam is supposed to expand isothermally. A curious mistake has arisen out of this. Because an ordinary engine gives an expansion curve, which nearly fits an isothermal line, it is deduced that the steam in an ordinary engine remains at constant temperature during the stroke; and a further curious deduction is made, that the whole of the work done by the engine is due to heat supplied by the jacket. This is all absolute fallacy. Nothing is more certain than that during the stroke the cylinder contains a mixture of water and steam; consequently the steam must have the saturation temperature due to its pressure. For the mass of steam initially in the cylinder, the real expansion line necessarily falls below the isothermal. But as steam is generated during the stroke by evaporation from the hot cylinder walls, the expansion curve is raised so as to agree roughly with what would be an isothermal if the mass of steam were constant during expansion. The actual expansion line is an expansion line for a varying mass of steam, and therefore no inference can be drawn from it as to the temperature of the steam. The true temperature law, unless this be sensibly affected by unhomogeneousness of the mass in the cylinder, is that the temperature is that of saturated steam due to the pressure at each point of the stroke.

FIG. 3. THE STEAM ENGINE.


Mr. Mair's Trial L.
Initial Condensation and Re-evaporation
Heat given from Steam to Cylinder walls
Heat given from Cylinder walls to Steam
Saturation Curve
Heat Exchange during expansion
Pressure, lbs per square inch
225
200
150
100
50
0
50
0

It may now be assumed that the condensation of steam in the early part of the stroke is a dominant factor in determining the efficiency of the steam engine, and that the hope of improving steam engines as we find them lies mainly in a study of the conditions which favour or diminish cylinder condensation.

In James Watt's first patent the steam jacket as a means of preventing condensation in the steam cylinder is mentioned, and in his second patent it is shown in the drawings. No doubt Watt had a general notion that it was good to keep steam in a cylinder warm, but it is very difficult to see that he could have justified the use of the jacket on any principle then known to science. In fact, we must go rather deeply into the most modern views of the action of steam to understand at all how a jacket can increase efficiency. For note, first, that a jacket does not diminish, but rather increases, the direct loss of heat due to radiation. Whatever radiation takes place from an unjacketed cylinder, the same must occur from the jacket, increased a little by the greater surface of the jacket and more continuous high temperature inside. In the next place, the heat supplied by the jacket to the steam in the cylinder would, at first sight, seem to be necessarily less efficient than heat supplied directly into the cylinder, for the heat supplied from the jacket acts on the average through only part of the stroke, and some of it passes away during exhaust, when it does no good directly in increasing the useful work.

There is another anomaly about the use of a jacket I should like to point out in a rather popular but, I think, striking way. Turning to modern and exact measurements, it appears that in good ordinary engines the initial condensation of steam in the cylinder at each stroke amounts to, in very favourable cases, 10 to 20 per cent of the steam admitted. In a great many engines, not recognised as bad, or generally considered to be working in unfavourable conditions, it amounts to 50 or 60 per cent of the steam admitted. Now, I suppose, it is not an uncommon idea about a steam jacket that its influence is very largely due either to its keeping the steam dry or to its causing direct re-evaporation of the water in the cylinder. But just see how totally inadequate a jacket must be for any purpose of that kind. Take an engine in which 40 per cent of the steam is actually condensed. To be adequate to re-evaporate 40 per cent of the steam supplied by heat transmitted through the wall, the cylinder surface ought to be at least equal in area to four-tenths of the boiler surface. In fact, from the small difference of temperature on two sides of the cylinder wall compared with that on two sides of the boiler wall, less heat goes through a square foot of cylinder wall than through a square foot of boiler wall. Yet the cylinder area is only a small fraction of the boiler area. Hence the value of the jacket so far as it acts in directly increasing the work in the cylinder by re-evaporation must be an insignificant one.[*]

Look at another point. Suppose it was possible to construct a cylinder with a perfectly non-conducting wall. How would the steam work in such a cylinder? There would be no loss by radiation; there would be no possible cooling of the steam during admission by the wall itself. In that case, if the steam entered the cylinder dry, I do not think there would be any initial condensation. For suppose we start with a pound of water put into the cylinder. Initially that must be heated up to the temperature of the entering steam, causing condensation. During exhaust evaporation would take place and the pound of water cool down again. In the main, each ounce of steam initially condensed to heat the water in the cylinder would be condensed at a high temperature (that of admission) and re-evaporated at a low temperature (that of exhaust). Hence as the total heat is less at the low temperature, less heat is taken to re-evaporate an ounce of water than it initially gave up in condensing. A little heat would be left behind, which would tend to dry the cylinder. Going on in this way, the pound of water initially put into the cylinder would gradually disappear.

Now, in a non-conducting cylinder, indeed probably approximately in any cylinder, the mass of the steam expands adiabatically, and water is formed probably as a mist or fog throughout the mass of the steam. If a material fraction of this water produced by expansion finds its way to the cylinder wall, it may even in a non-conducting cylinder keep the walls wet. I think it is rather improbable it does so. I think more likely it flows off to the condenser entrained in the steam like so much smoke. Anyway, there is in the non-conducting cylinder one powerful cause constantly acting, tending to dry the cylinder—the surplus of the heat of initial condensation over that of exhaust evaporation. There are also others, such as the piston friction.

Passing now to the case of actual steam engines with cylinders having walls capable of absorbing and giving out heat, let me first point out how very large the area of the cylinder wall is compared with the weight of steam in contact with it during a stroke. To take not a bad steam engine, but one of the very best, I select the data of the engine experimented on by Mr. Mair, and marked L.[*]

Trial L was on a single-cylinder beam engine, with jacket and about 4½ expansions, working at about 123 H.P. The total steam used per stroke was 1·14lb., or 31 cubic inches of water. This, condensed and spread over the cylinder wall, would only make a layer less than half a hundredth of an inch thick. Take the range of temperature between exhaust and initial temperature as roughly 200 deg. The heat which would be given up if the whole of the steam admitted in a stroke were condensed, if imparted to the cylinder wall, would only heat a layer of the cylinder wall open to admission one-fifteenth of an inch thick, from the condenser temperature to the initial steam temperature. If the cylinder walls are wet, the transfer of heat would be still more easy. At any rate, it is easy to see how enormously a conductive surface like that of a dry or a wet cylinder wall must affect the behaviour of the steam within it. Cooled during exhaust by the re-evaporation which goes on at low pressures, 1·14lb. of steam are admitted to contact with 3,000 square inches of cooled cylinder wall. Is it surprising that out of the 1·14lb. Mr. Mair found only 70 per cent remaining as steam at the cut-off. The heating of a minute layer of the cylinder wall during admission would explain the 30 per cent of condensation, and the re-evaporation of this during exhaust would prepare the walls to re-condense another 30 per cent of the steam admitted at the next stroke. Further, the whole of the action occurs in a quite thin layer of the inside of the cylinder. It may go on almost without any transfer of heat through the wall one way or the other.

Now, I thought it might be instructive to show graphically how important this kind of action in a steam cylinder is. In fig. 3, I have shown the indicator diagram of Mr. Mair's trial L. Its area represents the whole useful work done in a stroke. During the stroke there is an exchange of heat with the cylinder wall which Mr. Mair has calculated. During admission heat is given to the cylinder wall or to some layer of water on it, as the case may be. We have not settled yet the relative importance of iron and water in effecting this exchange. During expansion and exhaust heat is given back from the wall. Now, quantities of heat can be converted into equivalent quantities of work, and represented by areas. The rectangles on the diagram show the areas thus found for the heat exchange with the cylinder wall to the same scale as the indicator diagram. For the admission period there is a rectangle whose area is the work equivalent to the heat given to the wall. For the expansion and exhaust period there is a rectangle whose area is the work equivalent to the heat given back from the wall, and for the most part wasted during exhaust. Necessarily, if the engine is working steadily, the areas of these two rectangles are equal. Now, what I want you to notice is how large these areas are, compared with the area of useful work. It is this action which was spoken of as the action ignored or neglected in the older thermo-dynamic theory of the engine.

It is not the function of an address of this kind to replace a systematic treatise. It is not possible in a limited time to solve the complex problems suggested by the facts. Without attempting anything of this kind, I thought it might be useful to put before you some considerations on the theory of the steam engine in this unavoidably incomplete way. In all problems of this kind the first step is to get to understand the relative importance of the different actions involved. I trust I have given a kind of hasty glance into a region which in the more popular accounts of the steam engine, and even in the minds of some practical engineers, is forgotten or overlooked.

AMERICAN RAILWAYS IN 1888.—The *Railway Age* reports a total of 5,790 miles of new railroad completed in the ten months of last year up to the end of October. Taking into consideration the work now in hand, this indicates a total of over 7000 miles for the year. The greatest mileage reported for any one State is in California, where 485 miles of track were laid. Kansas and Georgia follow closely, both having added over 400 miles. Kentucky and Illinois each report between 300 and 400 miles, while five others—Texas, Alabama, South Carolina, Colorado, and Washington Territory—had each over 200 miles. In one respect this year's new railroad building differs from that of 1887; it has been made up chiefly of short lines. The 5,790 miles reported by the *Age* were on 280 different lines, the average length of the roads or additions being thus only a little over twenty miles. The American *Railway and Engineering Journal* says the building this year has been mainly what this fact would indicate—short branches, feeders, and local lines. Many of these are additions to existing systems, but there has been very much less construction of competing and interfering lines than last year, and no roads that can be called main or trunk lines are now in progress.

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[*] In actual engines a jacketed cylinder shows less re-evaporation, and has a lower expansion curve than an unjacketed one.

[*] Results of Some Independent Engine Tests. By J. G. Mair, M.I.C.E., Proc. Inst. Civil Eng., vol. lxxix.

HELICAL WHEELS.—IV.

There is no difference between the methods adopted in striking up or in the forms imparted to the striking boards employed for the formation of the bed and the cope of plain and helical wheel moulds. I shall therefore touch on these very briefly, devoting only so much attention thereto as is necessary to the completeness of the subject. In the striking of these moulds methods are modified according to the modified forms of the wheels themselves. I will only show one common and typical method applicable to a plain helical spur, and a plain helical bevel respectively.

By comparing the striking boards with the sectional views of these wheels (figs. 9 to 12), their connection is apparent. Fig. 10 shows the board which strikes the bed for the spur wheel (fig. 9)

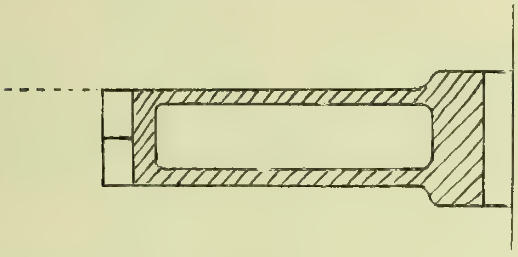


Fig. 9.

In this board the depth A is equal to the depth or face of wheel, and the portion B sweeps up the bottom boss. The edge C is sloped away to strike a wall of sand that shall not tumble down, an accident which would happen if the attempt were made to strike up sand vertically. The point D may or may not coincide with the points of the teeth. It may be struck to the same radius, or to a radius somewhat larger than these points, being a matter of no importance. At the time of ramming of the sand within the tooth spaces the narrow and weak inter-tooth sections are strengthened and bound to the body or wall of sand swept up by the board with long cut sprigs laid horizontally, two or three being superposed at intervals among the sand.

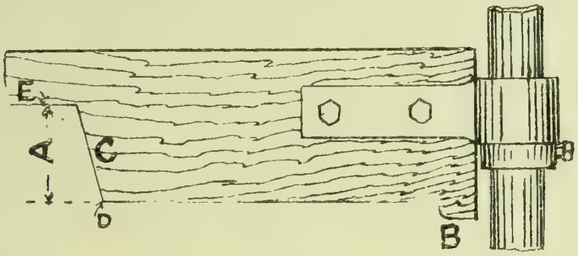


Fig. 10.

The board for striking the cope is like the bottom edge of that in fig. 10. The same board may be used by filling up the space cut out at A.

After the teeth have been rammed the arm cores are laid in place by measurement, without prints, and the cope is lowered upon them, resting both on the cores and on the joint face struck by the edge E of the board in fig. 10, and the pressure of the cope prevents the cores from becoming removed by the liquid pressure due to the metal.

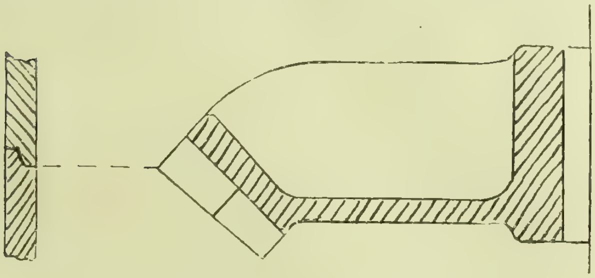


Fig. 11.

Comparing also the section of the bevel wheel (fig. 11) with its board (fig. 12), the edge A strikes the bed, and the edge B the cope, the board being, of course, reversed on the strap for the latter operation. In this board it will be noticed that there are two strips CC, exactly enclosing the edges of the strap of the striking bar D. These are frequently, though not always, put on boards, but they are a convenient means of obtaining a perfectly coincident joint between cope and drag. If the edges of the flasks are turned and cheeked, as in fig. 11, then if the edges E and F of the board rest thereon when striking cope and drag respectively, the inner edges of the strips CC being coincident therewith, it is evident that the upper and lower portions of the mould so struck will, when brought together, be also coincident. The value of this cheek is more apparent in bevels than in spur wheels. The copes of the former lie flat, and are not liable to cause crushing of the sand. But, in consequence of the sloping character of the concave copes of bevels, their pressure is very liable to crush the edges of cores and of teeth, unless there is absolute coincidence and contact all over.

The strength of wheel teeth, whatever their form, is estimated either for a static or a dynamic load, that is, either as dead or absolute pressure, or as horse power transmitted. The first is used for very slow-moving gears, the second for those in moderate or rapid motion. In the first the teeth are regarded simply as cantilevers; in the second velocity is introduced into the equations.

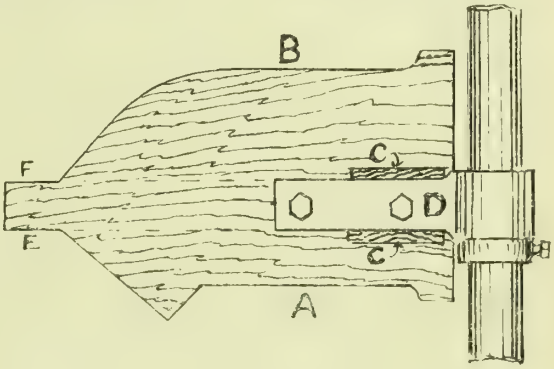


Fig. 12.

Taking the first case, we omit discussion as to the advisability of calculating the strength on the assumption that pressure takes place only across one corner of the tooth. This should never be the case in well-made gears, properly hung. Also we disregard the contingency of two teeth being in gear at one time, and base our calculations on the strength of a single tooth, regarded as a cantilever, subject across its whole width to bending stress. The simplest rule then is (fig. 13).

$$W = \frac{t^2 \times B \times M}{L}$$

where t is the depth of the beam, B its breadth, M a multiplier adapted to the nature of the material, and L the length of the beam. The strength of wheel teeth, therefore, varies directly as the breadth B and as the square of the thickness t, or, as it is calculated in practice, as the thickness on the pitch line. The value of the multiplier M will vary, not only with the nature of the material, but also with the nature of the stresses to which the gear is subjected. Professor Unwin and others take t upon the pitch line, and give to it a value which is a fraction of the thickness of new teeth, to allow for wear. The thickness of new teeth is ·48 of the pitch, but he bases his formulæ on a thickness of ·36 of the pitch only.

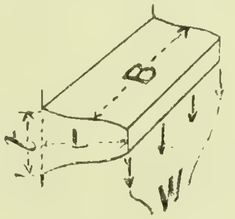


Fig. 13.

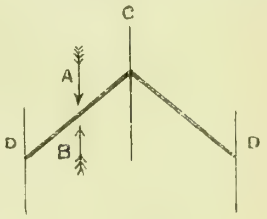


Fig. 14.

Taking the formula given above, supposing $t = 1\frac{1}{4}$in., B = 7in., L = 2in., and M = 6000lb., then the equation would give

$$\frac{1\frac{1}{4}^2 \times 7 \times 6000}{2} = 37812\text{lb.}$$

Dividing this by a factor of safety, say 5, we obtain

$$\frac{37812}{5} = 7562$$

the safe pressure in lbs. on a single tooth. Of course the factor of safety of 5 is simply given for the sake of illustration. It may be selected in a less or greater ratio, according to the circumstances of the case.

A rule given in Cromwell's "Toothed Gearing" is as follows: Multiply the total force to be transmitted by the ratio of the pitch to the face width, extract the square root of the product, and multiply the result by ·078 for violent shock, ·07 for moderate shock, ·05 for little or no shock. Put into the form of an equation, the rule is expressed thus:

$$p = \mathrm{M}\sqrt{\mathrm{P}\frac{\mathrm{P}}{\mathrm{B}}}$$

P representing the force transmitted, P_1 the pitch, and the other symbols as before. Keeping as closely as possible to the dimensions previously used, which would make $p = 2\frac{3}{4}$in., and putting 7562lb. just now obtained for P, we have

$$\text{For little shock } \cdot 05 \times \sqrt{7562 \times \frac{2\frac{3}{4}}{7}} = 2\cdot 70.$$

That is, p, by this rule, comes out 2·70in., which would be the pitch corresponding with a thickness t of $1\frac{1}{4}$in., before given. The ratio $\frac{\mathrm{P}}{\mathrm{B}}$ is necessarily assumed first, and this will vary in different gears; it is usually $= \frac{1}{2}$, or $\frac{1}{2\frac{1}{2}}$, or $\frac{1}{3}$.

Two good and simple rules for the nominal horse power of gearing are those of Molesworth and D. K. Clark respectively, as follows:—

$$\mathrm{H} = \cdot 06\ \mathrm{P}^2\mathrm{VB} \text{ where}$$

H = H.P. transmitted
P = pitch of teeth in inches
B = breadth of teeth in inches
V = velocity of pitch line in feet per second

$$\mathrm{H} = \frac{\mathrm{W}v}{550} \text{ where}$$

W = stress in pounds at pitch line
v = velocity of pitch line in feet per second.

Conversely the velocity may be deduced thus:—

$$v = \frac{550\ \mathrm{H}}{\mathrm{W}}$$

I am not aware that any experiments have been made or any data published bearing on the relative strengths of ordinary and of helical gears. It is a common statement that double helical teeth are stronger than the ordinary forms, because one half supports and stiffens the other. It does appear so on a casual inspection, but a little consideration would seem to show that such does not represent the whole truth. We may regard the double helical form of tooth as having some analogy to the arch. The teeth are strong to resist pressure coming in the direction of the arrow A (fig. 14), but less strong when the pressure comes as indicated by arrow B, and especially so as the pressure approaches the outer faces D of the wheel. In whatever direction the wheels are rotating, one must be stronger than the other; also the strength of the teeth in either wheel is a variable quantity, being greatest at the medium line C, where they are materially supporting and diminishing towards the outer faces D; and when the force is operating in the direction of the arrow B the outer corners D of the teeth are most liable to fracture. Hence the greater advantage in shrouding helical gears than common wheels, a practice which is usually resorted to in gears doing exceptionally heavy work, as those of rolling mill engines and hoisting machinery.

Taking these points into consideration, it appears that in the absence of any data bearing on the subject, we can, for all practical purposes, adopt the rules for strength and horse power for helical as well as common gears.

Actually, the superior value of helical wheels consists, as we have already noted, in the fact that the contact is entirely *rolling*, never sliding. It is because of this that they can be run at much higher speeds than common gears, with much less noise, backlash, or wear. Messrs. Urquhart, Lindsay, and Co. have run these wheels at as high a speed as 40ft. per second at the pitch line. At such a speed very high horse powers can be transmitted, H.P. varying directly as velocity.

These wheels afford an illustration of a lapsed patent revived. A Mr. White, of Manchester, patented them in 1808; but there were no wheelmoulding machines at that time, and the expense and difficulty of making complete patterns probably accounts for their lack of success.

J. H.

Wage Dispute at Hartlepool.—The erectors, turners, and fitters in the marine engineering trade in the Hartlepools have demanded an increase of wages of 2s. per week.

AN ENGINEER'S LIFE AT SEA.—XX.

BY A SEA-GOING ENGINEER.

Propellers, &c.

Occasionally the tunnel door should be looked to while in port, as, being liable to get stiff, it may be found out of order when required. This door is in reality a sluice valve, and is intended to form a water-tight bulkhead in case of accident, and thus cannot safely be overlooked. The hand wheel for shutting it is accessible on the upper platform, so that in case of a violent outrush of water from the tunnel, due to collision or other accident, the door can be closed from above. For the same reason the sluice valves in the stokehold should be kept ready for use at a moment's notice. Attention to apparently small matters such as these, which are readily overlooked by others, is the sure mark of a good engineer. For them the chief is directly responsible, and he should know the condition of every bolt and nut, and every pipe or tap which have even a remote connection with his department. Thus only can he be ready for every emergency, and have the confidence and coolness which only accurate knowledge can give. Frequently in painting the engine-room the guides of the tunnel door get painted over. Wherever this is found to be the case the paint should be at once scraped off, and the guides kept oiled, or sticking will infallibly occur. In order that this bulkhead should be water-tight, the small hole in it for draining the tunnel should have a tap, which can be opened and shut from the engine-room platform. This drain carries off to the engine-room bilge the cooling water used on the tunnel bearings and thrust block. In reference to such cooling water, great care has to be exercised if the steamer is in a muddy or sandy river. Any such water getting on the rings of the thrust may produce serious overheating, and in a vital part.

On the thrust the whole power of the engines is concentrated; all the complex mechanism of engines and boilers, with engineers thrown in, is for the sole purpose of maintaining a heavy pressure on the thrust block, and if this could be attained without such mechanism, it would all have to take itself away. With any given ship its speed is (under the same conditions) always the same as long as the pressure on the thrust is the same. As the resistance of a vessel when driven through the water is proportional to the cube of the speed, so to get a slight increase of speed a great increase of pressure is required here. Roughly speaking, the indicated power of the engines, as well as the coal consumption, varies in proportion to the pressure on the thrust, and therefore in proportion to the cube of the speed of ship.

With a slip on a propeller its load is thereby lightened, and its speed of revolution then increases, till the pressure on the thrust is the same as before. Hence it would seem at first that slip would have no effect on the speed of the ship and the efficiency of the engines. But while a screw with slip is much the same as a screw of less pitch without slip, yet, as each engine works best with a screw of a certain pitch (though designers cannot always hit upon this), so in some cases slip may be beneficial, and in other cases the reverse. But apart from increased friction in the engines, we must remember that with any ordinary amount of slip a column of water more than two hundred miles long is every day shifted about a foot astern in a horizontal direction, showing that the effect of slip cannot be altogether ignored. Many matters, however, come in to modify its action, and render its effects of little practical importance to the engineer. The speed of a ship may be approximately ascertained by multiplying the pitch in feet by the revolutions per minute, and cutting off two figures as decimals. This gives the speed in knots per hour. To allow for slip, subtract a foot from the pitch before multiplying, and the answer will be as near the truth as can be got.

Reduction of surface sometimes acts as if a propeller of smaller pitch or with greater slip was on, as the following shows: During a homeward run it was noticed that the engines ran three or four revolutions faster per minute, while the speed of the ship was as usual. On arrival in dock, and as the ship got lighter by its discharge of cargo, there was no sign of the propeller blade appearing above water. It is a peculiarity of propellers that if a blade be broken this part always comes to the top, owing to overbalancing, as if the damaged part was being held up for inspection. But in this case the blade did not put in an appearance at all, and it was ultimately found that it had been broken close off to the root. The vessel in leaving the last port had struck on the bar at the mouth of the river, and lost the blade then, and it was remembered that ever since the engines, when at rest, would not stand in their usual position. Increased speed of revolutions was the result of loss of surface, but the speed of the ship remained the same, and there was no knock or other irregularity of any kind to tell of the damage done.

Another point about propellers may be noted. In the temporary absence of the engineer a captain asked the chief engineer of a sea-going steamer to assist in taking a small launch out of dock. The latter consented, thinking that if he could take a large vessel a thousand miles, he could take a small boat half as many yards. After a careful look round he got up steam, and reported all ready. The captain on deck gave the order to go ahead, and the engines began to move. A shout of "full speed ahead," from above, was followed by more rapid revolutions. Thereupon the captain proceeded to stamp and shout, "Ahead, full speed ahead," while the engineer was busy abusing the fireman for not having enough steam to please the captain. This pandemonium was suddenly ended by a violent bump. The engines were stopped, and the chief, rushing on deck, found that, owing to the launch having a left-handed propeller, she had been running stern foremost across the dock, and had been brought up by the dock wall, with some damage to her stern.

There is a curious use to which a propeller is frequently put. In getting to her berth a steamer can be made to move sideways up to it. It is done thus: The propeller is put ahead, but as soon as the vessel begins to forge forward the engines are reversed and the helm is turned towards the wall. The rush of water forward from the screw is thus deflected to the outer side of the steamer, and the water, in violent commotion at that side, floods the vessel sideways towards the wall, as a boy brings his toy boat to shore by throwing stones on the far side of it.

In reference to speed of propeller and of ship, in one steamer every advantage used to be taken of favourable winds so as to make quick passages; but to the chief engineer a favourable wind meant reduction of coal consumption, and he kept a sharp lookout on his revolutions, shutting up the engines as soon as sail was set, thus disconcerting the captain, who never could get his ship to go any faster do what he would, and causing him to form a very poor opinion of the sailing qualities of his ship. To a chief this matter of coal consumption is most important, not only for the sake of economy, but in order that he may not run short on the voyage. Some superintending engineers are so unreasonable that if a chief gets enough coal on board to allow for casualties, and those casualties do not occur, he is blamed for coming home with bunkers full. If, on the other hand, he should run short on account of bad weather, he is blamed for not having made allowance enough. An engineer, who knew that he could make his "tally" of coal come in right by "cooking" his accounts, has been known to have coal thrown overboard at night when the ashes were "dumped," as in this way only could he escape unreasonable censure at home. In this, as in many other ways, penurious owners have frequently to pay more than others.

On ship captains also the same unfair pressure is frequently exercised, and in the case of sailing ships leads often to disaster and loss of life. Competition for posts, backed by pressure from owners, leads to such niggardliness, that some sailing ships will run for weeks without any side lights, in order to save oil. While all goes well, the owners pocket the profit and ask no questions, but when collision and disaster follow, all the odium is thrown on the captain by the blameless and virtuous owners.

Before leaving the last foreign port of the voyage, all bright work is polished and white-leaded, to be wiped off on arrival at home. To save trouble the connecting rods are frequently bronzed. This is done by first polishing them, and then occasionally giving them a coating of boiled oil when the engines are at rest. Beyond this, they require little further attention. Bright columns are sometimes varnished after polishing, and thus keep bright for an indefinite time. On the run home, the engine-room is cleaned and painted. In winter, if a painter is among the firemen, he may be set to grain and varnish the engine room, and this lasts far longer than painting and graining, and only requires washing over with water and hard soap. Every chief tries to bring his engines and engine-room into port as clean and bright as possible, even though with the beginning of overhauling its beauty should depart. The work begins with the skylights, and there is no greater term of contempt than to say that anyone begins his cleaning at the bottom and works upward. All the engineers assist in the painting, as all expect some share of the credit. The chief usually assists also, but a chief has been known to advance the preposterous claim that he should lie in his bunk during an anchor watch, while the second and third divided the post between them, and the superintendence of the firemen on duty. Such a claim would certainly be disallowed by the superintending engineer, who knows that a second's life is otherwise not a bed of roses.

IMPROVED SLOTTING MACHINE.

We illustrate, on page 22, an improved slotting machine constructed by Messrs. J. Spencer and Co., Hollinwood, near Manchester. The machine is of a substantial and superior character, and possesses all the details with which such tools are usually equipped according to the most recent practice. The machine is driven by single gearing in the proportion of 6 to 1, fitted with the usual cone speed arrangement, affording four variations of speed. The ram slide has a continuous bearing and can be raised or lowered by a screw and hand wheel placed within convenient reach of the workman. The stroke disc revolves in a recess in the main casting, and provision is made for taking up the wear by an adjustable die. The stud in the disc is regulated by a screw, while the face is graduated so as to permit of the stroke being adjusted to any length, while a quick return motion is obtained by means of a slotted link and slide block attached to the crank pin. The motions of the table are self-acting in all directions, the feeds being variable and independent of each other, while the table can be canted to any required angle, so as to give the requisite taper in cutting keyways.

SOME TYPES OF THE MODERN LOCOMOTIVE.—V.

That a high centre of gravity, contrary to what was at one time thought, promotes ease in running, and is consequently less destructive to the permanent way, has been proved beyond dispute, and that when a locomotive with a high centre of gravity takes a curve at speed, the weight is thrown almost entirely on to the wheels on the outer rail. This tends to keep the leading wheel flange hard against it; the load preventing the wheel from climbing. A reference to the diagrams (figs. 9 and 10) will, I think, make this clear. These diagrams, though not original, may be new to many.

Let us suppose that in the diagrams we have end views of two locomotives, one with a low and one with a high centre of gravity.

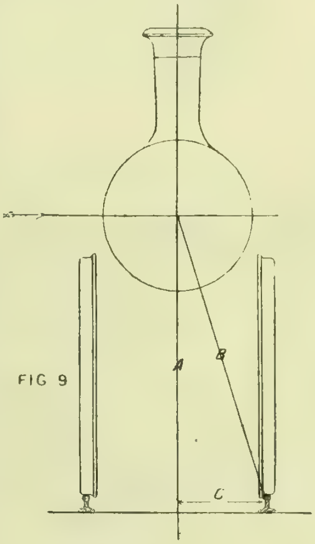


FIG 9

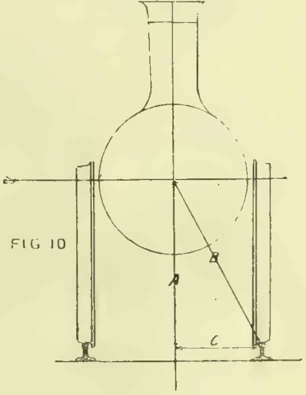


FIG 10

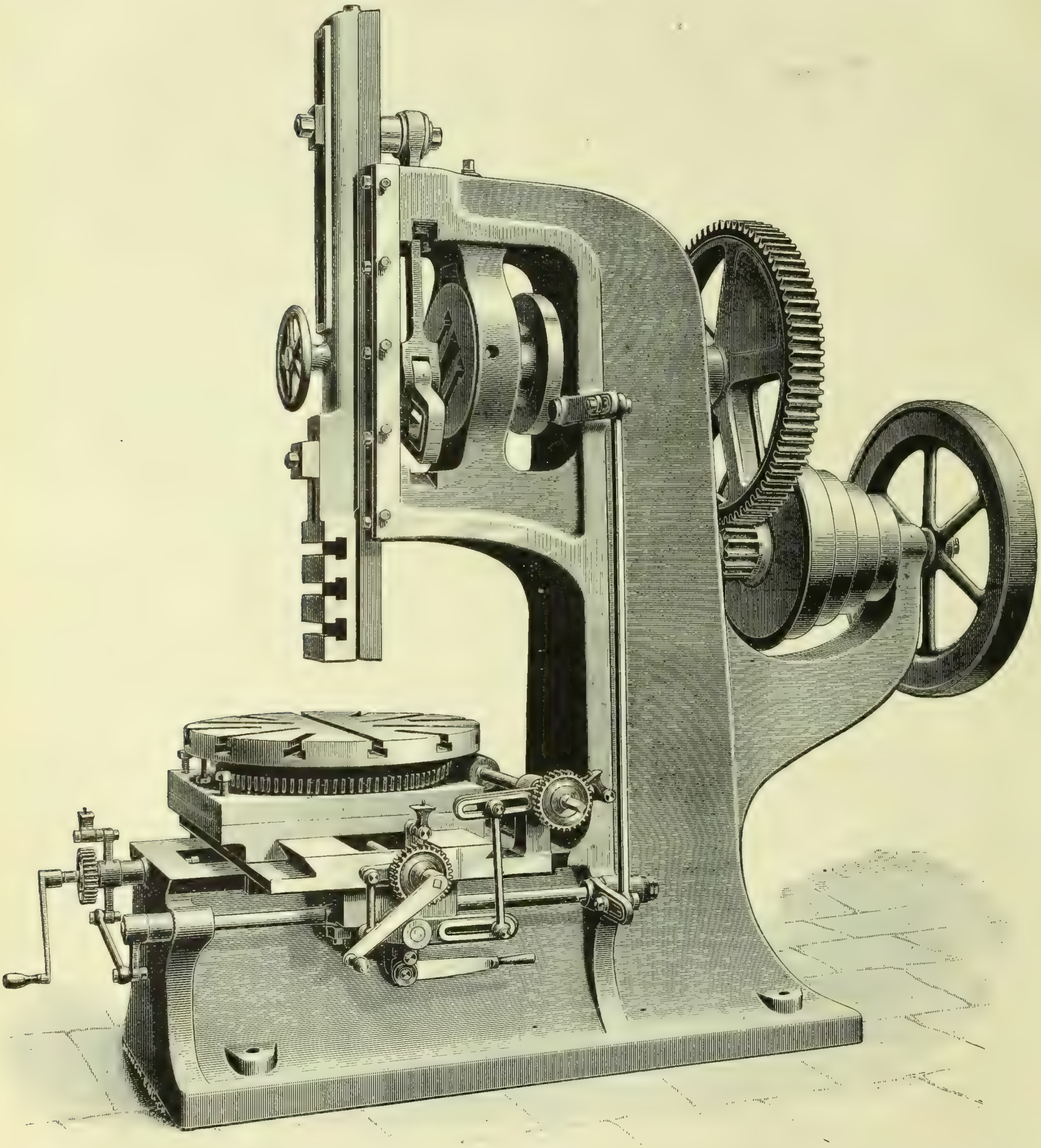
I may preface my remarks by saying that there is not an instance on record of an engine upsetting while the permanent way remained able to carry an engine at all. So that we may dismiss the fear of any accident of this kind happening, at least while the centre of gravity is kept to anything in reason. The direction of the overturning force is shown by the arrows, and is, of course, nearer the rail in fig. 10 than in fig. 9. A A are the overturning moments, while C C represent the bursting effort on the rail. The inclined line B B shows the direction into which this bursting strain will be resolved, it being evident that the force which tends to widen the gauge is much greater in fig. 10 than in fig. 9.

Now, we have further to consider that the engine is not rigid, being supported on springs, and the higher the centre of gravity, the greater may be the load put on the outer spring, as shown by the line B in fig. 9, and the less in proportion will be the bursting strain on the rail.

IMPROVED SLOTTING MACHINE.

CONSTRUCTED BY MESSRS. J. SPENCER AND CO., HOLLINWOOD, NEAR MANCHESTER.

(For description see page 21.)



With the high centre of gravity the engine will swing more than the low engine, but will ride easier, and the elasticity of the springs being brought more into play, the road is spared rough side shocks, and the wheels and axles are not so violently tested. Of course, the springs have more work to do, and will require designing accordingly, and we must not forget that with the high centre of gravity, when going round a curve, the load on the inside rail is greatly diminished, and may under certain conditions entirely disappear, although this lightening has advantages, which have been pointed out by Mr. Stroudley, inasmuch that it allows the inside wheels to slip. Still there may be nothing to keep the wheel to the rail but its own weight, and as the front end of the engine is liable at any time to be jerked to the inside, the engine may leave the rails. This is likely to happen if the super-elevation of the outer rail is too great.

For easing locomotives when going round curves, a jet of water is now very often employed, which acts as a lubricant, and augments to a great degree the efficiency of any locomotive which has many sharp curves to contend with; engines fitted with this appliance taking with ease loads round curves which they would not otherwise "look at."

Mr. Riches, of the Taff Vale Railway, has invented an ingenious arrangement for effecting this purpose automatically. It consists of a small tank fixed under the footplate of the leading end of the engine, to which water is supplied from the tender and kept at a certain height in the tank by means of a ball valve. At either side of the tank, projecting some distance above the water level, are two tubes, having connected to them pipes leading to the flanges of the leading wheels.

When the engine takes a curve, the centrifugal force washes the water to one side of the tank, and the level of the water being raised at that side higher than the stand pipe, it flows down to the rail, lubricating the wheel as required.

Anything which tends to make perfect the locomotive deserves our earnest consideration, if it be but in its minor details, whether for the attainment of higher speeds or efficiency of working, so that this annihilator of space may in time become the perfection of human invention and ingenuity.

The most useful improvement of recent date is, to my mind, the sanding apparatus before described, which will tend to reduce the weight required for adhesion, and as the maximum adhesion is only required when starting, or for an uphill piece of road, the weight for this purpose may be materially reduced, resulting in a less first cost for the engines, less wear for the permanent way, and greater hauling power.

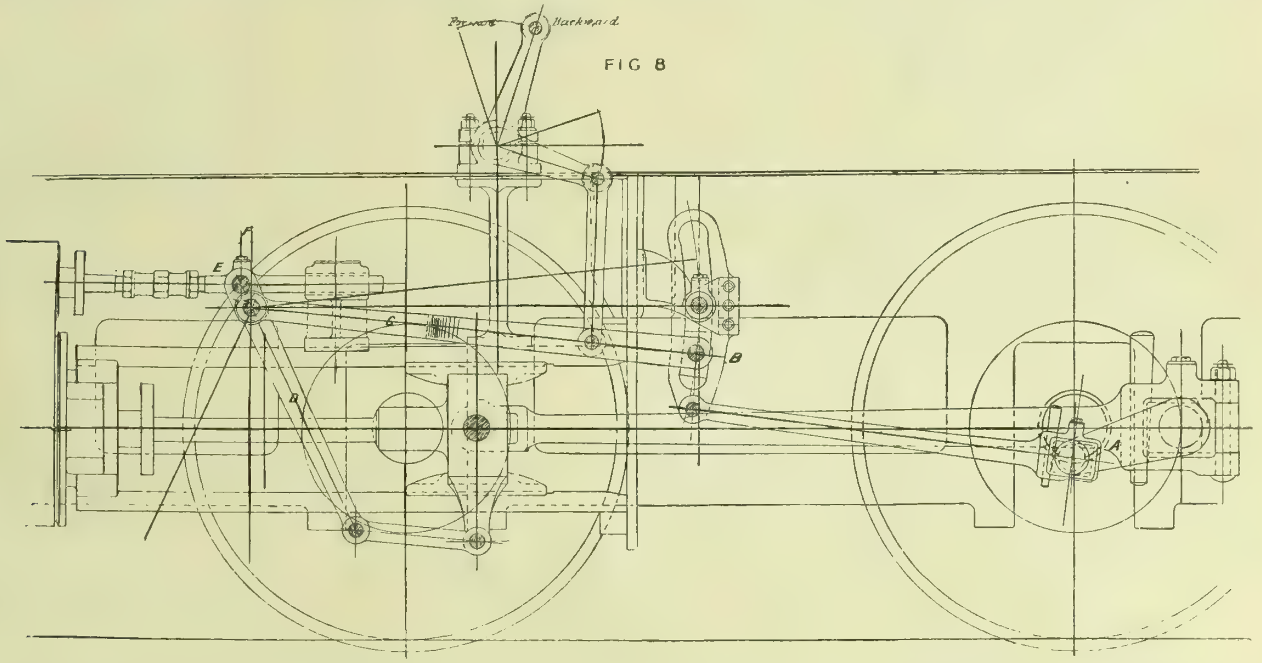


FIG 8

Turning to narrow gauge locomotives, I find that any remarks on this part of my subject must be of the briefest possible character, so that my paper may be kept within due limits. But the fact that the manufacture of locomotives in Great Britian employs so much capital and labour, and also that most of our railway companies make there own rolling stock, proves that a great part of our trade in this article is derived from our Colonies, or from those countries who require mostly engines suitable for narrow gauges.

In designing locomotives for the narrow gauges which have been generally adopted in our Colonies, and in most countries now being rapidly opened out to trade by railway communication, the conditions under which the locomotive has to exist must be taken into consideration. These conditions are in many cases so different from those on our own railways, that engineers who supply any of our ordinary English types without many—and in some cases radical—alterations, make a grave error, which error will no doubt be most unpleasantly discovered when other orders from the same customer are to be placed.

In these cases the practice which has found favour with American engineers is not by any means to be ignored, as they have for years been working under the very conditions that prevail in most of those countries into whose markets locomotive manufacturers *must* have entrance.

Badly laid roads with very light rails, steep inclines and sharp curves, the curves being sometimes less than 100ft. radius, and some lines in fact having hardly a straight piece in their whole length—this is the problem to which a locomotive constructor has most seriously to apply himself.

One line might be mentioned from La Guira to Caracas, in Venezuela, having a length of 23 miles, the distance being as the crow flies only 5½ miles from place to place, the total rise in the first 21 miles being 3,135ft., with a steady grade of 1 in 27. The sinuous character of the line is another feature, curves of 130ft. radius being frequent. The engines working the traffic on this railway are shown in fig. 7, and will be described hereafter.

The gauges generally adopted, and known as the narrow gauges, are the 3ft. 6in., the metre or 3ft. 3⅜in., and in some cases the 3ft. 0in. With these gauges, and in consequence a distance between the engine frame of at most 3ft. 0¼in., 2ft. 11⅝in., and 2ft. 6½in. respectively (if inside frames are to be used), outside cylinders must be applied; this point being at once disposed of.

Again, the ordinary English style of valve motion, with steam chests between the frames, and Stephenson's or other link motion, though having a directness recommending it to most English minds, is not available; for this reason, that however much you may contract the steam chest and throttle the exhaust, there still is not sufficient room for a workman to get at the valves for inspection, easily and expeditiously, which is indispensable, it being, I take it, an axiom with all who have to do in any way with locomotives, that expenses for repairs are to be kept at a minimum. This leads to steam chests outside the frames and above the cylinders.

Then we have the choice of say three kinds of valve motion. The Stephenson's link, with a rocking shaft, as adopted almost universally by American engineers; the Joy's motion, or the Walschäert's gear.

Taking the Stephenson's first. There is no doubt that this arrangement, when properly proportioned, gives a good distribution of steam, but it has several disadvantages. In the first place, the rocking shaft, inviting, as it were, a sinuous movement; secondly, the difficulty experienced in getting to oil the eccentrics, when, as is very often the case, a tank engine, carrying a large quantity of water, is in question; side tanks being used, as saddle tanks throw the centre of gravity of the engine perilously high on these narrow gauges. Then the one-sided manner that the expansion link is hung causes binding on the motion pins, and this one-sided hanging cannot be obviated without adding an extra valve rod, and in most cases shortening the eccentric rods, which are complications not to be desired.

The Joy's motion suggests itself as a way out of some of these difficulties, it being all outside the frame, and well within reach for oiling and inspection. The great drawback to the use of this motion is, to my mind, the unmechanical sliding action which takes place between the reversing quadrant and block, and when used in a sandy country, such as many parts of South America, although an almost mathematically correct motion when new and in good order, the amount of play that very quickly ensues between the quadrant and the block destroys to a wonderful extent its beauty and precision of motion. Another point is the attachment to the connecting rod, which sets up cross strains in this most vital element of the machine, although I do not lay much stress on it, as this can be made of ample strength.

The valve motion generally known in England as the Walschäert's gear, which was invented, however, by Von Waldegg, and only introduced into Belgium by M. Walschäert, though extensively used on the Continental railways, has until lately been little known in England; and as it may be somewhat new to many of our members, perhaps a short description may not be out of place.

By reference to fig. 8 it will be seen that there is but one eccentric (or in this case a return crank) employed, marked A on the sketch, which if the line of motion of the eccentric rod coincides with that of the engine, is placed 90 deg. either in front of or behind the crank pin, its position before or after depending on the position of the reversing shaft in relation to the expansion link. The return crank A communicates through the eccentric rod motion to the end of the expansion link B, which swings in fixed centres.

A pendulous lever D is connected to and receives its motion from the crosshead, and to this lever the valve rod C is connected at such a point below the valve spindle pin E, that the distance F is equal to the lap and lead of the slide valve when the piston is at the end of its stroke. This gives the requisite lead to the valve, the return crank being in the position that would be occupied by an eccentric for a valve without lap or lead.

The slide valve thus obtains its motion by a combination of these two movements, and by simply sliding the valve rod C from one end of the expansion link B to the other a reversal of the motion is effected, and any degree of expansion can be obtained by the intermediate positions.

It will be seen that whenever the crank is on either of its dead centres the expansion link B is vertical, and as it is struck to a radius, the length of the valve rod C, in consequence, the valve rod can be moved into any position on the expansion link without moving the valve, this of course giving a constant lead.

This motion looks more complicated on a diagram than it really is, and when well proportioned gives excellent results, whilst the slip of the expansion block in the link is almost nil.

The return crank and the number of joints seem to be against its efficiency, but very favourable accounts have been received of its working in countries where grit as hard as flint had always played sad havoc with valve motions, and taking all things into consideration I think that this is the motion to be recommended for the narrow gauge. Another advantage it has is that it lends itself readily to being boxed up, which is now often done to keep this grit from the vitals of the engine.

(To be continued.)

PATENTS FOR INVENTIONS.

Measured by the number of applications for patents which were made to the British Patents Office during the year just completed, it would appear that the inventive faculty runs little risk of dying out. From the returns just issued, it seems that the total number of applications for patents amounted last year to 19,070, as compared with 18,051 in 1887, or more than three times as many as in any year before the passing of the Patents Act, in 1883. That a large number of these applications possess considerable merit, and indicate on the whole a fair amount of industrial development, there can be little question; but, on the other hand, it is equally certain that a very large percentage of the applications are utterly worthless, and that this is impressed even upon the minds of the inventors themselves is pretty evident from the fact that little more than one-half of the original applications become completed patents, while the percentage of those which do attain maturity has slowly declined as the total number of applications has increased. Judging from the experience of the previous Patent Law, it would appear probable that not one-fourth of the completed patents will outlast the first period of four years. Under the old system, only about two-thirds of the patents for which application was made, were finally completed, and of this number about 70 per cent expired at the end of three years.

One important measure was passed during the last year, viz., the Patents, Design, and Trade Marks Act. This measure, which is based on the Act of 1883, is the result of the recommendations made in the report of the Board of Trade Committee, which sat during the years 1886-7. This Act, which has just been printed, and comes into force with the present year, establishes for the first time a register of patent agents. The rules by which the practice of patent agents will in future be regulated are to be made and issued by the Board of Trade, the Act only providing that from next July no unregistered person shall be allowed to describe himself as a patent agent.

Another provision of importance is the abolition of what are known as "notices of interference." It has hitherto (since the passing of the 1883 Act) been the practice for the office to send notice to an applicant of any subsequent application received at the office which appeared to interfere with his, in order to give him an opportunity of opposing the granting of a patent. This provision has never worked satisfactorily, the officials not having been able to make up their minds as to what constituted a "similar invention," and has, therefore, probably been of little practical value to patentees.

The remainder of the Act refers principally to designs and trade marks. There is a new definition of a trade mark, which does not appear much easier to construe than the old one, and there are other modifications of procedure, the result of experience in the working of the Act of 1883.

With the beginning of the year a fresh series of alterations begin. The *Official Journal*, the *Illustrated Journal*, and the *Reports of Law Cases* are combined into a single publication, with the title, the *Illustrated Official Journal (Patents)*, which will be issued every Wednesday, the first number appearing on the 9th inst.

The financial condition of the office is thoroughly satisfactory, and it still continues to provide an important source of revenue. In 1886 it earned over £40,000, and there is no doubt that when the accounts for the year just completed come to be made up they will show a still larger surplus, since the renewal fees at the end of the first four-year period of the first patents taken out under the 1883 Act are now coming in. Under these circumstances it is not to be wondered at if urgent appeals are being made that the Treasury should consent to the reduction of the still heavy fees charged for the later stages of patents. In the 1883 Act power was given to the Board of Trade, with the consent of the Treasury, to reduce any fees, and a movement is now on foot among patentees and others having for its object the lowering of the fees in question.

WATER-GAS.

An interesting installation of plant for the manufacture of water-gas has been at work for some months at the Leeds Forge Co., and as the plant, which has been erected under the superintendence of Mr. Samson Fox, the managing director, possesses several features of novelty and interest, a brief account of the apparatus may be acceptable.

As our readers will be aware, a number of different attempts to manufacture a combustible gas by the decomposition of water, have been made for years past, but very few of these have in practice proved to be commercially successful.

The installation at the Leeds Forge is not so much a new invention, as a combination of the best features of several processes already in existence, and as a result of a demand for a gas of a higher calorific intensity than that obtained either from the Siemens producer or the ordinary coal-gas.

The plant in question is capable of producing 40,000 cubic feet of gas per hour. This gas gives every satisfaction for metallurgical purposes, and also suffices for the lighting of the whole of the works.

Water-gas is the result of a chemical reaction which takes place in passing steam through incandescent carbonaceous matter, and may be considered as the practical result on a wholesale scale of the ordinary laboratory experiment of decomposing water by passing steam through a highly-heated iron tube. In the water-gas apparatus the fuel, which at Leeds Forge is coke, is raised to a high temperature in a generator by the aid of an air-blast. The blowing is continued for about ten minutes, by which time the fuel has reached a dull red heat. During this period what is known as producer-gas is given off, and this is led away to a range of Lancashire boilers, where it is utilised in raising steam for the engines in the works. At the end of ten minutes the valves are reversed, the air-blast being stopped and the further exit of producer-gas to the boilers prevented. Steam is then admitted at the top of the generator for four minutes, and, passing down through the incandescent fuel, becomes decomposed, and a fixed gas results. This gas, as formed, passes away to a scrubber, where it is treated much in the same way as ordinary coal-gas. From the scrubber it passes to the gasholder, where it is stored for use for metallurgical purposes in the works, such as heating and welding. For indoor illuminating purposes, a portion of the gas is conducted from the gasholder to the purifiers, where its purification is effected by means of oxide of iron. It will thus be seen that the process consists of alternately blowing the generator hot and making gas, and that a run of gas is made every fifteen minutes, during which time the yield from each generator is about 17,500 cubic feet of producer-gas and 5,000 cubic feet of pure water-gas for heating and lighting purposes. The gas is also used most successfully for driving gas engines.

To give one instance only, a piece of copper wire, placed in an ordinary coal-gas flame, will only become red hot, whereas a similar piece of wire placed in a water-gas flame, issuing from a similar burner, is quickly and perfectly fused.

An important consideration in the adoption of any new system is, of course, its cost; and in this respect water-gas comes out well. Its production per ton of fuel is about 30,000 cubic feet, and with fuel at 8s. per ton, labour at 3s. 6d. per man per day, and the production going on continuously, it is found that the gas costs slightly less than 4d. per 1,000 cubic feet. The experience of nine months' working at the Leeds Forge has led to the conclusion, based on carefully ascertained data, that the saving effected on the whole works is about £10,000 per annum. Looking at the advantages of water-gas for illuminating purposes, it is to be observed that, besides giving an agreeable light, it does not develop any noxious fumes, nor does it produce smoke; health and cleanliness being thereby preserved, and paintings, furniture, and decorations remaining uninjured. For lighting mansions this would prove a boon, while the producer-gas can be utilised for heating purposes. Similarly, a millowner laying down a water-gas plant for lighting his factory, will obtain gaseous fuel for steam-raising purposes practically for nothing. For small towns also the lighting could be carried out with water-gas, the producer-gas being used for steam-raising and manufacturing purposes generally. Although the installation of this water-gas plant at the Leeds Forge is the first in England, the system is being largely adopted in America and on the Continent, both at steelworks and for illuminating purposes.

RECOVERY OF SULPHUR FROM ALKALI WASTE.

A COMMENCEMENT has been made at Friar's Goose Works of the Jarrow Chemical Company, Limited, with the process for the recovery of sulphur from tank waste, by means of limekiln gases, Chance's patent. Up till 1883 the process principally in use for the recovery of sulphur was that of Messrs. Schaffner and Helbigs, but the action of the Pyrite Company in reducing the price of pyrites to one-half its former cost was the means of preventing any further development, and, in addition, stopping some of the processes then working.

On March 5th of the past year a paper was read by Mr. A. M. Chance, of Birmingham, before the members of the Chemical Society, London Section, in which the author described at some length a process he had patented for the recovery of sulphur from tank waste, the process having given very satisfactory results from the works of Messrs. Chance Brothers, Oldbury. Briefly, the process consists in the elimination of sulphuretted hydrogen from the waste by means of carbonic acid, obtained in the ordinary way by burning limestone. When the sulphuretted hydrogen is of sufficient purity, it is conducted to a large gasholder, and thence to a patent kiln, where it is burnt, the sulphur afterwards subliming in a cooling chamber, or, if it be so desired, the sulphuretted hydrogen can be used for the manufacture of oil of vitriol, by burning it in the ordinary pyrites kiln.

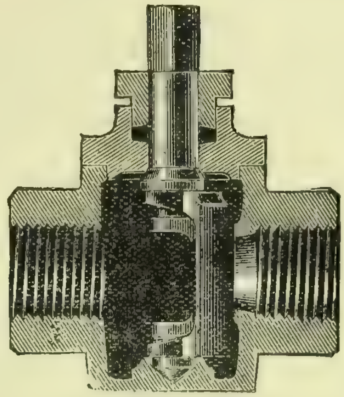
The inventor claims by his process that from 98 to 99 per cent of the sulphur in the tank waste can be accounted for when manufactured into sulphuric acid or vitriol, or 95 per cent in the form of sulphur. Shortly after the reading of the above paper, the Jarrow Chemical Company commenced to lay down plant for the purpose of obtaining the sulphur by Mr. Chance's patent, and a commencement with the process, as we have intimated, has already been made. As the company have not yet completed the building of the clans kiln for the production of pure sulphur, the sulphur obtained will be used for the manufacture of oil of vitriol. On the completion of the kilns, the company will be able to turn out perfectly pure roll or flowers of sulphur from the hitherto useless tank waste.

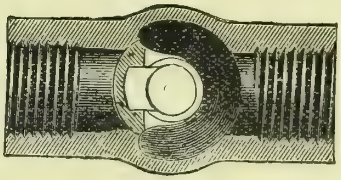
THE total imports of coal into London last year amounted to 12,519,346 tons, an increase of 465,298 tons, or nearly 4 per cent over 1887.

HUNT AND GREEN'S VALVE.

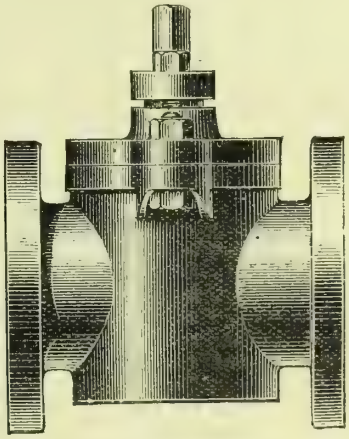
THE accompanying illustrations represent a somewhat novel form of tap or valve, which possesses several advantages over plug taps of ordinary construction.

Those who have had any experience with steam boilers will be aware how liable the blow-out tap of the simple plug construction is to stick fast, and how alarming it is to see the water rapidly disappearing from the gauge glass, with the fires under full weigh, with the blow-out tap open full bore, and defying all attempts to close it. This liability to stick is somewhat reduced when the plug taps are of compound gland construction, though even such taps require very careful treatment if their action is to be relied upon.





In the valve illustrated it will be seen that the movable plug consists of a sector of a cylinder, while the spindle upon which it revolves is slightly eccentric in its action, so that a very small movement of the spindle releases the plug from its seat and permits it to turn quite clear of the valve face. On the other hand, when the valve is closed the pressure on the back assists in keeping the valve in position.



This construction renders the tap well adapted for steam-boiler blow-out purposes, as well as for dealing with the gas tar and ammoniacal liquors, the viscid character of which renders ordinary plug taps very unsuitable; and, indeed, the valve was designed, in the first instance, with a view to rendering it suitable for this class of fluid.

It should be stated in conclusion that the valve is manufactured by Messrs. J. Cartwright and Sons, New Bond Street Iron-works, Birmingham.

BELT AND ROPE GEARING.—I.*

THE object of this paper is to consider certain points concerning the theory of belt and rope gearing, and at the same time to endeavour to impart a clear conception of a few of the numerous principles underlying the practice of the same.

Although my remarks may seem more strictly confined to belt, rather than rope gearing, most of the arguments adduced may be equally applied to the latter class of gearing, if the altered circumstances be duly taken into account.

TENSIONS OF AN ENDLESS BELT.

When two pulleys are connected by an endless belt or band, the *sum* of the tensions in the two sides of the belt remains the same whether the belt is in motion or at rest; that is, if

T=the tension of the driving span or tight side of the belt,
t=the tension on the trailing span or slack side of the belt when in motion; and
I=the initial tension on each side of the belt when at rest.

Then $2\,I=T+t$, or $I=\frac{T+t}{2}$ (3)

$$n=\frac{R}{2};$$

it follows therefore that the *greater tension*

$$T=I+\frac{R}{2} \qquad (6)$$

and that the initial tension

$$I=T-\frac{R}{2} \qquad (7)$$

Also we may write

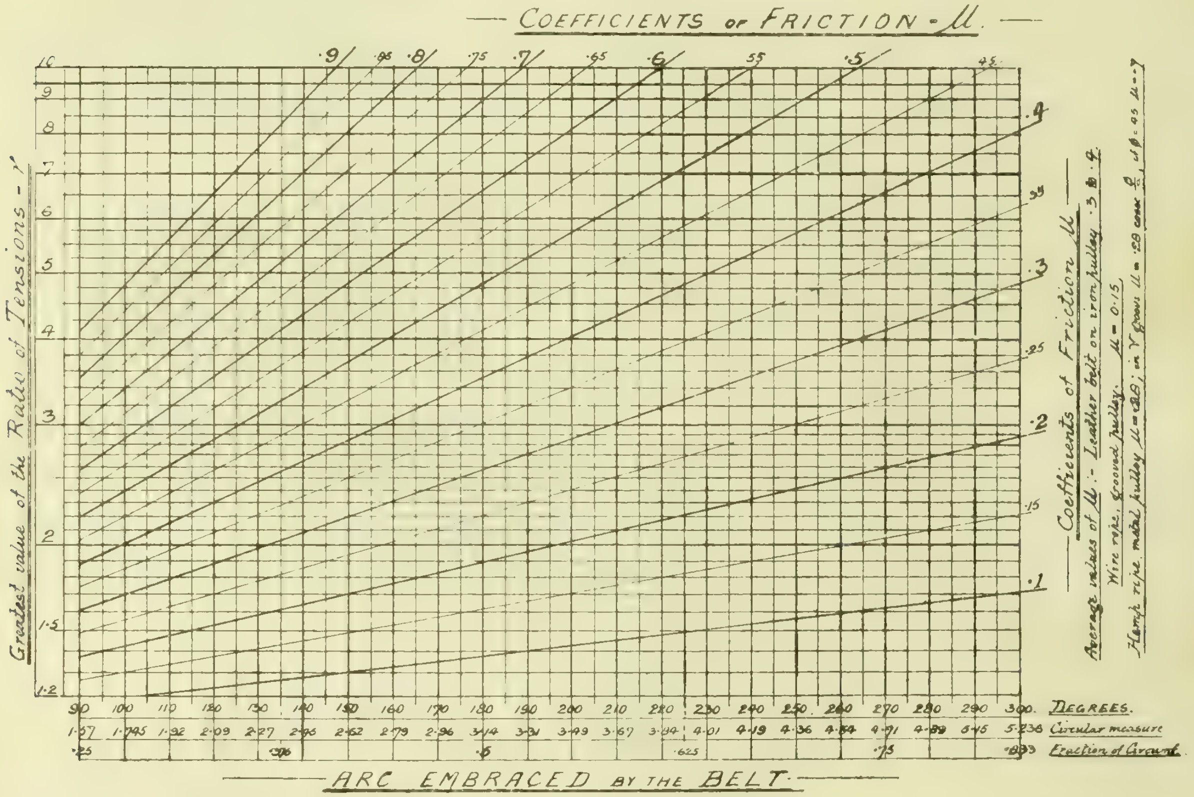
$$t=I-\frac{R}{2} \qquad (6a)$$

If the resistance to motion were sufficiently great, and we were to continue our experiment a little further, we should find that the belt would begin to slip upon the surface of the pulley.

At the exact instant when this takes place, the tensions T and t will be found to bear a certain fixed proportion one to the other. This proportion or ratio of tensions will, however, be found to vary for different surfaces in, and for different arcs of, contact.

The ratio of tensions $\left(\frac{T}{t}\right)$ is given by the formula—

$$r=\frac{T}{t}=\epsilon^{\mu\theta} \qquad (8)$$



GRAPHIC DIAGRAM No. 1.—Giving the value of the ratio of tensions in an endless band for various arcs of contact and co-efficients of friction.

The truth of this is easily proved by the help of a model shown. The initial tension on each side of the belt at rest is 15lb. When put in motion the tension in the advancing or driving side of the belt is increased from 15lb. to 22lb., while that of the retreating or slack side is diminished from 15lb. to 8lb., the increase in one case being equal to the decrease in the other.

This action continues until the *difference* in the tensions on the two sides of the belt is equal to the resistance which is offered by the driven pulley. Then the following equations hold good—

$$T-t=R \qquad (4)$$

where T and t have values as before and R equals the *resistance overcome* at the circumference or rim of the driven pulley, and if n=the *increase* of tension on the tight and the *decrease* of tension on the slack sides of the belt.

Then $I+n=T$, and $I-n=t$; so that by substituting in (4) we obtain

$$R=2\times n \qquad (5)$$

which means that the resistance overcome is equal to twice the increase of tension, or, *conversely*, that the increase of tension (n) is equal to *half* the resistance; *i.e.*,

where r = the greatest value of the ratio of tensions;
ϵ = 2·7182818285, the base of the system of natural logarithms;
μ = the co-efficient of friction of motion;
θ = the arc embraced in circular measure.

When reduced into a more simple form we obtain—

Common log r = $\cdot 434\mu\theta$ (8a);
= 2·729 μ × the *fraction* of the circumference embraced by the belt;
= ·007578 μ × number of degrees in the arc of contact.

For the purpose of readily finding the value of the greatest ratio of tensions, I constructed some years ago a diagram (No. 1), which I think will be of service to those who may have occasion to use these notes, as it will enable them to find at a glance the greatest ratio of tensions $\left(\frac{T}{t}=r\right)$ for arcs of contact ranging from 90 deg. to 300 deg., and for co-efficients of friction varying from $\frac{1}{10}$ to unity (0·1 to 1·0), so that a book of logarithms is not required when finding the value of r.

On examining the diagram, it will be seen that the intersection of the line of μ = ·25 with that of an angle of 210 deg. (or of circular measure = 3·67) gives us a value of r (the ratio of tensions) = 2·5.

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[*] Paper read before the Hull and District Institute of Engineers and Naval Architects, on Monday, December 3rd, 1888, by Mr. George H. Strong (Member of Council).

Again, taking $\mu = \cdot 4$, and angle = 180 deg., the value of r is given as 3·5.

It should be borne in mind that in all calculations made with reference to the value of the ratio $\frac{T}{t}$, it is essential that the data employed should be taken from that pulley possessing the smaller arc of contact (this is usually the smaller pulley of each pair), provided that both pulleys are of the same material.

The reason for this may be readily seen from an inspection of the formula (8), in which it will be noticed that the arc of contact appears as a "power," and not as a simple multiplier.

(*To be continued.*)

SUBSIDENCES IN THE CHESHIRE SALT DISTRICT.

The alarming subsidences that have taken place from time to time in the surface land overlying the salt beds of Cheshire have resulted in such extensive damage during recent years that the property owners of Northwich and district have drawn up a memorial to the Board of Trade appealing to the Government to appoint a Royal Commission to inquire into the causes and responsibility for the damage that has occurred. That the grievance is a very real one there can be little doubt. The supply of salt, as everyone knows, is obtained in Cheshire by evaporating the brine, which is pumped up from the salt wells, and which contains about 25 per cent of salt. As upwards of one million tons of salt are exported annually from the Cheshire district, it will be evident that a large amount of subterranean excavation is continually going on. As the brine is pumped out the earth subsides, and the damage done to roads, gas and water mains, buildings, &c., is enormous. In many places acres of land have subsided to such an extent as to be permanently covered with water. At Winsford, over 100 acres have sunk in this way, and are now covered with water to a depth of 20ft., and it is estimated that the damage done to public and private property in the neighbourhood is no less than £150,000. The Market Place has slowly sunk until it is now some 30ft. below its former level, while the Market Hall had to be rebuilt seven years ago. In some instances house property has been rebuilt several times, and in one part of the town a house has become so submerged that only the top part of the roof is now visible above ground.

The property owners contend that the damage which has been done is due exclusively to the pumping operations of the salt manufacturers, but as Mr. Baldwin Lathom, F.G.S., points out in a letter to a contemporary discussing the matter, it is questionable whether the brine pumpers can be charged with the responsibility for more than a small portion of the subsidence that takes place. He points out, in the first place, that the quantity of brine produced naturally depends on the amount of rain that percolates into the ground over a considerable area, and that no amount of pumping can increase this quantity. Hence experience has shown that the volume of brine to be pumped varies with the different seasons, like any other underground water. If the brine in Cheshire was not pumped, it would, he holds, still flow away by its underground channels into the river Weaver. In support of this he argues that subsidences have taken place in Cheshire in geological periods, probably long before the age when brine pumping commenced, and if brine pumping was at once to cease, judging from the history of the past, these subsidences would still take place. A person looking at a map of Cheshire will, he says, be forcibly struck with the large number of meres or lakes it contains, and he is of opinion that all these meres were formed by subsidences due to the underground water dissolving out the salt from the saliniferous beds. A number of subsidences have been caused in this way in modern times in places where no mining operations have taken place. From an account in Leland's "Itinery," written three and a half centuries back, it would appear that the present site of Cumbermere (one of the largest meres in Cheshire) was formerly a hill, which subsided, and that at first the water was sufficiently saline for the purpose of manufacturing salt. Evidence of another kind goes to prove the movement of the saline water into the river Weaver. Before the pumping of brine became so general, the water of the river Weaver, at Frodsham, was so saline that salt was manufactured directly from it; but as the effect of the pumping has been to stop the flow of the saline water into the river, the river water at Frodsham has become fresh, and salt can no longer be made from it, thus affording direct evidence of the movement of underground water, and the subsidence caused by it, which the cessation of pumping would not, in all probability, affect to any appreciable extent.

PETROLEUM STEAMERS.

The tank-steamer Oka, which has just discharged its cargo of Russian petroleum oil brought from Batoum, represents an important advance towards perfection in the design of ships intended for the carriage of this peculiar cargo. The vessel is 334ft. in length, and holds 3,300 tons of oil, the total dead-weight capacity, including coal, &c., being 4,000 tons. For so long a vessel its draught is inconsiderable, oil being a somewhat buoyant cargo. The difficulty has been, not to carry the weight, but to arrange the oil so conveniently and safely as to guard against accidents of explosion or leakage, and the arrangements made are in the highest degree interesting.

The somewhat recent explosion of a tank-boat near Calais was due to the fact that France imports only crude oil, which is infinitely more inflammable than refined oil, from which the explosive spirit has been distilled. With such vessels as the Oka the maximum convenience of transport appears to be reached.

The vessel was designed by and built under the supervision of Sir E. J. Reed, M.P., by Palmer's Shipbuilding and Iron Company Limited, of Jarrow-on-Tyne, who also built for the same owners, some eighteen months ago, a somewhat smaller tank-vessel, the Era, which has in that time completed twelve trips between Batoum and London, each time bringing a cargo of upwards of 2,000 tons. Between the deck and the oil cargo of the Oka there is a vacant space which may be filled with coals when the vessel is on its outward voyage, but which must be left open for the sake of safety when the oil has been stored below. The oil is injected into sixteen separate tanks, and it takes the place of water ballast when the oil cargo is complete. Between the oil tanks and the coal bunkers there is a partition filled with water; so that if a tank leaked the escaping oil could not well get to the coals or engine-room, or to the working parts of the ship, but would lose itself in the belt of water. The greatest precautions are taken to avoid sparks near the oil, which, as already mentioned, is separated from the main deck by an intermediary space. The electric light is used throughout the vessel. Moreover, the oil taken on board has undergone a refining process before shipment at Batoum.

Petroleum in the rough contains some volatile compounds, which make the vapour extremely inflammable. The worst of these have been left behind at Batoum. Nevertheless, there is still some danger that vapour may be given off, especially in the event of friction. It is impossible to confine the oil to a given space, inasmuch as difference of temperature causes it to swell or to diminish, as the case may be. To meet this difficulty some very ingenious arrangements have been attached to the deck commucating with the oil tank below. What looks like a hatchway is really the top of a more or less empty chamber, into which the expanded oil can flow if expanded by increased temperature. The maximum expansion is 2 per cent, and the chamber in question is adapted to hold the surplus 2 per cent of expansion, while there is a kind of crane-shaped funnel for the escape of the oil. Besides this hatchway there is a ventilating apparatus which allows the air to rush into the chamber below, so forcing out any vapour which may have accumulated from the surface of the oil. At the same time, and for the same end, there is a steam exhaust, which produces an artificial air current if necessary.

The vessel is constructed of steel. There are gauges to show the height of the oil in each tank, and altogether it is impossible to conceive a ship better adapted for the purpose in view. Probably no modern trade has evoked so much ingenuity applied to storage and distribution as mineral oil; and certainly few trades demand so much care in the appliances used.

MAGNETIC COMPASS NOT AFFECTED BY IRON.*

The compass needle is, on board iron ships, subjected to numerous forces tending to deflect it from the magnetic meridian, and consequently takes up a position determined by the joint effect of the earth's horizontal component and the single resultant of these deviating forces. The former varies in direction with the magnetic variation, and in intensity with the latitude, while the latter is continually changing as regards both these physical quantities. If two needles be mounted near one another, and with their points of support in the same vertical line, the direction and intensity of the earth's component will be the same for both needles, while for the deviating force the direction may be considered as the same, but the intensity to be different, so that the needles will not coincide in direction unless the deviating and terrestrial forces are in one line. In order to determine the meridian, the author has proposed the use of two such needles, a bar magnet being placed at equal distance from the two needles, this distance being at the same time sufficiently great to ensure equality of action on the two poles. This bar magnet is to be turned round the vertical axis passing through the needles, when two positions will be found at which the needles coincide in direction; this direction will be that of the resultant of the deviating forces, and will likewise bisect the supplement of the angle between the two positions of the bar; and if the action of the bar be made equal to that of the earth's horizontal component, one of the positions of the bar will coincide with the magnetic meridian. If, therefore, this component were tabulated for all places on the earth's surface, the only requirement would be the graduation of the instrument, so that the bar magnet could be placed at the distance corresponding to such tabulated value, and the magnetic meridian would be determined by the process above described. Another method, however, for which this knowledge of the terrestrial component is dispensed with, consists in placing a bar magnet in the direction, which may be determined as above, of the resultant of the deviating forces, and so that its action will annul that of the deviating force, when the needles will indicate the magnetic meridian. To effect this the action of the bar on the two needles must be proportional to, and at the same time the difference of this action must be the same as, the deviating force. The first of these conditions can be easily realised by using a compound magnet with opposed poles, the distance between the poles being regulated as required; while the latter condition is fulfilled by placing this compound bar at that particular height at which a needle placed in the same vertical line as the two needles will give a deflection a little less than the initial deviation of the two.

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* Foreign Abstracts, Proc. Inst. C.E.

Experiments conducted on board some French ironclads have given satisfactory confirmation to these propositions.*

CORRESPONDENCE.

COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—"Practical Observer's" talent for circumlocutory argument has no doubt led him to calculate the piston speeds of a great many North-Eastern locomotives to prove something quite outside the question at issue. At the same time I admit that the term "goods" does not quite convey the class of engine that I had in mind, which was the heavy goods engine for mineral traffic; although how anyone, reading the passage even as it originally stood, could include express goods in his averages, and serve up an olla podrida of slow passenger trains so as to bring the piston speeds together, and call it a fair argument, I cannot understand. Again, he must have wilfully misunderstood my quotation of the piston speed of Mr. Stroudley's express and goods engines. These were given to show—first, the high piston speed that is reached on our fast locomotives when doing their quickest times, and he will find that I said that this was the *highest*, whereas my reference to the 400ft. per minute was to the effect that it was the highest that I could find on the diagrams with a *late cut-off*. At the same time, I maintain that 16 miles an hour *is* about the average speed of heavily-loaded mineral trains, and these are the trains—burning, as many do, over 100lb. of coal per mile—on which, in my opinion, compounding could be applied with the greatest advantage. I may say that I am aware that locomotives are worked in a series of links, and also that the links are, or ought to be, composed of engines of the same class occupied in similar work.

"Practical Observer" doubts my power to explain how the boiler measures the power of the locomotive. He will readily see that a locomotive without a boiler would be unique, and also that there is nothing to limit the size and power of the engine (taken as distinct from the boiler) except the weight required for adhesion; but that to increase it beyond the capabilities of the largest boiler applicable on our present gauge would be madness. Again, he will admit that of two locomotives, identical in other respects, the one having the better boiler will prove more economical. With these axioms "Practical Observer" may evolve the rest with a little thought, "as he evidently is not aware" that on some of the continental railways the power of the locomotive is measured by its boiler.

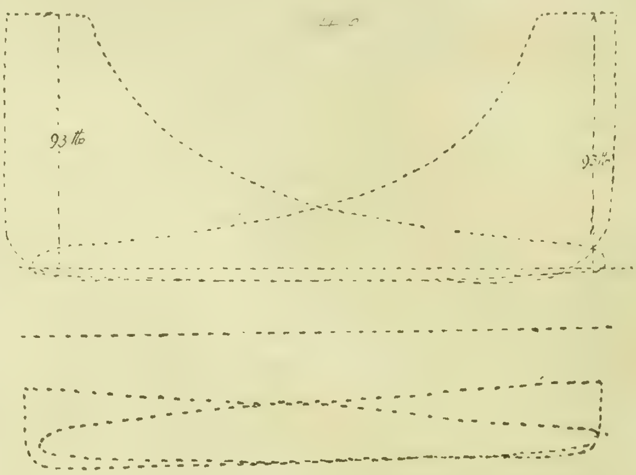
In reference to 60 miles in 60 minutes being a better performance than 125 miles in 125 minutes, "Practical Observer" will, I think, be able to see that to start, get up speed, and stop in a distance of five miles, and obtain an average speed of 60 miles an hour, would be impossible with our present locomotives. Can he now see the meaning of my assertion, that it is easier to obtain a good average in a long run? I may add, in conclusion, that "Practical Observer" shows a commendable discretion in not thinking it worth while to go into the details of my letter.—I am, yours, &c.

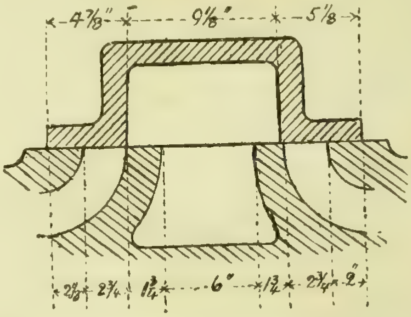
Patricroft, January 7th, 1889. JAMES BOLAS.

STEAM ENGINE EFFICIENCY.

To the Editor of "The Practical Engineer."

Sir,—I shall be glad if you or any of your readers will give me any information whereby I can reduce the coal consumption with the following engine and boiler: One Lancashire boiler, 28ft. long, 7ft. diameter, tubes 2ft. 9in. diameter, with four cross tubes in each flue, fires 6ft. long, working at 100lb. pressure, and horizontal compound tandem engine, with non-condensing cylinder 16in. diameter, condensing cylinder 28in. diameter, length of stroke 4ft., running at 58 revolutions per minute. The non-condensing cylinder is fitted with Corliss valves, and the condensing cylinder with slide valves. The power turned is about 132 I.H.P., and the coal consumed about 7lb. per I.H.P. for all purposes. The boiler has to supply steam for engine and heating shed, as well as for one sizing frame. Does the engine take more steam than is necessary to turn the above? If so, would putting a lap on the slide valve improve it, as the condensing cylinder is only doing about half the work of the non-condensing cylinder? What amount of lap should I put on the steam and exhaust edges of valve to equalise the work in both cylinders? I enclose diagram from engine and sketch of valve and ports. Any information on the above will be thankfully received by L. C. D.





CORROSION IN BOILERS.

To the Editor of "The Practical Engineer."

Sir,—Since writing you on the above, I have fallen in with a most peculiar case of corrosion. It is in a Lancashire boiler, which has been at work about twenty years, and the defect—a somewhat serious one—does not appear to have been noticed. The shell was considered to be in good condition, and as the furnace tubes had been patched, and were again leaking, it was considered advisable to put new flue tubes in; consequently the old flues were cut out and the boiler scaled, when all the shell opposite the right side flue was generally wasted by corrosion $\frac{1}{32}$in. to $\frac{1}{8}$in. deep—some places in pittings, others in blotches, but mostly general surface corrosion. The opposite side and bottom of the shell, in fact all parts of the shell and old flues (except the right side, where it should be heated from right-side flue), were quite good and free from corrosion.

I searched for a cause, but could not find a very satisfactory one, except it be due to the following: The right side flue was slightly damp, and the brickwork of the flues had the appearance of having been much hotter on the left side than the right, as though the draught had left the flue tubes at back end, returned to front end along left side, and then gone along bottom flue to chimney; thus the right-side flue would have little or no draught passing through it. This is perhaps one of the most peculiar cases I have met with.—Yours, &c.,

Jan. 5th, 1889. CHALKLINE

"Revue Maritime et Coloniale," October, 1886.

QUERIES AND REPLIES.

4. Engine Piston.—I should be glad if some fellow-reader could give me a word of advice with regard to the following: In one of the engines under my charge the junk ring is about $\frac{3}{16}$in. or $\frac{1}{4}$in. too slack for the cylinder, and the piston rod is bearing heavily on the gland. Would it be any advantage to turn the piston head upside down? as at present it is very hard to keep the asbestos packing which I use for the gland tight.

Answer.—The engine referred to is evidently a horizontal one, but as I do not know the exact construction of the slides it is impossible to say whether the piston can be turned upside down or not. It is usual in such cases as he mentions, that is if the engine is of medium size, to have say three-quarters of an inch turned off the diameter of the junk plates, and have good wrought-iron hoops properly bored out to suit, and shrunk on at the front and back, which are afterwards turned to suit the bore of the cylinder, into which they should be a slack fit. If any shoulders are worn near the ends of the cylinder, they should be removed before the repaired piston is put in. Should the cylinder be worn oval, it will be impossible to make a satisfactory job without its being re-bored.—F.

5. Coalpit Management.—Will some reader be good enough to favour me with the name of the best works on coalpit management, saying by whom published, and what is the price?

Answer.—There are really no good works on the above subject. Coalpit management can only be learnt by experience. There are many books which teach subjects, and describe appliances and methods used in practice, but although several (such as Hyslop's Colliery Management, price about 15s, which may be procured at the *Colliery Guardian* Office, Fleet Street, London, but suitable only for Scotch miners) profess to teach management, yet such are seldom of real value for more than one branch of the subject. The best information on mining matters is locked up in the papers of mining societies, which describe processes, machinery, and experience of the writers, but even these cannot teach coalpit management, but only show the practical miner how to improve his methods of work, and enable him to profit by the experience of others.—H.

6. Recutting and Tempering Taps and Dies.—I should be much obliged if any reader would give me a little information as to the process of softening, re-cutting, and tempering taps and dies.—Boltmaker.

Answer.—"Boltmaker" will find the book on "Screw-cutting and Tap and Diemaking," published by the author, T. Greenwood, Reliance Ironworks, Halifax, a very good and reliable one. The price of the book is 1s. 6d.—F. X. H.

8. Steel Spring.—Can you inform me where I can obtain round steel, $\frac{3}{8}$in. to $\frac{1}{2}$in. in diameter, fit to use for springs at once without tempering? Further, would hollow steel tubes have any spring in them?—G. C.

Answer.—We should think it would be quite impossible to make springs of ordinary dimensions out of such steel as you refer to without first making it red hot in order to enable the steel to be bent to the required shape. This being so, subsequent tempering after the springs were made would become imperative. We should think your better course would be to apply direct to some well-recognised maker of steel springs, such as Messrs. Salter and Co., West Bromwich, or Messrs. Sterne and Co., Glasgow. With regard to the latter portion of your query, there would be no difficulty in making springs of hollow steel tubes if you preferred to do so.—Ed.

2. Varnish for Papier-Maché Goods.—Would some reader kindly inform me how to make the black varnish that papier-maché goods are coated with? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished?—J. T. L.

3. Slide Valve of Hydraulic Engine.—Will some reader kindly inform me which is the best form of slide valve to adopt? The engine makes 20 strokes per minute, and the pressure is 1,000lb. per square inch. I should be glad also to learn what kind of stop valve is generally used for hydraulic cranes.

7. Blacklead Pencil Making Machinery.—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery?—B. B.

9. Grinding Optical Glasses.—Will some kind reader inform me how to grind optical glasses? Is there a book published on the sublect, and, if so, what is the price, and who is the publisher?

TO CORRESPONDENTS.

Scale.—We are not aware that a full report of Dr. Bailey's lecture appeared in any paper.

F. S. Green.—From an examination of the sketch sent with your letter, we do not see why you should not be able to get a pressure of 30lb. if you desire it. Of course many causes might account for the pressure being less than this. If the air is drawn off too rapidly from the receiver, the pressure would not have an opportunity of accumulating. Possibly the piston and valves may not be tight; you had better examine these, and make sure there is no leakage.

W. H.—The data you give are insufficient to enable a full answer to be given to your question, and, like many other of our correspondents, you appear to have somewhat hazy notions with regard to the principles that govern the design of a steam engine. The diameter of cylinder necessary for a given power will depend upon the speed at which it is intended to run the engine, and also upon the mean pressure that will be exerted throughout the stroke, while the mean pressure itself will be determined by the point of cut-off and the initial pressure of admission. The length of stroke, presuming the piston speed to have been fixed upon, is a matter that is subject to a considerable amount of adjustment, and would depend to a large extent on circumstances. It is usual to make the stroke about twice the diameter of the cylinder, but there is no arbitrary rule to be complied with. You will see from what we have said that your question opens up a wide field, to deal with the whole of which would occupy a series of articles. Your best plan would be to study some good text book on the steam engine, and make yourself familiar with the principles we have stated

Cymro.—Provided the centre of gravity of the lever and the two weights is in the same straight line, and also that the centre of gravity of the lever is at the point of suspension, then the lever would be in equilibrium, no matter what was the angle of inclination.

J. W.—We are not aware that any comparative trial such as you refer to has been made, but if you wrote direct to the Pulsometer Engineering Company, Nine Elms, London, they will doubtless furnish you with the information you require. The great advantage of the pulsometer over an ordinary pump, in a great many cases, consists in the ease with which it can be fixed in places where it would be almost impossible to erect a pump, while the fewness and simplicity of its working parts enable it to deal with muddy and dirty waters, which would quite disorganise a pump of ordinary construction.

Theory.—We cannot see our way at present to giving such a series of lessons as you refer to, and very much question whether they would be as generally appreciated as you appear to imagine. You will find full information regarding text books for the various subjects given in the prospectus issued by the City of London Guilds Institute and the Science and Art Department, which can be obtained from the respective secretaries.

W. Sisson.—You will find a pretty full answer to your inquiry as to the best method of getting on board ship on page 119 of our issue for March 9th last, under the heading of "To Intending Marine Engineers," while further supplementary information with regard to the Board of Trade Examinations was given in an answer to a query on page 467 of our issue for September 28th.

Boltonian.—We are not aware that any cut and dried method of procedure will be necessary to attain the position you desire, for which we should judge, from your letter, you are quite competent. The only plan we can suggest is that you should apply personally at the office of the various Atlantic liners if they have any berths of the kind open, stating what your experience has been. If they had no vacancies at the moment, they would probably enter your name on a list of applicants, and communicate with you the first time they are in want of a man.

Compass.—You will find full information regarding the necessary text books given in the prospectus of the examinations issued by the Science and Art Department.

MISCELLANEA.

The American Coal Trade.—The Philadelphia correspondent of the *Times* states that the anthracite coal-carrying companies are about to close the most successful year they have passed through, with an output of 38,000,000 tons, all having large surpluses.

Boyle and Son's Ventilator.—The jurors on ventilation at the late Brussels Exhibition have awarded to Messrs. Robert Boyle and Son Limited, of London and Glasgow, the gold medal for their latest improved patent self-acting air-pump ventilator.

Bolton Cotton Spinners.—In consequence of the Bolton Master Cotton Spinners' Association and the Operative Spinners' Society being unable to agree upon the terms of settlement of a dispute at one mill, involving about £12 weekly, the town, it is said, is losing in wages £11,000 every week, owing to the short-time movement adopted all through the trade by the employers.

New Ships to be Built at Portsmouth.—Rear-Admiral Hopkins, a controller of the navy, visited Portsmouth last Saturday, to make arrangements for next year's naval programme. It has been decided to lay down so many new ships at this yard that every building slip will be fully occupied, and the two docks will also be used for shipbuilding. The programme is stated to be the most elaborate that has been undertaken for the last 20 years.

Tramways in Damascus.—An imperial firman has, it is reported, been granted for the construction of a line of tramways in Damascus. Nor is this concession to civilisation the only sign that the far-famed city of Damascus is on the high road to becoming modernised. Gas also is to be introduced into the city, and the inhabitants are eagerly awaiting the promised innovations, which will, they believe, not only add to their own comfort, but will materially increase the value of property within the city boundaries. The latest estimate of the population of Damascus places it at 150,000.

The Lebel Rifle Cartridge.—In spite of the great pretence of secrecy maintained by the French authorities with regard to the Lebel rifle, the construction both of the weapon and the cartridge is pretty well understood, and may be obtained by anyone who cares to pay the price. A correspondent of a contemporary states that he had an opportunity for inspecting a cartridge in the city a few days ago. The bullet is of type metal thinly coated with steel, while the powder case is made of a solid-drawn copper tube.

The Growth of Tramways.—A statement has just been issued by the Board of Trade which shows very clearly the rapidity with which the street tramway system has been developed. In 1878 the authorised capital of companies in the United Kingdom amounted in round numbers to £6,580,000. Of this total £4,207,000 had been expended. In 1888 the authorised capital was £18,383,800, and the sum expended £13,735,600. In 1878 the length of line open was 269 miles, while in 1888 it was 904 miles. The passengers carried in 1878 numbered 146,001,223, as compared with 428,996,045 in 1888.

The Yellow River Inundation.—The magnitude of the calamity which recently occurred in China through the bursting of the banks of the Yellow River is so great that it is difficult for Europeans to form an adequate conception of its extent. From an account by a European eyewitness, just published, it appears that the gap in the river bank through which the water rushes measures 400ft. wide by nearly 100ft. deep. Through this chasm the flood rushes at the rate of eight or nine miles an hour upon the surrounding plains. It is estimated that upwards of 1,000,000 lives have already been lost, and that an equal number are houseless and entirely dependent upon the Government for sustenance.

Lithographic Stone in Canada.—The stones of the townships of Mador and Mamon, and of the counties of Peterboro' and Bruce, have been examined and practically tested by lithographers, and in several cases pronounced to be of good quality; they have also obtained medals at various exhibitions. They were obtained from the surface in small quarries, and possibly when the quarries are more developed, better stones, free from "sparks" of quartz or calcite, will be available in large slabs. It is a well-known fact that the Bavarian quarries do not produce now sufficient quantity of the best quality stones for the requirements of the American market, and this should lead to the development of the Canadian supply.

Flooding of a Colliery at Hyde.—A serious disaster has occurred at the colliery belonging to Messrs. Sidebotham, at Haughton, near Hyde, by which some 300 men and boys have been thrown out of employment. When the men left work on Saturday, the 29th ult., everything in the mine was in order, but when the first batch of men were lowered on Monday morning the mine was found to be flooded to a depth of about 6ft., and the occupants of the cage narrowly escaped being drowned. It is thought that the inrush of water has been caused by the accidental tapping of some old workings. Arrangement were made to pump water out of the mine, but for several days after the disaster very little headway had been made.

Graydon's Dynamite Gun.—A new pneumatic dynamite gun, stated to excel the Zalinsky gun in several important particulars, has been invented by Lieutenant J. W. Graydon, of the United States Navy. In this gun the defects attached to the older dynamite gun are said to have been avoided. The Graydon gun is much shorter than the Zalinsky arm; it may be moved rearwards as well as elevated and depressed. The projectiles are propelled at a higher pressure (3,000lb. to the square inch) than in the Zalinsky weapon, they have a flatter trajectory, and attain a range of two miles. They are also stated to be of a form more easily handled. The Graydon guns are intended both for board ship and shore batteries. They are also to serve as siege and field guns, in the latter case being of special construction, resembling that of the Hotchkiss revolver gun.

Evaporation of Ice.—Last Saturday Professor Dewar gave the second of a series of lectures at the Royal Institution on "Clouds and Cloudland," the lecture being chiefly devoted to the consideration of the phenomena of evaporation. The lecturer commenced by suspending two pieces of ice, one in the air and the other in a glass vessel in which provision had been made for producing a vacuum. He then proceeded to explain and illustrate the behaviour of the two pieces of ice under these conditions, the fact which he wished his audience to realise being that not only does ice melt and disappear by liquefaction and the evaporation of the filmy and watery element which surrounds it in ordinary conditions, but under the conditions of greatly diminished pressure ice ceases to melt at all, even in a warm chamber, if it be left still. The lecture was also illustrated by numerous other experiments of an interesting character.

The Manufacture of Screws.—It is not known when screws were first made and brought into use. The first instance known of machinery being applied to the making of screws was in France, in 1569, by a man named Besson, who contrived a screw-cutting gauge to be used in a lathe. The early method had been to make the heads by pressing the blanks, while red hot, between dies, and then to form the threads by the process of filing. In 1741 Besson's device was imported by Hindley, the watchmaker of York, and for a long time the watchmakers of England employed the latter's method in making the small screws used in their work. The first English patent appears to have been issued to Job and William Wyatt, 1760, for three machines—one for making blanks, another for nicking the heads, and a third for cutting the threads. Between that date and 1840 about ten patents were issued, only one of which is worthy of notice, viz., that of Miles Berry, dated January 28th, 1837, which was for a gimlet-pointed screw.

Consumption of Railway Sleepers.—The Belgian *Bulletin du Musée Commercial* gives the following information respecting the number of sleepers used on various railways. In France alone the six larger railway companies require a daily supply of more than 10,000 sleepers, making an annual consumption of over 3,650,000. As a tree of ordinary dimensions can not furnish more than ten logs, it follows that more than a thousand fine trees are cut down every day solely for the purpose of supplying the necessary sleepers for the French railways. In the United States the amount required is still greater. Over 15 million sleepers are annually used in this country, thus necessitating the annual destruction of 80,000 hectares, or 197,600 acres of forests. The *Bulletin du Musée Commercial* estimates at more than 40 millions the number of logs required for the railways of the world, and is of opinion that this estimate is rather below than above the mark.

Railway Accidents.—The returns published by the Board of Trade contain the statistics of railway accidents and casualties in the United Kingdom for the first three-quarters of the year 1888. In that space of time there were 74 passengers killed and 983 injured, a return which will compare favourably with 100 killed and 992 injured in the corresponding period of last year. The servants of companies or contractors also suffered less in mortal injuries, 275 having been killed as against 297; though the otherwise injured amounted to 1,547, which exceeds the number in the preceding year by 42. Adding to these two classes the other casualties, such as persons passing at level crossings, trespassers, suicides, and others, we find that the number of deaths was 648, as against 672, and of slighter injuries, 2,703, as against 2,661, in the first nine months of 1887. If accidents occurring on the premises of railway companies, though not occasioned by railway vehicles, be added to the above, the total number of accidents reported to the Board of Trade during the nine months amounted to 696 killed and 6086 injured.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

December 19th.

18556 Purifying Water, J. Pollock, Belfast.
18558 Fastener for Belting, J. K. Tullis, Glasgow.
18564 Oil Cans, T. McLeod, Birmingham.
18569 Rail Joints, R. Hundleby, Sheffield
18573 Purification of Gases, E. Solvay, London.
18585 Crushing and Grinding Machinery, G. E. Sherwin, Middlesex.
18592 Propelling Boats, F. Russell, London.
18593 Pipe Tongs, J. P. Johansson, London.—[Complete Specification.]
18594 Hat-sizing Machines, G. F. Redfern, London. (E. M. Bulkley, United States.)—[Complete Specification.]
18602 Steam Engine, A. M. Clark, London. (The Dake Engine Manufacturing Co., Incorporated, United States.)

December 20th.

18609 Drum-winding Frames, B. A. Dobson and J. Hill, Manchester.
18629 Compound Engines, W. Chilton, London.
18633 Drying and Ageing Woven Fibres, T. Barcroft and T. Barcroft, jun., London.
18636 Electrical Accumulators, J. C. Fuller and G. Fuller, London.
18646 Iron Fittings, J. Jeziorsky, London.—[Complete Specification.]
18653 Spanners, G. Townsend, London.

December 21st.

18678 Preventing Emission of Smoke, F. R. Jones, Huddersfield.
18679 Thermometer Fire Alarm, L. B. Bethell, Winchester.
18682 Water Heaters, W. J. Righton, London.
18687 Railway Signalling, A. Anderson, London.
18688 Water-tight Bulkhead Doors, W. Paterson and W. B. Cumming, London.
18691 Governors, Tangyes (Limited) and T. Meacock, Middlesex.
18692 Apparatus for Burning Gases, H. Darby, London.
18697 Nozzles or Sprays, R. Oakley and R. Pollock, London.
18699 Washing Paper Pulp, G. Fry, London.
18704 Furnaces or Fire-boxes, R. Marshall, London.
18706 Slide Lathes, E. Bellemere, London.
18713 Screw Propellers, C. C. Daevel, London.

December 22nd.

18721 Gas Fires and Stoves, W. T. Crooke, Essex.
18724 Lubricator Spring, W. Phillips, Birmingham.
18726 Tube Axle Carriages, W. Thompson, Northumberland.
18727 Current Transformers, R. P. Sellon and C. Watson, Surrey.
18728 Sand Blast Machinery, J. C. Peacock, Birmingham.
18729 Heating Apparatus, E. Rees, Swansea.
18732 Aluminium and its Alloys, J. Clark, Birmingham.
18733 Shiel's Patent Non-smelling Gas Stove, A. Shiels, Glasgow.
18734 Smoke-consuming Apparatus, G. H. Denison and E. J. Holmes, Leeds.
18735 Metal Spokes, R. Ball, Birmingham.
18740 Lubricators, W. O. Felt, London.
18743 An Uptake for Fire-places, &c., C. Chester, London.
18744 Ice-making, J. H. Green and A. Ingram, London.
18745 Furnaces, J. Gamgee, London.
18746 Locking Screw Nuts, E. P. Prince, Middlesex.
18747 Arc Lamp Regulator, H. A. Gigaroff, London.
18748 Copying Apparatus, E. Payne and E. L. Sheldon, London.—[Complete Specification.]
18750 Supplying Fuel Apparatus, M. Smith, Manchester.
18751 Float Valves, W. H. Wallis and S. Nichols, London.
18758 Heating Steel Wire, A. W. Brewtnall, Manchester.
18759 Shaping Sheet Iron, W. Crawford, J. Crawford, and W. W. Crawford, Glasgow.
18761 Internal Combustion Thermometers, J. Hargreaves, Liverpool.
18772 Packing Stuffing Boxes, J. A. Fowler, London.
18777 Motors, A. Franz, London.
18778 Thrashing Machines, E. F. Sandon and D. F. Tonge, London. (L. Pfaff, Argentine Republic.)
18784 Regulating Electric Currents, W. F. Lahmeyer, London
18798 Expansion Gear, G. A. Franke, London.

December 24th.

18799 Carding Engines, T. Forknall, Manchester.
18803 Steam Generator, J. Davies and T. Walmsley, Manchester.
18804 Fuel Economisers, R. Roberts and A. Roberts, Manchester.
18807 Electric Currents, T. Parker, Manchester.
18808 Centrifugal Filters, W. A. Richards, Liverpool.
18811 Wood Planing Machines, S. S. Hazeland, Cornwall.
18819 Cyclometers, E. H. Horne, Norwood.
18820 Signalling on Railways, S. B. Kincaid, Essex.—[Complete Specification.]
18822 Semi-portable Boilers, W. L. Gordon and A. W. Cooper, Forfarshire.
18830 Indicators, D. Smith, Birmingham.—[Complete Specification.]
18831 Screw Propellers, J. Y. Johnson, Middlesex. (La Société Salomon frerei et Tenting, France.)
18832 Miners' Safety Hand Lamp, E. T. Boston, Weston-super-Mare.
18833 Aluminium, J. A. B. Bennett, Birmingham.
18839 Apparatus for Closing Tubes, L. Chapman, London.
18842 Ingots, L. L. Burdon, London.—[Complete Specification.]

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER.

JANUARY 18TH, 1889.

MECHANICAL POSSIBILITIES.

ALTHOUGH the ends that may be attained by mechanical means are in variety and number indeterminate, yet they are not infinite. There are bounds to mechanical possibilities which cannot be overstepped, and it is in endeavouring to pass these that many fortunes and valuable lives have been wasted. It may seem rather antiquated to refer to the perpetual motion craze, but those whose practice lies much amongst inventors, or would-be inventors, know that many machines are projected at the present time which, although perhaps under other names, are, whether professedly or not perpetual motion machines.

Inventors of apparatus of the nature to which we refer may be broadly divided into two classes—those who are self-deceived, and those who, for financial ends, deliberately deceive others. The latter are, of course, only common swindlers, and in many cases their victims deserve but little sympathy; for those who, for the sake of great profit, will invest in any hypothetical "motor," without making any test of its capabilities, are to blame for their own credulity; and of these we have seen one or two notable examples of late. But of such charlatans, and those upon whom they prey, we shall not speak at length here. Wherever the spirit of speculation merges into that of gambling, such bubbles will naturally arise and attract greedy and inconsiderate investors.

It is to the honest but self-deceived inventors that we direct our observations, with a view to see how they may best be protected from being misled by their own deficiency of technical knowledge.

In regard to obtaining any proposed movement, or series of movements, by purely mechanical means, a thoroughly practical mechanician will be able, after consideration, to determine its possibility or otherwise. Thus, for instance, in sewing and stitching, the movement of the human hand cannot be reproduced mechanically, although a very good substitute has been found for it; but when physical forces have also to be considered, some further knowledge is requisite.

Calmly considered, no one would imagine that a given weight, falling through a given height, can raise an equal weight through an equal height; the weights would balance, would be at rest, unless set in motion by some external force. Yet this is the principle upon which numerous machines have not only been designed, but patented. To avoid this as well as less palpable errors, it must be remembered that it has been abundantly shown that we cannot create force or energy; we can only convert it from one form to another, and in this conversion the converted force will always bear a fixed proportion to that from which it is derived. Thus 772 foot-pounds of work is equivalent to the quantity of heat required to raise one pound of water one degree Fahrenheit in temperature. In propelling the piston of a steam engine, the steam loses heat, and that steam cannot by any mechanical arrangement be returned to the generator without doing at least as much, and practically more, work upon it than it has done upon the piston, although a machine of this sort has been imagined possible.

It is probably among the most earnest class of practical working men that the tendency to improve and invent exists most extensively, although their names may not always appear, or at all events not alone, on the specifications; and it is this class, therefore, that should have every opportunity of improving their technical knowledge, in order that they may not fall into errors such as we have mentioned. It may be urged that they have a means of protection by referring inventions to patent agents or consulting engineers. This ought to be the case, but it is not always so; otherwise we should not see impossible machines patented, and others which may be practicable patented over and over again. In Lord Herschell's Committee on the question of creating a roll of patent agents this point was brought prominently forward. The Committee say: "Strong representations have been made to us in favour of the creation of a roll of patent agents. It is said that there are persons calling themselves patent agents who possess neither the requisite knowledge nor integrity, and that occasionally inventors who are poor, and not highly educated, suffer seriously in consequence." Surely the general bulk of the profession would be glad were such excluded from practising.

Turning to another point, it is to be considered how best the means of self-improvement may be brought within reach of the young working man. Even if he has the means, he may not feel disposed, after a fair day's work in the shop, to attend evening classes. The tendency would generally be more towards working up at home, provided he could obtain text books which he could understand without a teacher—books that would talk to him in his own language. There is no reason why literature of this class should not be forthcoming, for it is most certain that the problems of mechanics occurring in every-day life admit of being analysed and demonstrated quite simply by diagram and otherwise, nothing beyond equational arithmetic being requisite, and that is only another form of rule of three. The works written by many of the academical professors are sometimes too apt to run into trigonometry and high algebra to be of use to the class in whose interests we at present write.

With the great reduction in fees for the protection of inventions, there is, of course, every opportunity for a working man to secure to himself the result of his ingenuity, instead of, as formerly, being placed at the mercy of those who might find the money requisite for taking out a patent; and therefore it is only natural that a fresh incitement to study and qualify himself to determine the practicability of his own designs should also come into existence, all aided, as it is, by the improved elementary education of recent times.

ABUSES OF THE FRENCH NAVY.

It appears that, notwithstanding all our grumbling and our fear of the French outstripping us in rapidity of shipbuilding for war purposes, comparatively we may congratulate ourselves on the condition of our Government dockyards. In the *Glasgow Herald* an interesting article deals with a new book as follows:—

The discussion on the Budget and the Naval Estimates in the French Chambers at the end of last year elicited some very startling statements from several representatives of maritime constituencies. It was asserted that while the estimates had been constantly growing, France had been hopelessly behind this country in naval construction, especially in torpedo boats and "torpedo catchers." The "truth" about the French navy was declared to be alarming, but it was not considered patriotic to dwell on these things, and the naval estimates were quickly disposed of. This rule, however, like every other, has been broken by M. Paul Bourde, who has just published a work devoted expressly to "Abuses of the Navy." The more interesting and sensational of M. Bourde's "revelations" have been reproduced in this country, and it must be allowed that, whether they are absolutely authentic or not, they are both edifying and amusing—for lookers-on. We have been accustomed of late years to hear charges of bad management, inefficiency, and ignorance levelled at our own Admiralty authorities, but the most irresponsible of grumblers in this country has never hinted at such a tale of extravagance, incompetence, and folly as M. Bourde describes in his book.

According to the French critic, the five French dockyards, naval ports, and arsenals—Cherbourg, Brest, L'Orient, Rochefort, and Toulon—together with their cumbrous staff of directors, commissaries, superintendents, clerks, artisans, and officials, are not kept up for the benefit of the navy; the navy is kept up that the staff may flourish at the expense of the Republic. The ideal of the Socialists has been actually attained, and the smallest amount of work, in every department of naval construction, equipment, and transport, is carried out by the greatest possible number of "hands." Every hundred francs' worth of work done, or provisions purchased, costs the State from two to three hundred per cent more than it ought to cost. At Rochefort works exist on land for the construction of the largest ships of war; but there happens to be no depth of water there to float that class of vessel when built. It was calculated that one ironclad commenced at L'Orient in 1882 would not be completed till 1992; the £30,000 spent on her was "written off," and an entirely new ship was started. The book contains throughout astonishing revelations of this kind, and M. Bourde has collected numerous statistics showing the enormous waste of money going on in the manufacturing, transport, and victualling departments of the French navy.

ELECTRIC MILITARY SEARCH LIGHTS.

The Prussian military authorities have recently conducted experiments on the use of search lights in time of war, with, it is said, relatively satisfactory results, and now trials have been made at Viborg by the Russian authorities on the same matter. The trials were undertaken for the purpose of determining whether the electric light can be advantageously employed in military operations, and whether it presents the inconvenience of revealing to the enemy the position of their opponent's batteries, &c. The following are the conclusions arrived at: (1) The ground in front of the military force should be lighted for reconnoitring, for which purpose a very powerful and concentrated light should be used. The trials gave some excellent results regarding the influence of time, colour, state of movement or rest of the objects on which the light was projected when two projectors were concentrated on the same point, or when one of double intensity was employed. (2) It is necessary to take into consideration the distance within which one force under cover from the enemy can accomplish its work, both in and outside of its lines. (3) As regards the use of the light for the purpose of concealing the position of one body of men, trials were made in order to determine what effect blinding, by means of an intense light, could have on the enemy's gunners, and, inversely, what effect could be produced on one's own gunners by the enemy's projectors. (4) Signalling operations were carried on. The result seems to be favourable to the more general employment of the electric light for military purposes, although no doubt many difficulties of detail would require to be met before it could be absolutely depended on.

ELECTRIC SUGAR REFINING.

Some four years ago a "Professor" Friend alleged that he had discovered a new process for refining raw sugar which possessed numerous advantages over that ordinarily in use. He stated that by his method the sugar could be refined without solution and re-evaporation, and without loss of weight. One ton of raw sugar was to produce one ton of refined. This he stated was accomplished by the aid of electricity. He succeeded in interesting investors in England, principally in Liverpool and Birmingham, and raised a large sum of money wherewith to erect plant and to obtain works for manufacture by his perfected machinery. For several years he kept his shareholders in a state of firm belief in the great things to be accomplished. Some time ago, however, he died, leaving his supposed valuable secret to his wife and a few relatives, and a few days ago one of the leading shareholders visited New York, where the works are situated, and insisted on investigation. It was then found that the scheme was entirely fraudulent, and that the supposed electric process accomplished nothing, but that the sugar exhibited to the credulous public was nothing more nor less than ordinary refined lump sugar doctored chemically, and merely crushed in a machine of usual construction. It appears that no shareholder had ever seen the process in actual operation, but was only permitted to witness the raw sugar put in a hopper at the top of the building and refined sugar come out below, the intermediate process being entirely hid from view of the more curious. That such a scheme could obtain the large amount of support is a melancholy comment upon the intelligence of some of our investors. Any acquaintance, in the most distant way, with the chemical properties of sugar and the action of the electric current would teach that the claims made were impossible of realisation.

Some time ago Professor Sylvanus Thomson sounded a note of warning, and pointed out the absurdity of the statement made, but with no result; ready believers at once asserted the impossibility of limiting the advance of science, and so forth. To some minds it seems impossible of comprehension that the very advance of science has given us the power to say that certain matters are definitely impossible, and it is but a waste of time trying to achieve the impossible.

LITERATURE.

Modern Steam Engines. By Joshua Rose. 321 pp.
London: Sampson, Low, Marston, Searle, and Rivington.

This book is an interesting and carefully written one, by a well-known practical engineer, but its title should have been modified by the insertion of the word American. To the engineer desiring to understand something of American steam-engine practice it will be most serviceable, and even to those practical men who have not studied the theory of valve action and steam distribution it supplies an easy means of acquiring a considerable knowledge of the subject, with but a limited use of geometry, and no mathematics. Many types of valves and valve gear are clearly and simply described, and their various points of comparative advantage pointed out, and in some cases short tables are given of the position of the piston and the valve openings, obtained by measurement from the actual engine placed in the various positions. This procedure is often a good one, as all practical conditions, such as play of pins, are included. It is seldom indeed that an engine in actual operation opens and closes its valves at the precise points indicated by the theoretical diagram of its action. In the first four chapters valves and valve motion are dealt with, and reversing gear touched upon. In the fifth and sixth chapters some adjustable cut-off valves are described. Chapter seven discusses various automatic variable cut-off engines, including those of Corliss, Porter-Allen, Westinghouse and Armington-Sims. Chapter eight is upon compound engines, limited to those without condensation; it is very short, and insufficient. Chapters nine, ten, eleven, and twelve are occupied with condensing engines, compound condensing engines, and the application of steam to various purposes, such as direct-acting pumps, fire engines, hoisting, and rock drills. There is not much really new matter in the book, and the principal advantageous points in American practice relating to the Corliss type of engines have long been familiar to English engineers. One detail, however, in the straight-line engine (page 185) strikes us as well worthy of note—that is, the long hollow piston, the length being about equal to the diameter. This ratio cannot, of course, be invariably used, but we are distinctly of opinion that our English piston proportions err in the direction of deficient rubbing surface, and consequently unnecessarily rapid wear. In vertical engines the matter is not a serious one, but in horizontal ones a longer or rather deeper piston would undoubtedly be an advantage. If this were generally attended to, much less would be heard of oval cylinders and leaky pistons. Some points in the governing and valve arrangements of several of the variable cut-off engines strike us as exceedingly objectionable. On the Armington-Sims engine, for example, the governing is effected by means of a radial arrangement, with springs acting upon a double eccentric, and changing the position of the eccentric centre upon the crank shaft, at the same time diminishing the stroke of the valve. The sensitiveness of this arrangement depends entirely upon the packing of the steam valve rod, as the governor has really to perform the duty to the eccentric usually allocated to a key. The Westinghouse, Ball, and Ide engines are open to similar objections. Piston valves are much used in which it seems a common practice to entirely dispense with packing rings. This seems to us very objectionable. The Worthington direct-acting pump, a duplex arrangement with pistons, each moving the slide valve of the other, is admirable, but is well known and appreciated by our engineers. The Knowles single-cylinder direct-acting steam pump does not seem to be so good as those of our own manufacture, such as the "special" and Pearns'. In conclusion, this book is well worthy of a place in the engineer's library, and we can conscientiously recommend it for reference and some insight into American practices; but the engineer who approaches it for information on the method of English firms will certainly be disappointed. The illustrations are numerous and excellent.

Steam and the Steam Engine. By Prof. Andrew Jamieson,
M.I.C.E. London: Chas. Griffin and Co.

Professor Jamieson has produced an interesting and valuable little work, intended as an introduction to his larger book on the same subject. He has succeeded admirably in conveying within small compass, and in simple, straightforward language, a considerable amount of sound engineering knowledge upon steam and steam-engine detail. The work opens with three lectures upon mensuration, which he considers absolutely necessary in the present state of arithmetical knowledge among apprentice students. This we think good, as from our own experience among young engineers in the shops we know that they are often very deficient in calculation, and here they will find just what they require to understand—the methods of solving many engineering problems. Several simple lectures then follow upon the thermometer, calorimeter, heat, and the equivalents of heat and mechanical work, gently leading up to the properties of steam and expansion curves. The remainder of the work is devoted to the engine and its details, and many modern forms are clearly indicated. A good idea is given of indicator diagrams, and their uses in determining power of the engine and discovering defects in the action of the valves.

Professor Jamieson will allow us to point out an error on page 70, stage 7, where, in treating of dissociation, he states that blowing steam over hot plates dissociates it, and makes water gas. This is hardly so. Water gas is a product of the decomposition of steam by carbon in an incandescent state, and the action is an ordinary chemical decomposition, not dissociation. The action is in its result—

$$H_2O + C = H_2 + CO$$

In conclusion, Professor Jamieson may be heartily congratulated on producing a work which should be in the hands of every engineering apprentice.

The Metallurgy of Gold. By M. Eissler. 188 pages.
London: Crosby, Lockwood, and Son.

In this work many practical details are described clearly, but with suitable brevity, and with the intention, as the author informs us in his preface, of affording an intelligent insight into the modes of dealing with gold in the various processes, mechanical and chemical, necessary for obtaining it from the state in which it occurs in nature. The mechanical processes are first explained, and the various forms of rock-breakers and stamps used in reducing the ore to a fine state of division are described and illustrated. The working details are fully entered into, in some cases rather more particularly than is necessary for the engineer. However, as the work is intended for the information of the investing public as well as the professional man, we readily understand any little over elaboration. If it is a fault, it is one erring in the right direction.

Gold in nature mainly exists chemically free or uncombined with any other non-metallic element, and in a state more or less mechanically diffused throughout quartz, and sometimes in slate, baryta, or talc. In all cases the ore must first be broken into convenient pieces by a rock-breaker, and then crushed in a stamp mill, with water to form a paste; lastly amalgamated, and the gold recovered from the amalgam by distilling off the mercury. In some ores the gold refuses to be dissolved by mercury, often from the action of sulphur or arsenic upon it, in which event roasting is necessary in order to oxidise the sulphur and volatilise both sulphur and arsenic.

Plattner's method of extracting gold by chlorination is also described, and some consideration is given to assaying and analysis. The chemistry of the work, however, is slight and general, and several well-known and recent methods are not mentioned at all. M. Eissler's work is not original in method, but is worthy of perusal by those desiring to gain a general idea of the nature of gold miners' methods, and who have not time to study the subject minutely.

ARTISANS AT THE PARIS EXHIBITION.

Mr. Quintin Hogg, of the Regent Street Polytechnic Young Men's Christian Institute, has originated and developed a scheme which we should like to see followed by many of our large employers of labour. This gentleman has made arrangements by which 600 of the young men of the institute will be enabled to visit the Paris Exhibition this year, under the personal guidance of Mr. Hogg himself, or of one of the other gentlemen connected with the institute. The total cost of the return journey, together with board and lodging, is fixed at the very low sum of £2 10s. for the week. Lodgings for thirty at one time have been secured at Washington House, in the Rue de Milan, close to the St. Lazaire Station, and well within the boundaries. The excursionists will therefore travel in groups of thirty, commencing on June 1st, and ending with the end of September. It is intended to group the young men according to their trades—engineers, plumbers, carpenters, &c.—in distinct parties, and to spend three days in the exhibition, each group paying the closest attention to the illustrations of their own particular craft. The remaining time will be occupied in sight-seeing. To enable those with small means to join these parties, weekly subscriptions of 2s. will be received from the members.

We call attention to this just now, because it appears that Mr. Hogg's initiative might be followed with advantage by many of our large firms, and even by smaller firms, working in unison. Numbers of our workmen would gladly avail themselves of the opportunities offered to the young men of the Polytechnic. Under ordinary circumstances a week's trip to Paris from London cannot be comfortably done for less than £6 or £7. The difference between this sum and say about £3 10s. (making an allowance of a sovereign for extras) would be quite sufficient to prevent thousands of workmen from undertaking the trip. The method of weekly payments also would make a trip possible for many who would not or could not otherwise gather the cash together.

It is not merely as a pleasant holiday that we advocate the pilgrimages of our workmen on a large scale to Paris this year. So much has been said to their discredit of the rivalry of their foreign brethren, that in justice to themselves, and as a matter of policy, they ought to be enabled to see and judge for themselves of the truth or otherwise of these statements. If the productions of the German, French, and American workmen are really superior in many or in all respects to our own, the workmen themselves will be the first to detect wherein the difference and superiority consist, and if improvement is seen to lie within their own province, they will not be slow to profit thereby. In order to do this they must go as a body, not by representatives. The latter was the plan adopted in 1878, and the result was practically *nil.* Not one in a thousand among the workmen probably ever saw the volume of official reports; and the perusal of reports demonstrates little in comparison with that knowledge which comes of personal observation.

In the interests of British trade, and for the benefit both of employers and workmen, we should be glad to see schemes like this of Mr. Quintin Hogg initiated in all the large towns of the kingdom. The difficulty will lie chiefly in the securing of lodgings, but this is not insuperable. It is probable, almost certain, that accommodation would have to be obtained without the ramparts, and brakes or wagonettes engaged to bring the parties into the city each day. But, we repeat, there is no insuperable difficulty, and our employers of labour are as favourably circumstanced for carrying out such schemes as Mr. Hogg himself.

STRENGTH AND CONDUCTIVITY OF GERMAN AND SWEDISH WIRE.*

Previous experiments had shown that no appreciable regular connection exists between the properties of iron and steel as elicited by mechanical tests and their conductivity, and therefore the Chemical Department of the Experimental Institute, at Berlin, was instructed to make further investigations as to the relations, if any, existing between the conductivity and the chemical composition and microscopic appearance of the same materials. The samples before used for mechanical tests were chemically analysed, and in the original the results are given in a table, together with the corresponding degrees of conductivity. An inspection of these results shows that the proportion of carbon present in itself has no influence on the conductivity, and the same remark applies to silicium. Manganese and phosphorus appear to vary with the conductivity; the proportion of sulphur in all the samples was very small, and varied irregularly. It is not practicable from the data obtained to arrive at any conclusion as to the effect of individual constituents, and therefore the authors have instituted a comparison between the conductivity and the proportions of the sums of various constituents.

From this it appears that the material may be divided into various groups, in each of which a given range of conductivity corresponds to a certain proportion, within limits, of the sum of several constituents. The combinations used for comparison are the following: (*a*) all elements except iron; (*b*) all except carbon and iron; (*c*) manganese and phosphorus.

In Group I. are included wires for which the conductivity † ranges from 10·11 to 9·70. For these the sum of (*a*) is below 0·3; the sum of (*b*) below 0·15; the sum of (*c*) below 0·13.

Group II. contains wires of the conductivity 9·32 to 7·77, for which the sum (*a*) is greater than 0·3, but less than 0·5; the sum (*b*) greater than 0·15, but less than 0·45; the sum (*c*) greater than 0·13, but under 0·40.

Group III. includes wires ranging in conductivity from 7·60 to 6·46; for these the sum (*a*) is over 0·5, but under 1·0; the sum (*b*) over 0·45, but under 0·9; the sum (*c*) over 0·4, but under 0·8.

In Group IV. are classed all wires of inferior conductivity, for which the sums *a*, *b*, and *c* are greater than 1.

For the microscopic investigations, the sections, after polishing, were tempered in an air bath at a temperature of 210 deg. Centigrade, in order to give different colours to the different constituents of the iron, and then photographed under reflected light impinging on the surface at a certain angle—38 deg. to 40 deg. The apparatus for this purpose is described and illustrated in the original. At first magnesium light had to be employed, as electric light was not obtainable, and no other suitable, but the results were not satisfactory. Zirconia made incandescent by burning coal-gas was then tried with complete success. The microscopic investigations showed that the finer the grain of iron and the more regular its structure, the higher is the conductivity, while the latter is reduced by blow-holes, fissures, and seams.

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* Foreign Abstracts, Proc. Inst. C.E.

† The conductivity is expressed relatively to that of mercury at 0° Centigrade.

Although neither chemical composition nor microscopic inspection alone is sufficient to determine the conductivity of wire, more complete information may be obtained by a combination of the two. In the original a table has been compiled in which are given, for each sample, the conductivity, breaking strength, total extension, sum of all elements except iron, sum of manganese and phosphorus, and the microscopic appearance of the section. From this the following conclusions are drawn :—

(1) A wire of first-class conductivity (9·7 and over) should not have a breaking strength greater than 36 kilogrammes per square millimetre (23 tons per square inch), nor an extension less than 12 per cent, the sum of all foreign elements must not exceed 150 (0·150), nor the sum of manganese and phosphorus 125 ; the structure must be uniform, fine-grained, and without flaws, &c.

(2) A wire of second-class conductivity (7·77 to 9·32) should have a breaking strength less than 45·1 (28·6 tons per square inch), an extension not less than 17·2 per cent, the sum of all foreign constituents should not exceed 450, nor the sum of manganese and phosphorus 400 ; the structure may be coarse-grained, but must be uniform.

(3) A wire is of third-class conductivity when, although the breaking strength, extension, and chemical composition correspond to those of the second-class, the structure is irregular or contains flaws.

(4) A wire belongs to the fourth class when the breaking strength is over 50 (32 tons per square inch), extension less than 8, sum of all foreign elements, or manganese and phosphorus alone, over 1,000, and the structure is coarse-grained and irregular ; in this case it is altogether unsuited for electrical purposes.

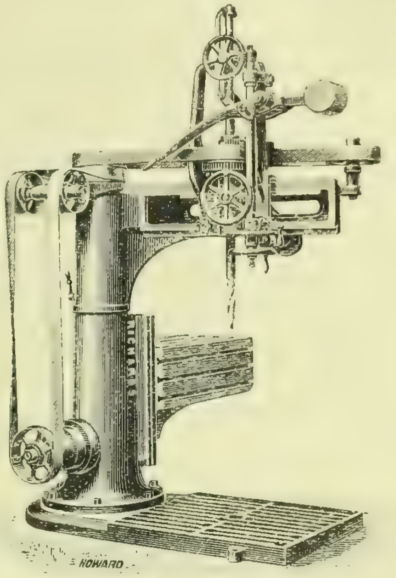
PROGRESS AT THE FORTH BRIDGE.

Notwithstanding the frequent stoppage of labour, in consequence of stormy weather, rapid progress has been made recently at the Forth Bridge ; indeed, so materially has the work been advanced, that the gigantic structure is now assuming a shape which indicates that the bridge is within measurable distance of completion. The great centre gaps which require to be spanned are every day being reduced in length, and to the non-engineering eye this part of the works now presents less difficulty of accomplishment than it may have done a few months ago. Never anticipating any serious obstacle in the building of the spans, the engineers are finding this section of the work more simple than many of the previous stages. Both on the Queensferry and Fife sides bay No. 3 has been completed, and No. 4 commenced. As has been the case throughout, the work on Inchgarvie is behind that on either side. At the south end of the island, however, the third bay is pretty well advanced, while another month will bring the north side as far forward. Some idea of the limited extent of work yet to be undertaken may be gathered from the fact that during the months of August, September, and October material was erected on the three piers at the rate of 2,000 tons per month, and that only 9,000 tons are now required to finish the work. From this it is calculated that, should the weather not interfere, and the workshops at Queensferry be able to cope with the demands made upon them, the bridge proper may be completed by the beginning of May next. In the sheds on the south side, night and day shifts are being constantly employed, but only one staff of men is found necessary on the erections. The 30th of October is the date fixed for the entire completion of the bridge, and it is confidently expected that everything will be in readiness by that time. While the bridge is in this forward condition, the approach railways on each side are also being pushed rapidly forward, large staffs of men being employed by the contractors. The most serious engineering difficulty, perhaps, which has been encountered in connection with the railways is between North Queensferry and Inverkeithing, in consequence of the great masses of rock which exist there. At one point the cutting required is so deep that it has been resolved to construct a tunnel.

RADIAL DRILLING MACHINE.

CONSTRUCTED BY GEO. RICHARDS & CO., BROADHEATH.

The accompanying illustration shows one form of radial drilling machine, as constructed by Messrs. Geo. Richards and Co., engineers, Broadheath. The drill is driven by belt, without the intervention of gear, which gives a very smooth motion, without jar.



A counterpoise and lever allow of rapid adjustment of the drill when required, but the slow mechanical feed is also used, and the spindle frame is rapidly moved by rack and pinion. The machine is very neat, simple, and well designed.

COMPOUND LOCOMOTIVES.

At the ordinary meeting of the Institution of Civil Engineers, on Tuesday, the 8th of January, the President (Sir George B. Bruce) being in the chair, the paper read was on "The Compound Principle as applied to Locomotives," by Mr. Edgar Worthington, B.Sc., Assoc.M.Inst.C.E.

The author stated that the primary object of the various attempts which had been made during the last thirty-six years, and more especially within the last ten years, to apply the compound system to locomotive engines, was to expand the steam in the cylinder more than was commonly done at present, and thus to save fuel. In an ordinary engine, during the first portion of the forward stroke of the piston, the steam at, say, 180lb. pressure and a temperature of 379·7 deg. Fahr., was suddenly admitted to a cylinder at 253·9 deg., and instantly began to condense and lose its pressure. During the latter half of the forward stroke the water of condensation was re-evaporated into steam, which action continued during the return or exhaust stroke, extracting heat from the warm cylinder. If, on the other hand, steam at 180lb. were expanded through two cylinders on the compound system, with a receiver pressure of 80lb., the average temperature of the high-pressure cylinder would be 98 deg. above that of the low-pressure cylinder. Condensation and re-evaporation would still go on in each of these cylinders, but the steam at 180lb. pressure would, in one case, enter a warm high-pressure cylinder at 338 deg., and in the other a cool single cylinder at 253·9 deg., there being a difference of 84·1 deg. in the temperatures of the two cylinders in favour of the high-pressure one. The chilling action of the exhaust steam at 212 deg. would no longer be felt in this small cylinder, so that work would be developed in it before much steam could be condensed. The final exhaust steam could only draw heat from the low-pressure cylinder, the temperature of which would be 240 deg. ; whereas, in the ordinary engine before named, the single cylinder was maintained at the higher temperature, 253·9 deg., thus having more available heat to be extracted and wasted by its exhaust steam. It would also be noticed that the whole of the heat absorbed from the high-pressure cylinder by re-evaporation during the latter half of the forward stroke, and the whole of the return stroke of the high-pressure piston, would be utilised in maintaining the pressure in the low-pressure cylinder. From this point of view, therefore, less heat would be thrown away by re-evaporation in engines built on the compound system than in ordinary engines. The same reasoning might be applied to triple and quadruple expansion engines.

But the extremes of very early cut-off and multiple expansion in triple or quadruple cylinder engines were beyond the scope of practical locomotive engineering, where the limits of working had hitherto been found to lie within an eight-fold expansion and two cylinders.

After giving a historical account of the application of the compound system to locomotives, from the date of Mr. James Samuel's "continuous-expansion engines," in use on the Eastern Counties Railway in 1852, to the modern compound engines now being adopted in all parts of Europe, and specially noticing the share of Mr. Anatole Mallet in the general introduction of the system, the author proceeded to consider the proper capacity of the low-pressure cylinder in relation to the high-pressure one. Mr. Mallet, who had experimented perhaps more than anyone else on this question, stated in 1883 his conclusions that the low-pressure cylinder should have a volume at least double that of the high-pressure cylinder, which was confirmed by Mr. von Borries and Mr. Worsdell's practice. Mr. Webb adopted the larger cylinder ratio of 2 25 or 2·30 to 1, without inconveniently crowding the cylinders, and was thus enabled to obtain a higher ratio of expansion for the steam. Mr. Mallet had always preferred to make the point of steam cut-off in each cylinder variable, and he therefore employed two independent reversing gears. Mr. Webb's ingenious single-screw reversing gear allowed the steam cut-off in both high and low-pressure engines to be adjusted independently. Mr. Borodin fixed the cut-off in the low-pressure cylinder at from 70 to 73 per cent, and varied the speed of the engine by adjusting the high-pressure cut-off, and by the regulator. Mr. von Borries made the lifting links of different lengths, the difference being about 1/20 the total lift of expansion link. This gave a later cut-off in the low-pressure cylinder. There was one manifest objection to this simple method of permanently fixing the valve motion in order to specially suit the forward gear, namely, that the back gear was unavoidably changed for the worse.

All locomotives should be able to exert at starting their full tractive power. In the Worsdell and the von Borries types of compound locomotives a special starting valve was provided, enabling the engine to exert more power during its first revolutions than afterwards when in motion. There were certain positions in the three-cylinder compound engine when the high-pressure axle only was available for starting; but as a superabundance of power was brought to bear upon this one axle, owing to the absence of back-pressure in the receiver, the use of sand beneath the tread of the wheels might enable the engine to start at all times with a very heavy load. The high-pressure cylinder should be made about 1in. larger in diameter than the cylinders of an ordinary engine of equal power, even though an advance of 30lb. per square inch of boiler pressure was contemplated for the compound engine.

At very great speeds, where high expansive working was essential, compound engines used the steam more efficiently than simple engines, and under these circumstances appear to greater advantage than at low speeds. Indicator diagrams had been taken from Mr. Webb's engine, showing over 1,000 H.P., and Mr. Worsdell's passenger engine, with its ordinary average train, indicated 911 H.P. at 60 miles per hour.

A most detrimental steam wire-drawing took place at the edge of the slide valve itself; and as the low-pressure valves in compound locomotives must necessarily be very short compared with the diameter of their cylinders, the Allen, or double-ported, valve had been used to double the effective length of the steam admission port. In ordinary cases, the steam ports of slow-moving goods engines need not be so large as those of passenger engines running at high speed.

The receiver capacity of a two-cylinder compound locomotive, having its cranks at right angles to each other, should be not less than the capacity of the small cylinder; for it must be capable of containing at least one-half the small cylinder full of steam, discharged during the latter part of the stroke of the low-pressure cylinder, when the latter was not taking steam, as well as the steam which was left in the receiver after the previous stroke. The largest amount of work would be obtained from the expanding steam in a compound engine, if the cut-off in the low-pressure cylinder were permanently fixed at a point where the volume of steam admitted would be equal to the capacity of the high-pressure cylinder. This advantage, however, must be sacrificed; for it was more important to arrange the low-pressure cut-off, so as to divide the work equally between the two cylinders.

The use of high pressures in one cylinder, with a single slide valve controlled by any ordinary valve gear, was attended, at high speeds, by much loss of pressure, caused by throttling and condensation of the steam. Therefore pressures of 150lb. to 200lb. were worked most economically either by independent steam and exhaust valves, as in the Corliss engine, by double slide valves, employed on the Central Pacific Railroad since 1883, or, if ordinary locomotive valve gears were used, the steam must be expanded through more than one cylinder; that was to say, the locomotive must be compounded.

An average saving of 18 8 per cent was effected in fuel by the substitution of compound for ordinary engines, the boiler pressure being higher in the compound engine than in the ordinary engine.

The following minor advantages might be classed under this head:—

1. Prolonged expansion of steam in one cylinder was avoided; the high-pressure steam developed the first portion of its work in a very hot cylinder, and the latter portion in a cooler cylinder.
2. Re-evaporation was not so great as in an ordinary engine. Condensation took place chiefly in the cool low-pressure cylinder, and very little heat was abstracted by re-evaporation from the high-pressure cylinder.
3. Leakage at the pistons was reduced, the effective pressure per square inch on each piston being small.
4. High grades of expansion could be frequently used, without the wire-drawing action attending an early steam cut-off.
5. The wear and tear of the boiler was less, notwithstanding the higher pressure.
6. The force of the blast was lessened, and fewer sparks were drawn through the tubes and thrown from the chimney.

The boiler was required to evaporate only from 80 to 85 per cent of the water necessary for an ordinary engine to do the same work; and thus, of two boilers of equal size, the one on a compound engine was not driven so hard, and would, therefore, last longer, than the other on a non-compound engine.

Compounding, on the one hand, compelled a certain amount of expansion, and on the other allowed more than double the expansion possible in the ordinary engine. The blast-pipe could be made ¼in. or ¾in. larger in diameter, and, the beats of exhaust being lighter and reduced to half their previous number, the tearing action of the blast was diminished, especially at high speeds.

The pressure on the piston, and consequently the working strains throughout the machinery, were more uniform when steam was expanded through two cylinders than when the same ratio of expansion took place in one cylinder. In simple engines, working with high expansion, the pressure on the piston at the beginning of the stroke was greater than in the compound engine. This was the portion of the stroke when the progress of the piston was small, and the crank was doing the least amount of useful work; therefore, in a simple engine, the increased pressure at the beginning of the stroke, while creating a corresponding increase of friction on the crank pin, caused very little extra useful effort. Again, the sustained pressure during the stroke of the compound engine was advantageous, because, in the middle of the stroke, nearly all the pressure was transformed to useful effort, and a relatively small proportion was lost in friction. When at work, the effective pressure per square inch on the back of compound engine valves was less than that on the valves of ordinary engines, inasmuch as the sum of the pressures on the high-pressure and low-pressure valves could not together exceed the boiler pressure. But the full boiler pressure, and consequently heavier strains, were brought to bear upon the high-pressure valve and machinery, both when the locomotive was starting, and at other times, when the high-pressure and low-pressure engines were worked independently with live steam, admitted to the cylinders by means of the various automatic and non-automatic starting valves in use for that purpose. The more uniform distribution of strains enabled compound locomotives to run with exceptional steadiness. This result, however, might be partly due, in the German and in the three-cylinder compound engines, to the position of the cylinders, which were placed far back near the middle of the wheel base, where their disturbing influence was little felt; and also to the position of the large central low-pressure cylinder, the disturbing forces of which, though great, lay on the centre line of the locomotive. The increased power of starting a train belonged only to those compound engines fitted with one of the numerous intercepting or starting valves. The effect of these valves was to admit steam to both cylinders direct from the boiler, and at the same time to prevent this steam, so admitted to the large cylinder, from acting as back-pressure on the small piston. It was evident that a large increase of tractive power might thus be exerted at starting, which was useful in overcoming the friction of rest of a long train.

The adoption of high-pressure steam was attended by the following drawbacks: The boiler and all steam joints must be more carefully made. Only the better kind of lubricants were admissible, such as were not decomposed at the higher temperatures of this steam. The gland packings must be constructed to withstand heat, for which purpose several systems of metallic packing had given good results. For using very high-pressure steam in compound engines, it had been suggested that the first cylinder, which would be small, should be made of gun-metal or steel, because high-pressure steam corroded cast iron. Until suitable piston valves had been invented for the high speeds required by locomotives, these increased steam pressures might be dealt with by balancing the ordinary slide valves, a practice successfully carried out in American locomotives for the last eight years, and which was being revived in this country by Mr. Webb.

Large cylinders were an essential feature of the compound system. They were cumbersome, and had more cooling surface than small compact cylinders. Much valuable heat might be lost if the large cylinder were not carefully protected by wood, felt, or air jackets.

A large quantity of water of condensation might be observed in the chimney, thrown from the blast-pipe of the large low-pressure cylinder. At each end of this cylinder Mr. Webb and Mr. Worsdell placed safety valves, which relieved it of any undue pressure caused by the accumulation of water. This large cylinder might also be drained by cutting a groove in the low-pressure cylinder cocks, about $\frac{1}{16}$in. wide, to allow a constant leak of the condensed water.

The momentum of a piston, 26in. or 30in. in diameter, together with that of the other reciprocating parts of the large engine, caused severe strains, which must be provided for.

Those compound engines which had more than two cylinders, connecting rods, and valve gear, had a corresponding additional number of joints and wearing parts, and therefore required more oil than ordinary engines. In the two-cylinder compound system it had been shown that the pressure on the moving parts was not so great or fluctuating as on the corresponding parts of a simple engine; and it might therefore be expected that the compound engine would need less lubrication than the simple one. This, however, did not appear to have been confirmed in practice. Whether it was due to the use in the compound engines of higher steam pressures, or to the extra oiling given to a new and less understood class of machinery, it was difficult to say; but several instances had come under the author's notice in which two-cylinder compound locomotives had required more oil than simple engines doing similar work.

In the three-cylinder type of locomotive the low-pressure engine worked on an independent axle, and developed an irregular propelling power, which was felt throughout the train at starting; but as soon as a moderate speed was attained the pulsations, which corresponded to each stroke of the low-pressure piston, had little appreciable effect when the momentum of the train was great.

There was a danger in "over-cylindering" a compound engine; for, when running with a light load, such an engine might be obliged to expand its steam to below atmospheric pressure. On the other hand, with the 4ft. 8½in. gauge, the difficulty of placing the two cylinders between the frames limited the power of inside two-cylinder compound engines. It followed, therefore, that the same compound locomotive could not adapt itself so well as an ordinary engine to both light and heavy traffic.

It thus appeared that on long level roads, and with such regular loads as were found on the Continent and in North and South America, the compound system might prove more successful than in Great Britain, where inclines were more frequent, traffic more varied, and fuel cheap. The system had hitherto met with most favour and success in Germany and in England.

To save unnecessary expense, Mr. Mallet constructed his early compound locomotives as much like the ordinary locomotives as possible. There could be little doubt, however, that a compound engine, as constructed now, was a little more expensive in first cost than a simple engine of the same maximum power.

In the compound engine the boiler, steam pipes, joints, &c., must be made stronger, to resist the greater pressure, and extra precautions had to be taken to prevent radiation from the hotter boiler, the high-pressure cylinder, and from the increased surface of steam pipes where they were exposed. These extra items were to some extent balanced by the smaller size of boiler.

To roughly estimate the justification for adopting the compound system it might be interesting to compare the cost of fuel consumption by a compound locomotive with that of a simple engine, running, during one year, 20,000 miles, and burning 30lb. of coal per mile, which figures were slightly below the average for English railways.

Coal burnt in one year by an ordinary locomotive

$$= \frac{20,000 \times 30}{2,240} = 268 \text{ tons.}$$

Coal saved by compound, 15 per cent of 268 tons = 40 tons. Thus, in a country where coal costs 10s. per ton, £20 per annum would be saved. This represented interest at 5 per cent on a capital of £400, and if the cost of maintenance were the same in the two engines, and the lifetime of each were, say, twenty to thirty years, it might be concluded that, in a country where coal costs 10s. per ton, an extra outlay, not exceeding £400, would be justified in the price paid for the compound engine. Under the above conditions a two-cylinder compound would be very economical, but the saving of the more expensive three-cylinder compound would be about half swallowed up by the additional interest on its first cost, and it was not likely that the four-cylinder compound would be economical. The cost of converting ordinary engines into compound engines was greater than their difference of cost when both were new. A careful investigation into the cost of converting some small simple locomotives, on one of the Staffordshire tramways, to the compound system, showed that the value of the fuel thereby saved would not pay for the alteration in ten years. It was probably due to the enterprise of English and German locomotive engineers that the compound system had hitherto been introduced so successfully where coal was cheap. Its success under these conditions was the strongest argument in favour of introducing the system into foreign countries which imported coal from abroad, as, for instance, Northern India, where the price of Welsh coal was £2 14s. 6d. per ton.

In conclusion, it appeared that the compound principle, in its application to locomotives, had been attended by considerable saving of fuel, but that sufficient time had scarcely elapsed to prove the value of some of the other advantages claimed. Increasing the number of cylinders to three or four rendered it possible to construct extremely powerful locomotives. Certain minor difficulties, connected with the distribution of steam at low pressure, had not yet been entirely overcome in compound locomotives running at high speeds; but although the system might not be suitable for engines working intermittent slow heavy traffic, yet on main line trains, and in countries where fuel was dear, its advantages were well established.

ROBURITE.

The monthly meeting of the Manchester Geological Society was held at Wigan, on the afternoon of the 11th inst., and the use of explosives in mines was the subject of two papers, one by Mr. Grundy, inspector of mines, on the possible explosion of gunpowder, &c., in shot holes by the heating of the air owing to compression whilst the shot is being tamped, which he illustrated by the well-known laboratory experiment of flashing gunpowder in a closed cylinder on the sudden depression of a piston.

The principal paper, however, was by Mr. James Hilton, mining engineer, who described the different experiments that had been conducted by the Wigan Coal and Iron Company, Limited, in order to test the qualities of Roburite. It is claimed for this explosive that the gases (chlorine principally) generated by the explosion of Roburite will quench all flame. Mr. Hilton's experience, however, gained by the firing of over 3,500 shots, leads him to think that about one shot in a hundred either shows flame or sparks. This, whilst much superior so far as relative safety in blasting is concerned, is still far from perfection, and the explosive can by no means be described as "safe."

Roburite can only be exploded by a strong detonator, and is not liable to explosion from decomposition or sudden shocks; but it must be kept dry, as it loses power if allowed to get damp. Weight for weight, its power relatively to gunpowder is double in blasting coal; but in rock and metals it has from three to four times as great an effect.

It appears that Roburite cannot be handled with impunity, as several cases have been noted where contact with the hands of workmen has produced symptoms of poisoning.

The general opinion of the mining engineers present at the meeting was that Roburite, on the whole, was the best and safest of the high explosives now in use.

MATERIALS OF ENGINEERING.—X.

Copper.

The extraction of copper involves a troublesome and costly series of processes, the expenditure of coal alone amounting to something like eighteen times the weight of marketable metal produced. The necessity for this lies in the numerous foreign elements which occur in the copper ores, and which have to be removed by distinct successive operations; elements, too, which if allowed to remain even in very minute quantity in the metal, have a most deleterious influence upon its qualities and usefulness. Moreover, the different ores of copper, having different chemical compositions, require distinct methods, or variations in treatment, some ores being in the main oxides of copper, others containing a large quantity of sulphide, &c. Speaking generally, the processes employed consist of a succession of calcinations and meltings on the hearths of reverberatory furnaces of special types, as follows:—

In grey copper ores there are copper, iron, sulphur, antimony, and arsenic, present in variable proportions. The object of the preliminary roasting or calcination is to expel the arsenic and sulphur, and change the condition of the iron. The calcination is performed in a reverberatory furnace having a hearth of large area, over which the fuel and ore, broken into small fragments, are spread. Special management of the furnace is necessary, to prevent the heat from attaining the melting point. The roasting continues for about twelve hours, during which period the arsenic combines with oxygen to form arsenious acid, and a portion also of the sulphur with oxygen, to form sulphurous acid; each of which pass away as vapour. A large portion of the iron takes up oxygen, becoming an oxide of iron, and some portion of the copper also forms, with oxygen, suboxide of copper.

In a second stage of the smelting operations, which is performed in a smaller reverberatory furnace, called an ore furnace, the oxide of iron last formed is removed as a ferrous silicate, and the copper present is melted and tapped as a matt, or regulus of "coarse metal," containing, however, only a small proportion of metal.

The methods by which the oxide of iron are removed vary; copper ores containing quartz are sometimes introduced for that purpose. A basic slag (metal slag), from a later stage in the process of copper smelting, is also introduced to assist in fluxing the silica in the ore. Sometimes fluor spar is added.

The regulus of coarse metal, granulated at the time of pouring by being passed through the perforated bottom of an iron box, through which water is kept running, is returned to the calcining furnace and re-roasted to remove more of the sulphur still present, as sulphide of copper. The resulting product is again fused with suitable slags and ores, and the next product is a "fine metal," containing something like twice the percentage quantity of copper present in the "coarse metal," its amount varying from 60 to 80 per cent, specific names, as "blue metal," "white metal," "pimple metal," indicating certain appearances corresponding with varying percentages of copper.

In the next process, the blue metal, in the form of pigs, is introduced into a reverberatory furnace and roasted, to convert the sulphide yet present into oxide. After this is effected, the temperature is raised to the fusing point, sulphurous acid gas escapes, and the metal is run into sand moulds, yielding "blister copper," the blistered appearance being due to the continued escape of the gases during solidification.

The blister copper is still highly contaminated with foreign matters, and the ingots are now arranged in a reverberatory furnace, and roasted for several hours, during which period, oxidation of sulphur, arsenic, tin, lead, &c., goes on. Subsequently, it is melted on the same hearth, the surface being covered with wood charcoal to prevent excessive oxidation of the copper itself, and the metal is "poled," that is, stirred with a stick of green wood. The heat of the metal produces the evolution of combustible gases from the wood; these unite with the oxygen which is present in the copper in the form of suboxide, and remove it, leaving the metal fully reduced. An almost infinitesimal proportion of oxygen present suffices to render the copper brittle. The metal is now "tough cake copper."

I have treated the preparation of copper at considerable length to show the difficulties which attend the extraction of pure metal. Both for constructive and electrical purposes pure copper is of the first importance. It is a metal which is fully as susceptible to the presence of small percentages of foreign ingredients as iron or steel. After iron or steel, it ranks as the most valuable metal employed by engineers. In its pure state, and alloyed in the various bronzes and brasses, its uses are practically unlimited.

Of pure copper there is little to note. It is mainly used by engineers for locomotive fire boxes, pump rods, pipes, and bolts. Even for fire boxes it is now being largely superseded by mild steel. Its tensile strength is low in comparison with that of steel, being about 12 or 14 tons per square inch, and, moreover, this strength diminishes very rapidly with moderate increase in temperature, in this respect contrasting unfavourably with wrought iron and steel. Copper, in being heated from the freezing point to the boiling point of water, loses 5 per cent of its strength, and at 550 deg. F. it loses about 25 per cent. On the other hand, copper does not become incrusted to the same extent as iron, it is a better conductor of heat, and by virtue of its better ductility it is enabled to sustain, without injury, the strains due to the action of extreme changes in temperature.

Copper can be worked either hot or cold; cold rolling and hammering renders it hard and brittle, but its ductile condition is restored on annealing. Cast copper is always very much honeycombed, unless poured under the pressure of head metal. I have seen cast copper used thus for lining friction cones. The addition of a very little zinc will diminish the amount of honeycombing.

Cast copper is weak, its tenacity ranging from 8·5 to 11·2 tons. The strength of forged copper increases very much with the addition of phosphorus, having, according to Dr. Anderson, a tensile strength of 22·32 tons, when ·04 per cent of phosphorus is added.

The terrible explosions of copper steam pipes on board the Elbe, Lahn, and Konvoy, in 1887, were the means of causing a series of most searching investigations to be undertaken on the behaviour of that metal, under conditions involving heating and brazing. The tests proved clearly the evil results of overheating on copper, rendering the otherwise fibrous and ductile material granular, brittle, and discoloured. In the case of the Elbe pipe, while the metal in its normal condition showed a tenacity of 33,000lb. per square inch, with an elongation of 33 per cent in 5in., the pieces cut from near the brazed seam gave a tenacity of only 24,418lb., and an elongation of only 4·6 per cent. The fact that the Elbe pipe burst at a pressure less by one-half than that which it had safely borne by cold water test simply illustrates the well-known fact that the strength of copper is very injuriously affected by the action of heat.

Although the deposition of copper by electricity has been practised for many years in the arts, its application to purposes of engineering has usually been deemed impracticable by reason of the want of cohesion present in copper so deposited. But the desirability first of obtaining a material perfectly homogeneous, and of abandoning the injurious practice of brazing, have emphasised the necesssity of employing, if possible, the methods of electro-deposition in the formation of seamless copper pipes.

Mr. Elmore, of London, has succeeded in manufacturing these. He deposits the copper electrolytically on a revolving mandrel, continuing the process until the required thickness is attained. To increase its density, tenacity, and ductility, he employs the pressure of an agate burnisher, traversed from end to end of the tube by suitable mechanism. Every separate film of copper is thus compressed.

In tests performed for Mr. W. Parker, of Lloyd's Registry, on electrically deposited, on solid drawn, and on sheet copper pipes of equal size, the bursting strengths were respectively 3,450lb., 2,200lb., and 2,200lb. per square inch. The tensile strengths of strips cut therefrom were, at atmospheric temperatures, 23¼ tons, 20¼ tons, and 14 tons per square inch respectively.

The substitution of electrolysis for the uncertainty of brazed joints will, if it becomes general, be useful in more ways than one. It is well known that small quantities of foreign matters, as arsenic, bismuth, and antimony, very injuriously affect the strength of copper. The one-thousandth part of antimony will alter the best selected copper into the worst conceivable. Mr. Preece has stated that a telegraphic cable, as now made, of comparatively pure material, will carry twice as many messages as a cable made in 1858, of the less pure material then in use. There is an ever increasing demand for electrically deposited copper for telegraphic and electric lighting purposes, and the use of the burnisher will probably entirely obviate the necessity for melting and casting the deposited metal previous to wire drawing, as has hitherto been the practice. J. H.

Construction of a New Warship.—The Admiralty have decided on building another large and powerful armoured ship at Chatham Dockyard, plans for which are now in course of preparation. The work to be carried out at Chatham during the ensuing year will, it is expected, necessitate a considerable addition to the dockyard employés.

AN ENGINEER'S LIFE AT SEA.—XXI.

BY A SEA-GOING ENGINEER.

In preparing for the Board of Trade examination, one of the text books published for the purpose of assisting the student is indispensable. Of these there are several, each excellent in its own way. Besides exercises in arithmetic, these books give also many valuable practical hints. By carefully going through one or more of these, an intelligent and experienced engineer will have little or no difficulty in getting his "ticket." As to whether the applicant should or should not go to a tutor before trying to pass depends greatly on his acquirements and his temperament. Some who are backward in their studies find a tutor invaluable, while others, more proficient, by joining a class get more self-confidence. An engineer well up in figures may yet find profit of another kind by joining, for by conversation with his fellow-students he may get much useful information about some class of engines he is not familiar with. Besides this, the teachers usually can out of their experience give a shrewd guess as to the questions likely to be put. Of course to men strongly self-confident such hints as the above are hardly needed, but in all ordinary cases it will be found the safest plan to join a class before "going up," even as a matter of ultimate economy.

Information regarding the knowledge required can be got from the text books, but in any case a mathematical training is not required, though always of advantage. Arithmetic up to decimals and to the extraction of the cube-root, the ability to make rough working drawings of the principal parts of his engines, to be able to calculate steam valve pressures and to interpret indicator diagrams, as well as familiarity with all the other duties of an engineer, are the main requirements in order to pass as chief engineer. For calculations of all kinds the student will find that an intimate acquaintance with the rule of three will enable him to solve numberless problems, for its applications are infinite. It may be noted in passing that though not by any means required for these examinations, nothing can be of more value to a mechanic than some knowledge of simple equations. The stating of questions frequently leads to much mental labour, and at the end the calculator is not sure if he should not have multiplied by a certain figure instead of dividing by it, and perhaps is in doubt as to whether addition was not needed where he used subtraction. The stating of mechanical questions is sometimes very puzzling in practice, and even though the engineer may be able to work them readily when stated, yet a slight knowledge of algebra enables the formulæ to be both made and handled with ease. Such knowledge is, however, not needed in order to pass the Board of Trade.

Every opportunity must also be taken of getting practical knowledge. Instead of despising uneducated engineers because they cry out against book-learning, which they are without, a little tact will often draw practical information from them, and even their "rule-of-thumb" working should be closely watched, that it may be understood, and improved upon, if possible. Book-learning without practical insight is as useless as practice without education in getting a man past a Board of Trade examination, and an engineer must, therefore, see that his training is an all-round one.

The examination day has been so long looked forward to, that it is almost a relief when it actually comes, for so much the sooner will it be over. But yet the engineer will feel a sudden and surprising sympathy for all captured criminals, as he, with others, goes to meet his fate. He now makes the acquaintance of the curious examination nerve, which is said to begin at the head, to wind round and round him in a spiral, while he feels it tingling at all his extremities. The very doorkeeper is looked on with respect, and the inoffensive examiners become as awe-inspiring as inquisition judges.

Before the examination paper is put before him, the engineer will, if of nervous temperament, be putting all sorts of questions to himself, selecting with surprising ingenuity all those to which he does not know the answer, and by the process making himself supremely uncomfortable. When the paper is put before him he should look through all the questions before answering any, and will doubtless be rejoiced to find that they are old familiar friends when narrowly scanned. If this should not be so, he will probably find that a little patience and care will give a key to problems which, at first sight, seemed impenetrable. In any case, he is not obliged to answer all the questions correctly in order to pass, and, as a rule, these examination questions are so arranged that everyone who has spent time and care in preparation will be sure to succeed. Even men who are very backward in figures may on one of the following days display such practical knowledge of their engines that they get through, or, if turned back, a little further practice with figures may be all that is required before coming up again for examination. A man may show such dogged resolution by coming up again and again, that he will win the respect of his examiners, and be let off easier than he would otherwise be. One good feature of these examinations is, that they are not competitive, for it is the passing of a fixed standard, not the passing of one another, which ensures success. It is said that this standard is steadily rising year by year, but this it is only reasonable to expect.

By some the verbal part of the examination is most dreaded, though the self-confident but half-educated man fears the figures most. With the verbal much depends on keeping cool, but as the examiners are only human beings after all, they take into account the applicant's trepidation, and try to put him at his ease, for they know that the best stored mind is liable to become a sudden blank with a nervous individual. As, however, excessive nervousness might in another way prove a serious drawback to an engineer in an emergency, he will sometimes be tested by "catch questions." For instance, one engineer was asked what should be done with a badly leaking boiler at sea? The answer being rightly given, the question was then narrowed by making the conditions more stringent. Again answered, it was again narrowed. The applicant, who had exhausted his ingenuity on the other cases, was now brought to a stand. The ceiling and the floor of the torture chamber, with all the objects around, impressed themselves indelibly on his memory, while in the silence that ensued he looked longingly round for his hat. A gentle smile stole over the face of the examiner, as he stated that in his opinion nothing could possibly be done, while to the relieved applicant was at the same time handed a paper authorising him to get his "second's ticket." A somewhat similar instance is given of one who was asked what would he do if the donkey pump failed to pump from the sea. Having verbally overhauled it, with all pipes and connections, and still being asked for another cause, he answered, hopeless of passing, that he would go on deck and look over the side and see if there was any water to pump. One engineer was asked how many cocks and valves there were about an engine. He stated a certain number, and stoutly maintained that there was exactly that number, no more and no less. Then it transpired that he had been on one steamer all his time, and, having counted the number there, could not be persuaded that it differed on other ships. He got his certificate. In one case the giving of correct answers to unexpected questions about the flanging and riveting of a marine boiler passed a candidate for chief. Sometimes it is skill in making working sketches, and sometimes readiness in interpreting diagrams, or a knowledge of the qualities of different kinds of coal, that will turn the scale in the applicant's favour. For a "second" the examinations are much less exacting.

THE NEW EXPLOSIVE BELLITE.*

Mr. Carl Lamm, the inventor of bellite, has experimented with it in the Argenteuil quarries. It is composed of four to five parts by weight of ammonium nitrate, and one part of dinitro-benzene. The powder is pulverulent, yellowish, almost dry to the touch, and has the taste and smell of the ammonium nitrate of commerce. In the first experiment, a cartridge of compressed bellite, weighing $2\frac{1}{5}$lb., placed on a block of stone, was exploded by a detonator containing $7\frac{3}{4}$ grains of fulminate of mercury. A violent detonation took place, with the production of white smoke, and the block was broken, showing that bellite can be exploded in the open air by a small charge of fulminate. The second experiment consisted in exploding five blasting holes, $1\frac{1}{2}$in. in diameter, and from 2ft. to $11\frac{1}{2}$ft. long, filled with charges of from a little less than 1oz. up to $2\frac{3}{4}$lb. of bellite rammed in hard. All the blasts gave good results; and though the charges were just half the weight of the requisite charges with blasting powder, they could have been reduced without affecting the results, which show that bellite acts like a good slow powder in blasting, and does not crush up the rock. A tin box containing $1\frac{1}{10}$lb. of bellite was placed, in the third experiment, between two ordinary iron rails, $2\frac{2}{3}$ft. long, and when exploded with a detonator of $7\frac{3}{4}$ grains, with a Bickford fuse, the rails were shattered into minute fragments, projected a considerable distance. It is estimated that about 3oz. of bellite would suffice for breaking a rail.

A shell weighing 55lb. was next filled with $3\frac{1}{3}$lb. of bellite, and exploded with a detonator; and, from the weight of several fragments picked up, it is reckoned that the shell was shattered

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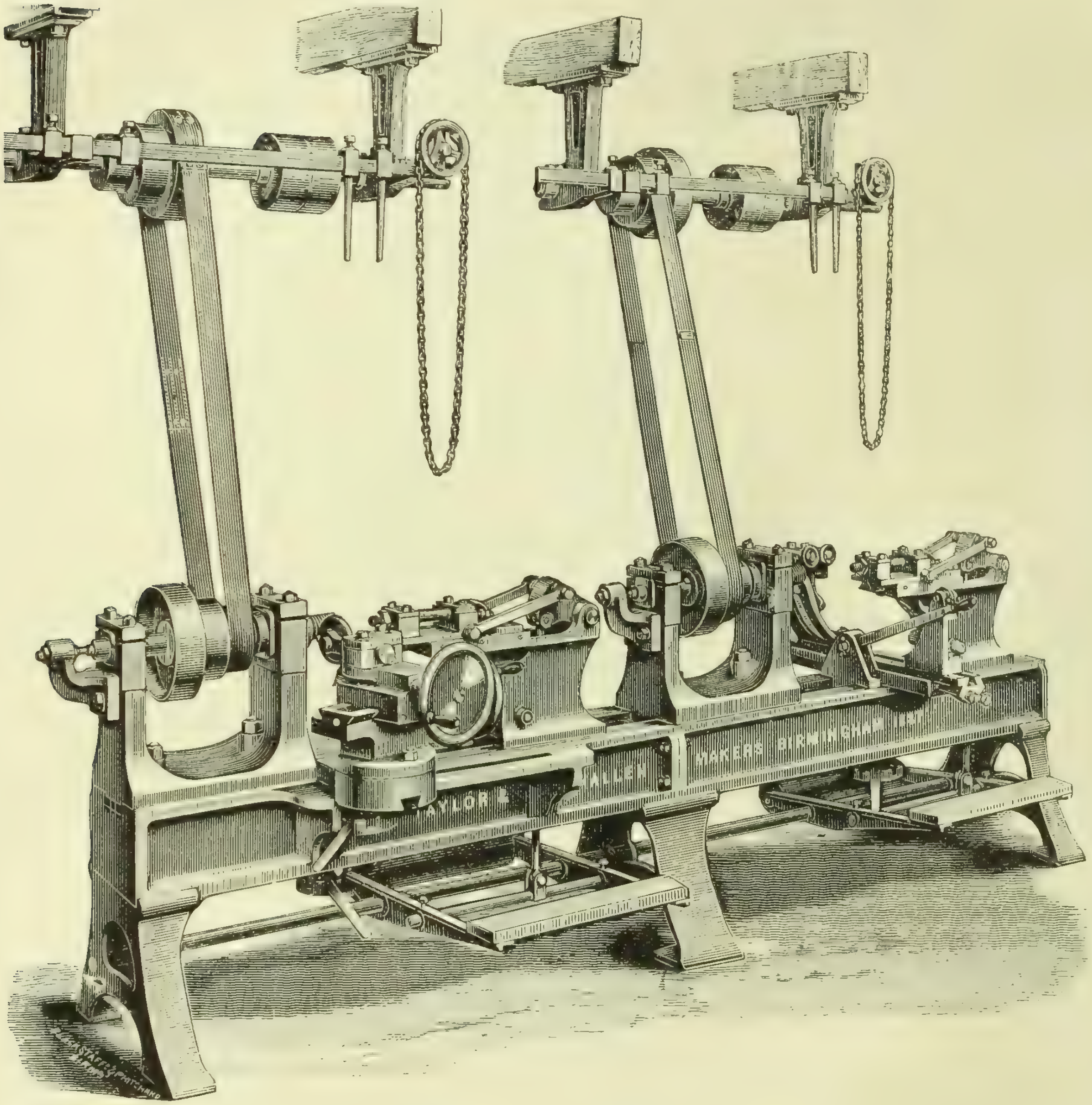
* Foreign Abstracts, Proc. Inst. C.E.

IMPROVED DOUBLE LATHE FOR SPINNING AND WIRING.

CONSTRUCTED BY MESSRS. TAYLOR AND CHALLEN, ENGINEERS, BIRMINGHAM.



by the explosion into over 350 pieces. An oval bomb of tin, filled with 5lb. of bellite, was then placed in an underground hole at a depth of 5ft. The explosion sent a shower of earth and stones 26ft. to 33ft. up into the air, and to a distance of over 100ft. The conical hollow funnel formed by the explosion had a diameter of $11\frac{1}{2}$ft. at its widest point; and the effect produced was equivalent to the estimated effect of a charge of blasting powder three times as great. Lastly, to test the behaviour of bellite under blows and in the fire, pieces of bellite, about 1oz. in weight, when hit violently on a rail with a $6\frac{2}{3}$lb. hammer, were crushed without exploding; and pieces of bellite cartridges, and handfuls of bellite in powder, when thrown on the fire, melted and fused without detonation, resembling in this respect ammonium nitrate. Bellite is evidently quite as powerful as dynamite No. 1; and its simple composition, its security, and its effects, render it an important rival to all nitro-glycerine explosives. Its gradually increasing effect, like the best slow powders, will render it very valuable for coal-mining; and it is probable that, owing to the large proportion of ammonium nitrate in its composition, it will produce very little flare in blasting.

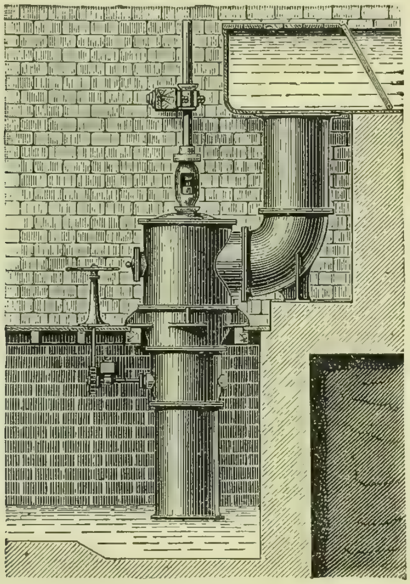
IMPROVED DOUBLE LATHE FOR SPINNING, &c.

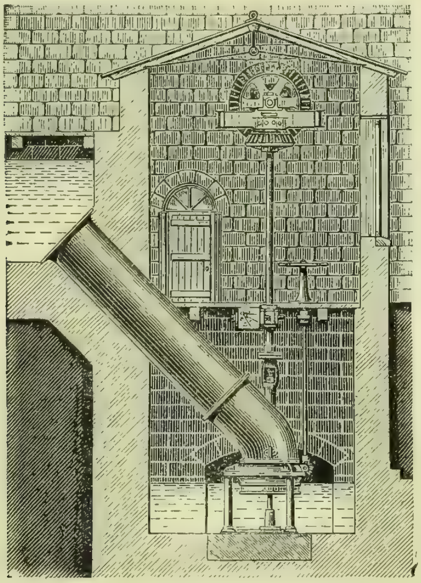
We illustrate above an improved form of double lathe for metal spinning, wiring, trimming, &c., as adapted to Birmingham trades. The compound slide rests, it will be observed, are of very massive proportions, and are most conveniently arranged for their special work. The substitution also of a reciprocating movement instead of the usual rocking one in the rest for trimming and wiring, seems to us a distinct advantage. It is a 15in. centre lathe, and is capable of accomplishing much heavier work than is usually possible with tools of similar dimensions. The loose heads are fitted with an improved treadle action, and the overhead gear is arranged to transmit ample driving power.

Telegraphs in Japan.—The telegraphs of Japan have attained to a total length of more than sixteen thousand miles, connecting every town and village of any importance with the capital. These are all worked by the Government, the operators being trained in special schools at the expense of the State.

JONVAL TURBINES.

Turbines have long been a favourite subject of investigation and discussion to engineers and mathematicians. The problems presented are so varied and interesting, and the combinations of impulse, pressure, inward flow and outward flow, give such scope for fascinating discussion and difference of opinion on points of detail, that many forms have arisen, had a more or less brief existence, and have disappeared. Of the numerous wheels described in Rankine's great work, few have survived the ordeal of time and use. Among the most vigorous survivors, however, are turbines of the Girard and Jonval type; the first representing what is best of the impulse class of machine—that is, a machine where the water to be used arrives at the guide ports with the full velocity due to its head, and acts almost solely by the impulse given, due to that velocity. The second represents what is best in the pressure type, and in it most of the weak points of such machines have been eliminated by long years of practical working. We illustrate here two modifications of the Jonval type, as constructed by Mr. W. Günther, of the Central Engineering Works, Oldham. The first is vertical, with suction below; the second is also vertical, but without suction—that is, it acts with a free discharge. We are given to understand that Mr. Günther has several in progress now of this type, and capable of developing 300 H.P. Various methods of governing are used, according to circumstances. The first is shown as governed by throttle valve; the second by adjusting the guide ports; both are actuated above. All may be controlled by a centrifugal governor, similar to that illustrated by us in a recent issue. In Jonval machines the efficiency is high, but not so good as in the Girard with reduced flow. It is a most difficult matter to arrange a wheel to give great efficiency under varying conditions, but that is a circumstance common to most forms of motive power.





ALLOYS: THEIR CONSTITUTION AND PROPERTIES.—IX.

Throughout Japanese art metal work, in which I hope you will take increasing interest, there is the one principle of extreme simplicity and absolute fidelity to nature. The brilliant metals, gold and silver, are used most sparingly, only for enrichment, and to heighten the general effect; these precious metals are never allowed to assert themselves unduly, and are only employed where their presence will serve some definite end in relation to the design as a whole. A Japanese proverb asserts that "He who works in gold puts his brains into the melting-pot," meaning, I suppose, that this metal, so precious from an artistic point of view, demands for its successful application the utmost effort of the workman, and suggesting that gold should not be employed in massive forms such as would result from melting and casting, but should be daintily handled, beaten on the work or embedded with the hammer.

Bear in mind that in Birmingham, when a really fine work is produced in silver, the surface is often made grey by chemical means—"oxidised," as it is termed—and this subordination of the brilliancy of silver to artistic effect is well understood by the celebrated American firm, Messrs. Tiffany, of New York, who are doing so much to catch the spirit of Japanese art metal work. All I ask artists to do is to carry this still further—to cover base metals with these glowing coloured oxides, and thus to add to the permanence of art work, by producing surfaces which will resist the unfavourable atmospheric influences of our cities.

The Oriental art metal workers often blend metals and alloys of different colours by pouring them together at a temperature near the solidifying point of the more infusible of the metals and alloys to be associated. In this way, by pouring the comparatively fusible grey silver-copper alloy on to fused copper which is just at the point of "setting," the metals unite but do not thoroughly mix, and a mottled alloy is produced. The Japanese use such alloys in almost every good piece of metal work.

The art of complex casting has been practised in India for a thousand years or more, almost exclusively in the Presidency of Madras, as I am informed by Mr. C. Purdon Clarke, C.I.E., to whom I am indebted for the image of Hanuman (fig. 4), the monkey ally of the god Rama. It was analysed in my laboratory at the School of Mines by Mr. Arthur Wingham. The face, legs, and arms are of rich bronzed copper, while the dress is of yellow brass, the metals being so skilfully blended that no signs of joins or added pieces can be detected. A section cut vertically through the figure revealed the fact that the brass had been cast over a roughly-fashioned solid core of copper, which is less fusible than brass. This investing layer of brass could be readily cut away, and finished so as to leave only the dress and delicate anklets and bracelets on the copper limbs. The method of *cera perduta* was probably used in the production of such castings.

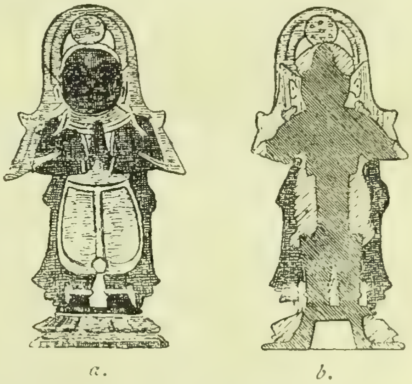


Fig. 4.

(*a*) Image of Hanuman in copper and brass. The dark cross lines of the section of the figure (*b*) indicate the relation of the copper core to the investing layer of brass, which is marked with lighter section lines.

Hitherto we have considered the union of metals by fusion, but fire is not the only agent which can be employed for this purpose. Two or more metals may be deposited side by side by the aid of the electric battery. Birmingham was, as you well know, the early home of electro-metallurgy, an industry to the development of which the great firm of Elkington has so materially contributed. I have no statistics as to the amount of precious metals annually employed for electro-deposition in Birmingham, but it is known that a single works in Paris, belonging to M. Christofle, deposits annually six tons of silver, and it has been estimated that the layer of silver of the thickness actually deposited on various articles would, if spread out continuously, cover an area of 140 acres. I will not, however, dwell upon the deposition of gold and silver in their normal colours. I would remind you that copper and zinc may be deposited by electrolysis so as to form brass, and that all the beautiful bronzes and alloys of the Japanese can be obtained by galvanic agency; and further, by suitable admixtures of gold, silver, and copper, red gold, rose-coloured gold, or green gold may be deposited, so that the electro-metallurgist has at his command the varied palette of the decorative artist.

[The images of beautiful deposits of coloured gold, specially prepared by Messrs. Elkington, were then produced on the screen.]

I ought to allude to what has been called the moral aspect of colour; and although I cannot follow Goethe in his attributes of colour, which seem to me to be fantastic and overstrained, I quite recognise the poetic sympathy of Shakspere in making Bassanio select the casket of lead which contained the warrant for his earthly happiness, because "its paleness moved him more than eloquence." I ask you to remember Ruskin's words, that "all men completely organised and justly tempered enjoy colour: it is meant for the perpetual comfort and delight of the human heart; it is richly bestowed on the highest works of creation, and the eminent sign and seal of perfection in them being associated with life in the human body, with light in the sky, with purity and hardness in the earth; death, night, and pollution of all kinds being colourless."

I must briefly turn to the concluding part of our subject. It has long been known that thin films of certain metals and certain metallic oxides act on light in the same way as thin films of other translucent substances; and since this lecture was originally delivered, at Birmingham, Dr. A. Kundt has published a very interesting paper to which reference should be made. He has with great care and difficulty prepared sufficiently thin transparent metallic prisms, and by their aid has determined the mean refractive index for seven metals, and for six of them the direction and approximate value of the dispersion. Dr. Kundt has been led to the conclusion that "the velocity of light in the metals stands in close relationship to their power of conducting electricity and heat; for in respect to the velocity of light the metals range themselves in the same order as in respect of their conductivity for electricity and heat." The important generalisation that alloys conduct electricity and heat in the same order I have already referred to in the first lecture.

I have here thin films of oxide of lead, which, many years ago, Nobili, Bacquerel, and Gassiot taught us to deposit, and such films have since been used in decorative metal work.

[Carefully prepared examples of such films were projected on the screen.]

I wish I had time to point to the great interest and importance of films of coloured oxide of iron in the tempering of steel, for it is well known that, apart from the scientific interest of the subject, the shades from straw-colour to blue which pass over the surface of hardened steel when it is heated in air afford precious indications as to the degree of temper the metal has attained, and in no industry is this better shown than in the manufacture of steel pens. I must pass this over, and turn to one other instance of the formation of coloured films on metals.

Here is an ordinary plumber's ladle (fig. 5) filled with lead, which will soon be molten when it is placed over this flame. The air will play freely on the surface of the melted lead, and as a certain temperature is reached very beautiful films will pass over the surface of the metal. If the lead contains very minute quantities of cadmium or antimony, the effect will be greatly heightened. If the light from the electric lamp be allowed to fall on the surface of the bath of lead, it will be easy to throw the image of the metallic surface on the screen, and you will see how beautiful the films are, and how rapidly they succeed each other when the metal is skimmed. What, then, is the special significance of the experiment from our point of view? It represents in a singularly refined way the one experiment which stands out prominently in the whole history of chemistry; for the formation of a coloured scum on lead when heated in air has been appealed to, more than any other fact, in support of particular sets of views, from the time of Geber in the 7th century to that of Lavoisier in the 18th. It was the increase in the weight of the lead when heated in air that so profoundly astonished the early chemists; and finally the formation of a coloured oxide by heating lead in air was the important step which led Priestley to the discovery of oxygen; and Birmingham may claim to have been connected, through him, with one of the most splendid contributions ever offered to chemical science.

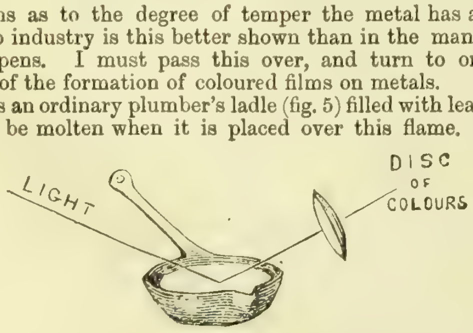


Fig. 5.

I have tried to set before you many of the more important facts which have been deduced from modern researches on alloys, but it has not been possible in this brief course of lectures to deal with the results of the very promising and fruitful thermo-chemical method of investigation, and which have enabled a distinction to be made between true combinations of metals with each other and mere mixture or solutions of metals. The following is an outline of the principles by which experimenters have been guided. When a chemical compound is formed, heat is evolved and energy is lost. If, on the other hand, one metal simply dissolves another, the solution would be attended with absorption of heat, and that product, when attacked by a suitable reagent, should liberate practically the same amount of heat, but certainly not less than would be evolved by the individual metals present in association. Proceeding on such a basis, Berthelot, whose calorimetric method is well known, examined amalgams of sodium and potassium with mercury. Troost and Hautefeuille, by attacking carburised iron with chloride of mercury, and measuring the heat liberated, showed that the carbon in cast iron and steel was probably dissolved, and not combined, a result of great importance. Recently M. Joannis, by decomposing alloys of potassium and sodium by water in a calorimeter, has been led to the conclusion that the alloy NaK_2 is the only one of the potassium-sodium series which is a true compound.

The guidance of the well-known law of Dulong and Petit has been valuable in examining the constitution of alloys, and it has, moreover, long been recognised that the specific heat of alloys approximate to the means of those of their constituent metals. Recently M. Pionchon has shown that the specific heats of alloys of platinum containing 10 per cent of iridium, and of platinum containing 12 per cent of palladium, bear out the view that the metals are simply mixed. On the other hand, Pionchon and Châtelier have, independently and by different methods, shown that at a temperature of about 700deg.C. iron passes into an allotropic state, and Osmond has further proved that in carburised iron a change in the relation of the carbon and iron takes place during its cooling from a high temperature. The evidence as to molecular change in metals is thus being made very clear, and it is to be hoped that by adopting such methods it will be possible to trace many cases of the passage of alloyed metals into allotropic states.

The Strength of Ropes.—The quality of workmanship, strength, extensibility, and elasticity of round and flat ropes of hemp and aloe, and of iron and steel wire, have been experimentally investigated by A. Duboul, and the results of his experiments published in the "Bulletin de la Société Encouragement des Arts, Paris." In his experiments M. Duboul used a horizontal hydraulic press and a weighing apparatus consisting of a steelyard and sliding weight, by which tension of from 130,000lb. could be recorded. For higher pressures a gauge on the body of the press was used. Specimens were fastened by winding each end on a grooved pulley of special construction. The usual length of specimens for testing was 13ft. The results of all the tests gave for the average tensile strengths of ropes, in lbs. per square inch, the following: White hemp, 10,500 to 11,200; tarred hemp, 7,700 to 8,400; white Manilla, 9,800 to 10,600; white aloes, 5,600 to 7,000; flat, tarred hemp or Manilla, 7,800 to 8,400. A factor of safety of four, or even three in some cases, is considered safe ropes. A rope of unannealed wire has an ulimate tensile strength of about 55,000lb. per square inch of section of metal; when annealed the ultimate strength is reduced to about 45,000lb., but the elongation is nearly doubled, being 12 to 15 per cent in annealed wire. The best wire ropes for mining purposes have a much higher tensile strength. Another writer on the same subject says that the tensile strength of a wet rope is only one-third that of the same rope when dry, and that a rope saturated with soap or grease is still weaker

BELT AND ROPE GEARING.—II.

Co-efficients of Friction.

The value assigned to μ, the co-efficient of friction, ranges, according to the different authorities, from—

μ = ·28 to μ = ·423 for leather belting, running on cast-iron pulleys, under ordinary conditions of working;
μ = ·47 to ·50 for leather belts on wooden pulleys;
μ = ·50 for hemp ropes on wooden pulleys
μ = ·28 for hemp ropes on a metal pulley;
μ = ·25 for a wire rope on leather or gutta-percha;
μ = ·15 for a wire rope running on the bottom of a grooved pulley.

With the aid of a model I have obtained the following results when $\theta = 3·1416$, *i.e.*, 180 deg.:—

Leather belt on iron pulley, $r = 2·75$, so that μ = ·325;
Dick's (gutta-percha and canvas) belt, canvas side to face of pulley, $r = 5·$, so that μ = ·515;
Dick's ditto, gutta-percha side to pulley, $r = 11·$, so that μ = ·75.

Note.—It should be observed that in rope driving, where the rope is run in a V groove turned in the rim of the pulley, the co-efficient of friction, μ = ·28 (hemp rope), *virtually* becomes

$$\mu_I = \mu \times \text{cosecant}\,\frac{\phi}{2} \qquad (9)^*$$

where ϕ equals the angle formed by the two sides of the groove.

This is due to the fact that the pressure between the rope and the pulley is artificially increased, and becomes much greater than the force pressing the rope *into* the groove; therefore the resistance to slipping is greater (see fig. 1 and footnote to formula 9).

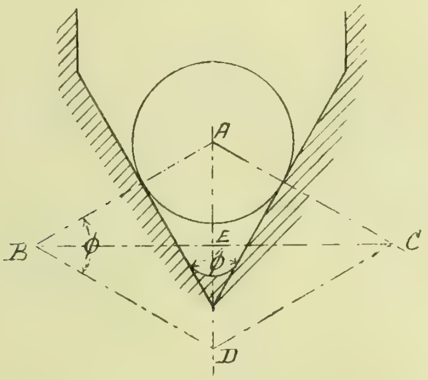


Fig. 1.

The following are a few values of the increased co-efficient μ_I, as applied to ropes working in V grooves, when the ordinary co-efficient of motion μ for hemp ropes on iron is taken as μ = ·28. When

ϕ = 40 deg; μ_I = ·28 × 2·9238 = ·82
,, = 41 deg.; ,, = ·28 × 2·85545 = ·8
,, = 42 deg.; ,, = ·28 × 2·7904 = ·78
,, = 43 deg.; ,, = ·28 × 2·7285 = ·76
,, = 44 deg.; ,, = ·28 × 2·6694 = ·74
,, = 45 deg.; ,, = ·28 × 2·6131 = ·73
,, = 46 deg.; ,, = ·28 × 2·5593 = ·71
,, = 47 deg.; ,, = ·28 × 2·5078 = ·7
,, = 48 deg.; ,, = ·28 × 2·4586 = ·69
,, = 48 deg.; ,, = ·28 × 2·4114 = ·67
,, = 50 deg.; ,, = ·28 × 2·3662 = ·66

The following is a method of *determining the value of θ, the amount of arc embraced by the belt.*

In fig. 2 it will be seen that the belt embraces an arc on the smaller pulley represented by the angle AGO. In order to find the value of this angle, it is necessary that we should know the respective diameters of the pulleys, as well as their distance apart. Then the most ready method of arriving at the required result is to first find the value of the angle AGD, and then to subtract twice its value from two right angles, or 180 deg.

For an *open* belt, as in fig. 2, the value of the angle AGD may be found from the formula—

$$\textit{sine}\text{ of angle AGD} = \frac{\textit{difference}\text{ in the diameters of pulleys}}{\text{twice the distance apart}} \qquad (10)^\dagger$$

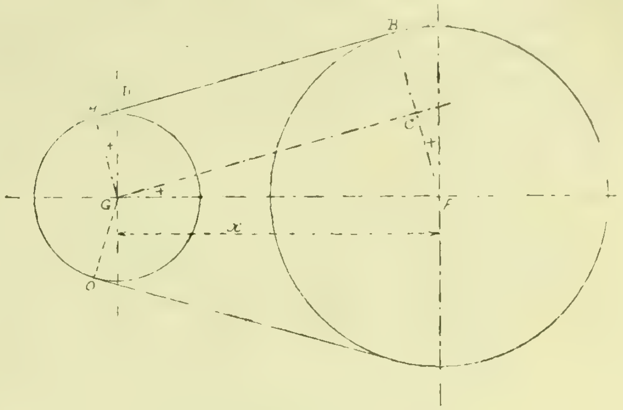


Fig. 2.

For a *crossed* belt, as in fig. 3, the formula becomes—

$$\textit{sine}\text{ of angle LKM} = \frac{\textit{sum}\text{ of the diameters of pulleys}}{\text{twice the distance apart}} \qquad (11)^\ddagger$$

Twice the angle thus found to be *added* to two right angles.

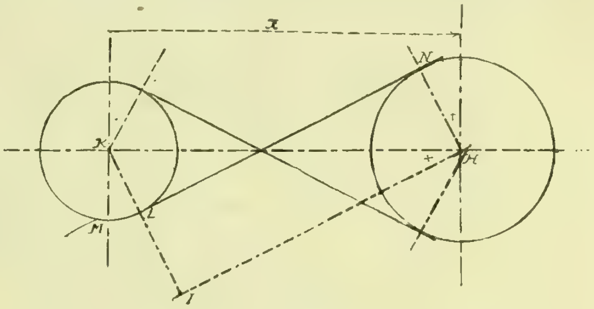


Fig. 3.

Taking a case for example, let it be required to find the value of the arc embraced by a belt upon the smaller pulley of a pair whose respective diameters are 15ft. 10½in. and 7ft. 8in., the belt to be an *open* one, and the centres of the shafts to be 80ft. apart; *i.e.*, the distance x (fig. 2) equals 80ft.

$$\text{Then sine angle AGD} = \frac{(15\text{ft. }10\tfrac{1}{2}\text{in.}) - (7\text{ft. }8\text{in.})}{2 \times 80} = ·0513;$$

so that the value of the angle AGD = 3 deg. (very nearly), and the *angle* embraced by the belt will therefore be

180 deg. − (2 × 3 deg.) = 174 degrees.

---

[*] By the parallelogram of forces the resultant AD is equal to the two components AC and AB. So that if we make the length of the line AD represent the pressure of the rope in the direction of the axis, the two equal lines AC and AB will represent to scale the pressure at right angles to the surface of the rope on each of the two sides of the groove, and therefore if p = pressure of rope in the direction of the axis, and P = normal pressure of rope on each of the sides of the groove,

$$\text{AD} : \text{AC} :: p : \text{P}$$

As AD = 2AE, we have $\frac{2\text{AE}}{\text{AC}} = \frac{p}{\text{P}}$ and $\frac{2\text{AE}}{\text{AC}} = 2\text{ sine }\frac{\phi}{2}$; therefore $\frac{p}{\text{P}} = 2\text{ sine }\frac{\phi}{2}$, so that $\text{P} = \frac{p}{2\text{ sine }\frac{\phi}{2}}$; therefore the normal pressure P on each side $= \frac{1}{2}p \cdot \text{cosec}\,\frac{\phi}{2}$

and, as both sides count for friction, we obtain: Agregate pressure $\frac{\text{P}}{1} = p \cdot \text{cosec}\,\frac{\phi}{2}$

and, as friction is proportioned to pressure, we may write: Effective co-efficient of friction, $\frac{\mu}{1} = \mu \cdot \text{cosec}\,\frac{\phi}{2}$ (9)

[†] Referring to the sketch given (fig. 2), the line GC is drawn parallel to the line AB (representing the line of belt). It may easily be shown that the angle AGD is equal to the angle CGF. Now, the angle FCG is a right angle, and therefore sine $\text{CGF} = \frac{\text{perpendicular}}{\text{hypothenuse}} = \frac{\text{CF}}{\text{GF}}$, and as the distance CF is equal to the *difference* between the radii of the pair of pulleys, or to *half* the *difference* between the respective diameters, we obtain sine CGF = sine $\text{AGD} = \frac{\text{D} - d}{2 \times x}$ (10) where x = GF = the distance between centres F and G.

[‡] Referring to the sketch given (fig. 3), KL is produced to I, making the length LI equal to HN, the radius of the larger pulley. Respecting the *angle* KHI of the triangle KHI, the value of its sine is equal to the perpendicular KI divided by the hypothenuse KH = x. Now, KI equals the *sum* of the radii of the pulleys or *half* the sum of the diameters of the same, so that sine KHI = sin $\text{MKL} = \frac{\text{D} + d}{2 \times x}$ (11)

Launch of a Steamer at Aberdeen.—An iron screw steamer of the following dimensions—length, 120ft.; breadth, 20ft.; depth of hold, 10ft.; gross tonnage, 250 tons—has just been launched from the shipbuilding yard of Messrs John Duthie and Sons. The steamer, which was named the Clunie, is to be supplied with compound surface condensing engines of 45 horse power, and is expected to attain a speed of nine knots per hour. She is to be engaged in the coasting trade, and has been built to the order of Mr. W. Todd Moffatt, Aberdeen.

SOME TYPES OF THE MODERN LOCOMOTIVE.—VI.

On fig. 7 (page 45) will be seen a tank locomotive for the 3ft. gauge, and is of the type which works the traffic on the La Guira and Caracas Railway before mentioned.

These engines were built some years ago by Messrs. Nasmyth, Wilson, and Co., of Patricroft.

They have cylinders 14½in. diameter and 20in. stroke, and six coupled wheels 3ft. in diameter. The driving tires are without flanges, to allow greater freedom in passing round the many sharp curves; and owing to the sinuous nature of this line the engine has been designed to run with the awning end first, so that the driver may have a better view of the road.

The heating surface and other leading dimensions will be found on the drawing, and also the weights on the rails, so that I need not further refer to them.

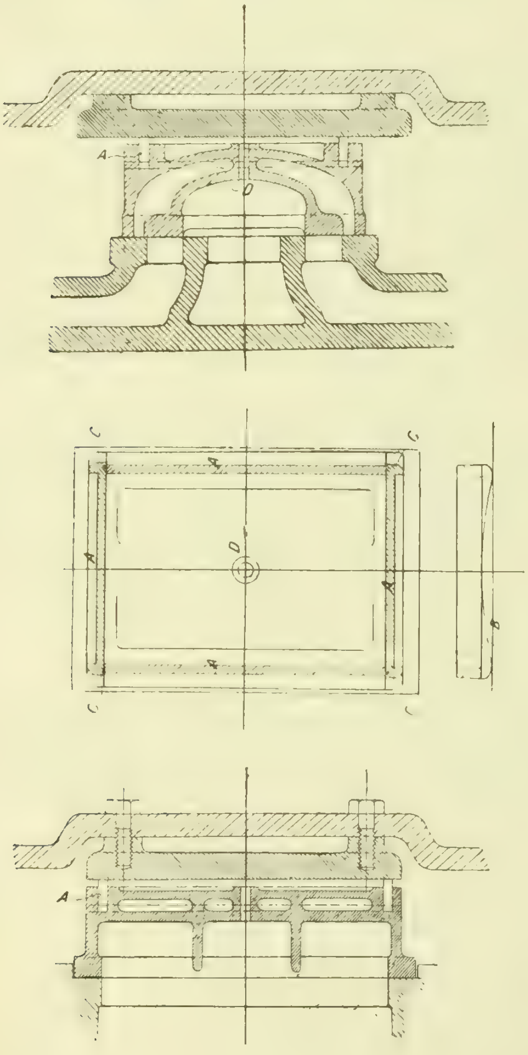


Fig. 11.

This engine takes a load of 80 tons up the ruling gradient of 1 in 27, for a distance of 21 miles, at a speed of 10 miles an hour.

It will be seen that the distance between the frames has been increased at the fire-box end, so that a respectable width of grate might be obtained, and as the engine does not haul its load through this part of the frame, this is quite admissible.

Again, the drawgear is arranged so that the pull of the train is taken from a point as near the rigid wheel base as possible, to ease the engine on the curves.

I fear that my paper is exceeding the recognised dimensions allowed on these occasions, but before concluding I should like to refer to one or two details of construction.

And as it is now becoming the practice to use balanced, or more correctly speaking partially balanced, slide valves on locomotives, one style will be found illustrated in fig. 11.

This valve is the invention of a Mr. Richardson, and is of American origin, being extensively used in the United States, and is said to give satisfactory results.

Four grooves are planed in the back of the valve, and four rectangular section strips A A are placed in these grooves, and are kept against a relief plate by light springs B, shown below. The distance between the strips A A being greater than the travel of the valve, each strip wears its own path on the relief plate, and never crosses the ridges made by its fellows; this consequently tends to keep the valve tight.

It will be noticed that the joints between the strips at C C C C at the corners of the rectangle freed from pressure, are in a line with the travel of the valve, thence are always in contact with the ridges caused by this joint, and by this means are kept tight, the steam pressure binding the whole together, and any slight leakage is conveyed to the exhaust by the hole D.

The sketch shows the balancing applied to a Trick or Allen valve, its double ports giving a sharp admission and cut-off, which are great advantages, but it is apt to wear quickly as its bearing surface on the valve face is diminished.

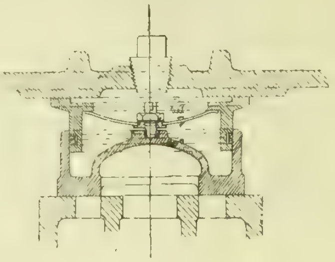


Fig. 12.

Another arrangement for balancing the valve on the same principle is shown in fig. 12, having instead of the balanced rectangle a balanced circular piece, which is fitted with rings to make a steam tight-joint.

A new tire fastening is shown in fig. 13, and is Messrs. Carlton and Stroudley's patent.

The tire is turned with the groove marked F, and rings of the sections G and H are dropped in, each having a piece ½in. wide cut out of its circumference to allow of their being sprung into place, when separate small pieces are inserted to make the rings complete. The tire is afterwards hammered over the taper section ring, and the whole forms a tight arrangement without the use of the usual set screws; though whether this will be successful, where other fastenings of this kind have failed—that is, when the tire has rolled itself larger in diameter through its contact with the rails—is a moot point.

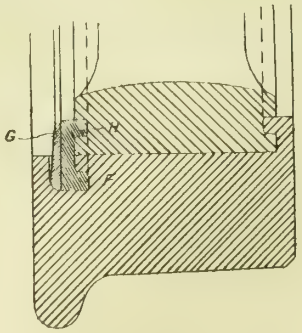


Fig. 13.

I should like to have gone into the question of fixing the position of the centre of gravity in the locomotive horizontally, as this is a most vital question, but that my paper has grown to an inordinate length as it is, and this of itself might very well form the subject of a separate paper.

I cannot conclude without thanking Mr. W. M. Wilson, of the firm of Nasmyth, Wilson, and Co., for his kindness in lending the various photographs which are here displayed, and my thanks are due also for the kind and considerate attention that you have given to my efforts to place before you a few points, I hope of interest, in connection with the locomotive in a few of its various types. And although my efforts may appear crude, my apology must be my inexperience in literary matters, and, as the subject is of some importance, the hope of learning something in the discussion which I trust may follow.

EXPERIMENTS WITH THE "DAFT" ELECTRIC RAILWAY MOTOR, "FRANKLIN."

According to the *Electrical World*, the public trials of the "Franklin" have received due and discriminating notice from both technical and general press, but very little description has appeared of the preliminary tests leading up to them. They were naturally conducted with a certain degree of privacy, and the subsequent exhibitions so fully occupied public attention that it would have been premature to exploit them earlier.

They signify, however, so much more to the professional mind than the runs of November 25th and December 5th as to demand a special notice.

The qualities which it was necessary to demonstrate were: 1, tractive capability; 2, speed; 3, mobility and handiness. Deliberate and exhaustive tests were applied, which are considered to have resulted in fully establishing the "Franklin's" excellence in these respects.

The tests for tractive capability were cumulative in their method, and were abandoned only when the load drawn exceeded by 40 per cent that which the motor was guaranteed to pull, and up to this limit there was not the faintest intimation of overload or strain of any kind. On the contrary, everything indicated that the motor was working well within its ultimate capacity, and its prompt, responsive action in starting, acceleration, and stopping was a surprise to the most sanguine.

Eight empty cars were taken up the maximum gradient, nearly 2 per cent, at a speed of 7½ miles per hour, developing in so doing 120 H.P. Another achievement with this train consisted in backing it from the main line to a siding, and necessarily around the reverse curve connecting them, upon a gradient of 53ft. per mile.

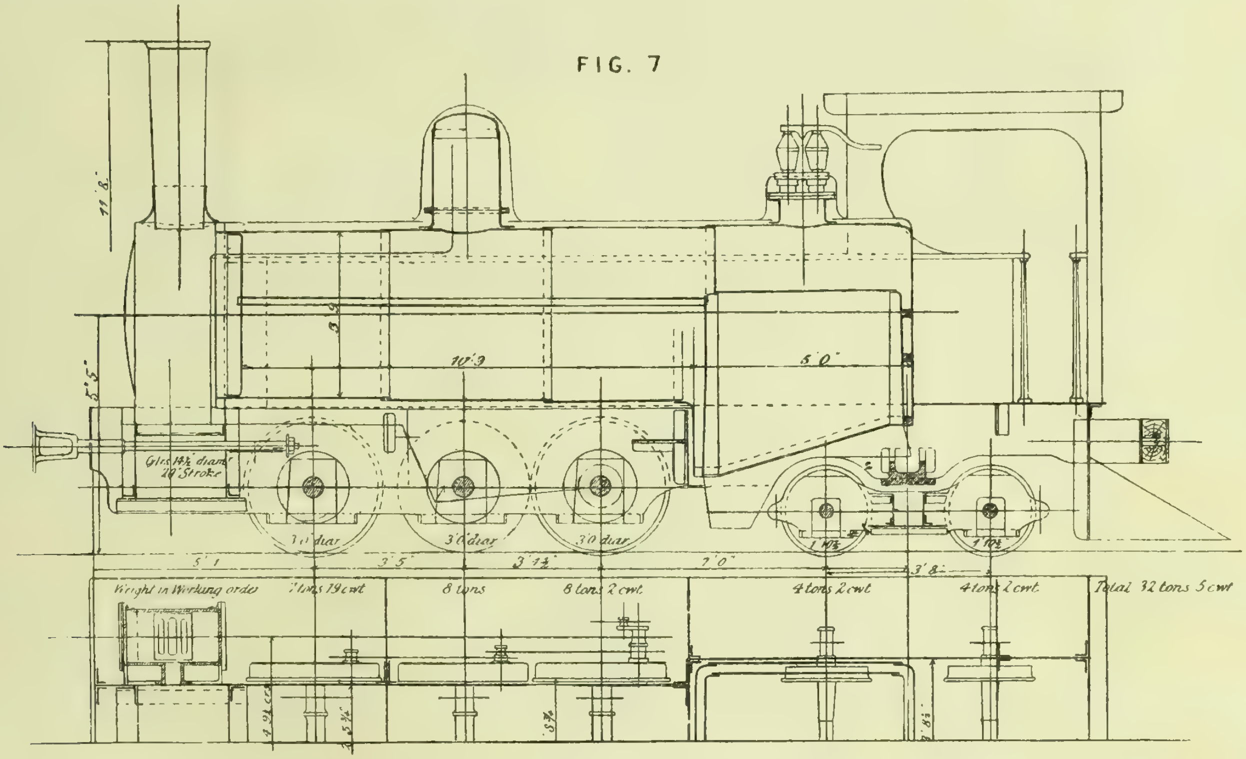
The trials for speed under loads fell, on both occasions, upon the worst nights of the recent stormy weather, and in spite of it results were obtained equalling and exceeding the schedule speed of steam locomotives at ordinary service. With the standard trains of four cars and a little over half of the possible seated load, a speed of 15½ miles per hour was obtained, an excess of two miles per hour over the regular steam traction speed, and this without effort or resort to ample means still available for its increase. On two occasions, with three empty cars, speeds of 30 miles per hour were obtained without taxing the motor in the slightest degree.

The free speed trials might have been carried to a much higher degree than they were, as the power limit was not nearly approached; but various considerations rendered it advisable to confine them to the specified conditions, the chief of which was an earnest desire to have the test continue to the end, as it was from the beginning, unattended by the slightest accident or disappointment.

On the point of mobility and handiness, a short anecdote will exhibit fully its completeness. During preliminary trials, while handling a train of six empty cars—a total load of 94 tons—it became necessary to shunt the train on a siding to permit the motor to be in front on the return trip. The standard train on the Ninth Avenue line is composed of four cars, and the sidings are built of a corresponding length. In looking over the situation, before shunting, it was discovered that the siding was only four feet longer than the train, and great nicety of manipulation would be necessary to accomplish it, especially as the motor was unprovided with means for working the air-brakes, leaving the train entirely dependent upon hand-brakes worked by only two men. The attempt was made, however, and by skilful handling of the motor, and zealous use of the ordinary brakes, the shunt was successfully accomplished, the train coming to a complete stop within the narrow limit of four feet.

In this country we have but slight experience of electric locomotives working with accumulators, and accordingly tests such as these detailed are of special interest, particularly as attempts are now in progress to apply such engines to tramway purposes.

FIG. 7

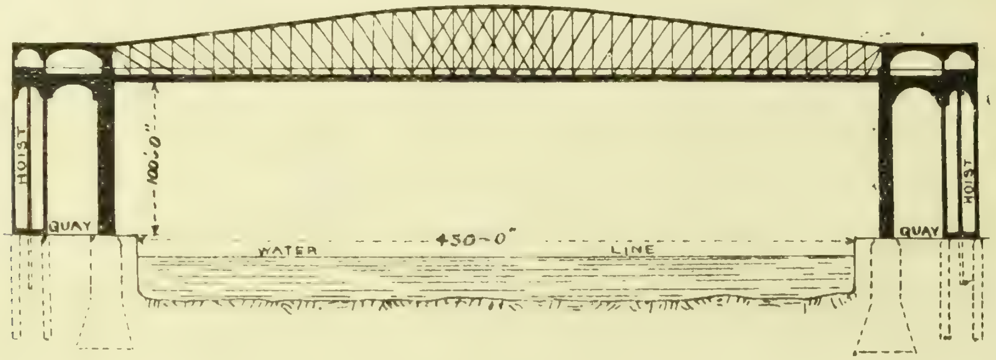


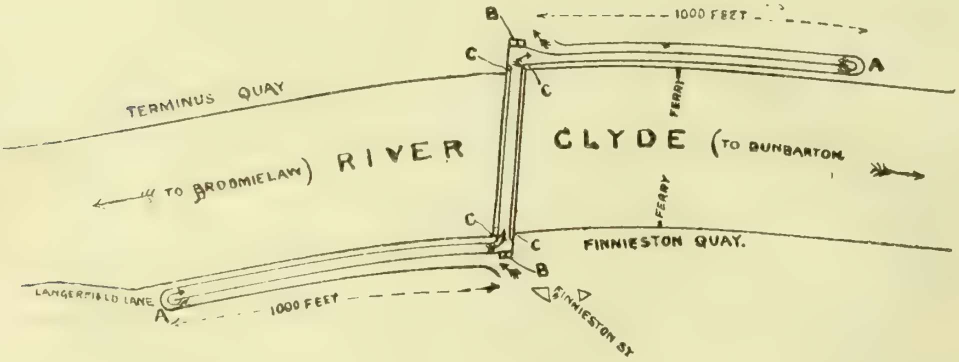
PROPOSED HIGH-LEVEL BRIDGE OVER THE CLYDE AT GLASGOW.

The enormous growth of Glasgow and its gradual expansion down the river has caused a difficulty, for many years most keenly felt, that of cross-river communication between the north and south sides towards the Partick and Govan districts. All the traffic of those large districts has at present to pass by the Broomielaw Bridge, nearly two miles up the river, or by horse ferry or steam ferry for passengers. Many proposals have been broached, including swing bridge and tunnel, but all present difficulties, as the first would interfere too seriously with the shipping constantly passing up and down. The *Glasgow Herald* described, a few days ago, a proposal by Mr. William Arrol, world-wide known as the constructor of the gigantic railway bridge over the Forth, and of which we give a sketch elevation and a plan on page 46.

Mr. Arrol's proposal will be easily understood by a study of the plan given. He proposes the construction of a high-level bridge, with 100ft. of clear headway above the quay level, and with approaches on each side with a gradient of 1 in 20. Some idea of this may be formed when it is mentioned that this gradient is slightly less than that of Renfield Street, one of the leading thoroughfares in the city. At such a gradient each of the approaches would require to be 2,000ft. long. To attain such a height by easy gradients without taking up much ground, which is very valuable here, must have been a difficult part of the scheme to mature, but the designer has produced a most ingenious plan of accomplishing this. The bridge, as will be seen from the plan, is to cross the river almost in a line with Finnieston Street, and Mr. Arrol proposes that a roadway should commence from a point near the foot of Finnieston Street, and proceed eastward for a distance of 1,000 yards on the back half of the quay shed, and from thence return along the front half of the shed for an equal length, the roadway gradually rising until the required height is attained. The bridge is then crossed, and the passenger or vehicle descends on similar roadways, the approaches on the south side of the river extending 1,000ft. westward over the top of the Mavisbank Shed. The back half of the quay sheds would only be seriously interfered with for a length of 120 lineal yards from the commencement of the ascending approach, and the only interference with the sheds in addition would be the columns supporting the roadways, and which are to be 40ft. apart and of steel. Indeed, the whole structure is to be of steel. The approaches are 24ft. broad, with a footpath 6ft. wide along the outside edge. Where the approaches take the turn, as shown on plan (see A), the design provides stairs from the level of the quay. The bridge has a roadway of 40ft. broad, with a footpath on each side 10ft. wide. The bridge is to be of one span, supported on piers with concrete foundations. Two hydraulic lifts are provided at each end, as exhibited on plan (see B), for the transfer of railway wagons from the one side of the river to the other, and of such vehicular traffic as parties would prefer being taken up and let down by lift, by payment, rather than have fully three quarters of a mile to traverse, one half of which, except 143 yards of the level bridge, would be on an ascending and the other half on a descending gradient of 1 in 20. These lifts are each 29ft. long and 21½ft. wide. At the corners of the footpaths on the bridge (see CC) there are passenger hoists 10ft. square. Six minutes will be required for a complete journey by the hoists, and 2,000 persons may cross the river in this way in one hour, in addition to 10,000 persons who may go round the approaches. The lifts for vehicles enable 80 to cross in an hour, and in addition 1,200 may cross each hour by using the inclines.

It will be observed that by this proposal no interruption would be occasioned by a continuous flow of traffic during the whole of twenty-four hours, and, in the opinion of those best acquainted with the requirements, nothing short of such a service will satisfy public necessity. The estimated cost is about £150,000.





CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STEAM-ENGINE EFFICIENCY.

To the Editor of "The Practical Engineer."

Sir,—In reference to "L. C. D.'s" diagrams and slide valves, I am sorry to find no scale given with them, and "L. C. D." has also omitted to give travel of valve, which is a very important point in solving the valve problem; but I should advise the addition of five-eighths of lap on steam edges of valve. This will give double face of lap on steam edges. And I should prefer on exhaust edges—back ¼in., front edge ⅜in., if the travel will allow of it. If the travel will allow, a port opening of ¾in. will be quite sufficient to drive your present load. The amount of lap cannot be given with accuracy without knowing travel of valve and length of connecting rod. If this had been given, I could have made it more lucid. If the above alterations be carried out, it will increase compression in low-pressure cylinder, reduce condensation to initial pressure, and correct the present deleterious effect upon the engine in passing centres. Better distribution of power in the cylinders will also follow. "L. C. D.'s" average pressure in high-pressure cylinder is too low for economical working, being only about 31·25lb., and in low-pressure cylinder only about 5·20lb. Now, as the constant for the high-pressure cylinder is 2·82, and as the constant for low-pressure cylinder is 8·63, and 8·63 × 5·20 = 44 indicated horse power, and high-pressure cylinder average 31·25lb. × 2·82 = 88 indicated horse power, therefore the total is 44 + 88 = 132 indicated horse power for both cylinders. I may say that this engine will work more economically at 200 indicated horse power, as the proportions of cylinders are not good. The above average pressures I find from "L. C. D." giving the power 132, and high-pressure cylinder driving twice the load the low-pressure cylinder is; so this enables me to come near enough for practical information. If "L. C. D." fires easily with his boiler, shorten bars to 5ft., and keep up a sharp draught; this will keep up the temperature of flues, and add to the economy of fuel. I may say that the diagrams given by "L. C. D." do not appear as if using 7lb. of coal per indicated horse power, or half that amount. The loss shown in diagrams is due to condensation in cylinders, from having insufficient load upon the engine. I should prefer an average pressure in high-pressure cylinder of 40lb. to 45lb., with 100lb. in the boiler; then this would bring the average in low-pressure cylinder up to something like 10lb. to 12lb., which favours economy.—Yours, &c.,

R. Bramall.

Bradford.

To the Editor of "The Practical Engineer."

Sir,—In reply to "L. C. D." as to steam-engine efficiency, from the general appearance of your diagrams and the near approach of the pressure curves of the high-pressure cylinder to the hyperbola, together with the form of the pressure curves of the low-pressure cylinder, although no scales are given with them, we may, in lack of further information as to clearance and receiver spaces, with other details, reasonably conclude that the steam used by the engine is fairly doing its duty. The work done by each of the two cylinders cannot be equalised by any arrangement of valve on the low-pressure cylinder with the present proportion of cylinder areas used and the very high pressure and high grade of expansion adopted in the high-pressure cylinder, by which the greater portion of the available energy of the steam has been expended in that cylinder, leaving little to be gleaned by the following low-pressure one. The great expenditure of coal, if such there be, would therefore seem to be from some other cause.

Is the interior of the boiler covered with scale? At what temperature is the feed-water supplied to boiler?

The amount of steam used for warming the shed may be ascertained by collecting and weighing or measuring the water from the condensed steam used for warming; as may also that required by the "sizing frame," by the weight or measure of water or condensed steam as it leaves the machine. These quantities of water, with their respective temperatures, compared with the quantity and temperature of the water supplied to the boiler during a period of say 24 hours, will show the relative proportions of heat in each, and may perhaps also show that there is no excessive consumption of coal when measured by water evaporated instead of by the horse power developed by the engine, which is only a portion of the work done by the coal.—Yours, &c.,

Cheetham. W. A.

QUERIES AND REPLIES.

4. Engine Piston.—I should be glad if some fellow-reader could give me a word of advice with regard to the following: In one of the engines under my charge the junk ring is about $\frac{3}{16}$in. or $\frac{1}{4}$in. too slack for the cylinder, and the piston rod is bearing heavily on the gland. Would it be any advantage to turn the piston head upside down? as at present it is very hard to keep the asbestos picking which I use for the gland tight.

Answer.—Your junk ring is quite correct. The weight of your piston should be borne by the packing ring, which, instead of springs at the bottom, should be fitted with a solid strip, filling up the space between the piston and packing ring, and of a sufficient thickness to support the piston in a central position. Turning the piston rod head or cross-head might effect this, and if suitable to its other connections, you could try it. To see if you lined up each end correctly, take back the gland and place the crank at each end of the stroke, or as nearly these positions as will allow you to keep the gland out of the stuffing box, and by measurement ascertain the position of the piston rod in the box. Adjust the liners till the rod and box are concentric in each position of the crank. G. R.

2. Varnish for Papier-Mache Goods.—Would some reader kindly inform me how to make the black varnish that papier-mache goods are coated with? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished?—J. T. L.

3. Slide Valve of Hydraulic Engine.—Will some reader kindly inform me which is the best form of slide valve to adopt? The engine makes 20 strokes per minute, and the pressure is 1,000lb. per square inch. I should be glad also to learn what kind of stop valve is generally used for hydraulic cranes.

7. Blacklead Pencil Making Machinery.—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery?—B. B.

9. Grinding Optical Glasses.—Will some kind reader inform me how to grind optical glasses? Is there a book published on the sublect, and, if so, what is the price, and who is the publisher?

10. P. E. Reader, Paisley, will feel obliged for a sketch and description from any reader of the principle of Higginson's speed regulator as applied to governors.

TO CORRESPONDENTS.

Basso.—The rule you require for determining the diameter of a shaft necessary to resist a given bending moment will be found in Molesworth's twenty-first edition, page 408. D=diameter of the shaft required in inches, L = length of shaft between points of support in feet, W = weight on centre of shaft in lbs.

$$D = \sqrt[3]{\frac{LW}{k}}$$

This gives the diameter necessary to support the weight of the flywheel in your case safely, but at the place where the flywheel is keyed on the diameter must be further increased to allow for the keyway, which must not, of course, be allowed to encroach on the required strength. In Rankine's "The Steam Engine" the matter is dealt with at page 75, article 73. If you find any further difficulty there, we shall be pleased to explain.

Bangor Man.—Messrs. E. and F. N. Spon, London, publish two works upon turbines, one by Cullen, price 12s. 6d.; another by W. Donaldson, M.I.C.E., price 5s.

W. E. L.—Messrs. E. and F. N. Spon, London, publish several works upon ironfounding. The one entitled "Ironfounding," by Claude Wylic, would probably suit your purpose. They also publish a work on "Brassfounding," by Jas. Larkin.

MISCELLANEA.

"The Miners' Handy Book."—Under this title the publishers of the *Labour Tribune* have just issued a cheap and convenient manual of the Coal Mines Regulation Act, 1887. The provisions of the Act are given in a form which renders them intelligible to the lay reader, and in every case where it seems at all necessary the meaning of the text is elucidated by notes, contributed by the member for North-West Durham, Mr. L. Atherley-Jones, whose qualifications for the task are sufficiently well known. A copious index stlll further increases the value of the little book for purposes of reference, and it deserves to obtain a large circulation amongst the mining community.

Trial Trip of the Ormea.—The new steam yacht Ormea, after being tried over the usual Clyde course, has given every satisfaction to her owner. Designed similar to the swift cruisers of the Galatea type, she has every facility to engage in warfare. With her twin propellers she can manœuvre quickly; her boilers are protected by her coal bunkers, and her rudder is out of reach of shot and shell by being entirely immersed, and her steel deck, sheathed with teak, forms a strong platform to fight her guns upon, at the same time giving protection to the men below. The Ormea can give sleeping accommodation to over 40 men besides her crew.

Trial Trip of the Lady Brassey.—The official trial trip of the steamship Lady Brassey took place recently at Stokes Bay, Portsmouth. This vessel, which was constructed by Messrs. Ernest Scott and Company, Close Works, Newcastle-upon-Tyne, to the order of Hastings and St. Leonard's Steamboat Company, has been selected by the Hon. Mr. Brassey, in conjunction with the Naval Volunteer Home Defence Association, to be used, when not engaged in excursion work, as a training boat for marine volunteers. She will be armed with light but powerful machine guns. The result of the trial was in every way satisfactory, the speed attained being over 12½ knots, which is considerably in excess of that contracted for. The machinery, which is of the semi-torpedo boat type, worked very satisfactorily.

Shipbuilding.—The steamship Joseph John has just been successfully launched from the yard of Messrs. W. Doxford and Sons, at Palion. She was built to the order of Mr. Otto Jaffe, of Belfast, for the general trades, and is entirely of steel, built to Lloyd's 100 A1 class. The principal dimensions are: Length between perpendiculars, 280ft.; breadth, 38ft. 3in.; depth moulded, 21ft.; with cellular bottom fore and aft. The engines are triple expansion, three cranks, with all Messrs. Doxford's latest improvements, the cylinders being 21in., 35in., and 57in. respectively, and the stroke 39in. They are supplied with high-pressure steam from exceptionally large boilers. The vessel is a duplicate of the steamship Daniel, recently built for the same owner by Messrs. W. Doxford and Sons.

Electric Welding and its Application to the Arts.—On January 7th the Civil Engineers Students' Association opened its session in the Philosophical Rooms, Mr. J. M. Gale presiding. Mr. E. J. Duff (Whitworth scholar) read a paper on the above subject. He traced rapidly the development of electricity for practical purposes, and described in detail the various machines in use for electric welding. He showed that although in Britain electricity had not been applied to any great extent for welding, yet on the Continent—especially in Germany and Russia—it had been much made use of. In St. Petersburg work was done by means of the Bernardo method, and in America by the Elihu Thomson system. The lecture throughout was full of interest and was illustrated by numerous diagrams.

Gasholders.—Another use of metal, either iron or steel, is predicted. Brick tanks have long been employed in gasholder construction; but there is in this month's *Gas Engineers' Magazine* a proposal that wrought-iron or steel tanks built above ground should be used instead. It is claimed that the cost would be less; that the time in construction would be shorter; and that there would be accessibility to all parts of the tank and inlet and outlet pipes. These are advantages if they could be attained; and it is stated in the technical journal named that at New York and at Memphis large gasholders, with wrought-iron tanks above ground, have been successfully erected. It is a further proof that this is an age of iron or of steel.

Shipbuilding Notes.—The shipbuilding returns compiled by Lloyd's Register show that, at the end of the year 1888, there were 445 merchant steamers in course of construction, of 811,468 tons. More than seven-eighths of the total were steamers, and steel forms the material for seven-eighths also. The work in hand at the end of the year was about 85 per cent more than at the end of 1887. As to the sizes of the steamers in course of construction, it may be stated that, at Belfast and Londonderry, the vessels average more than 3,000 tons each; that on the Clyde they are over 2,000 tons each; on the Mersey they are smaller; on the Tees and at West Hartlepool they are above that size; and on the Tyne and Wear they are just about 2,000 tons each. It is significant, however, that there is a diminution in the number of vessels for the construction of which preparation is being made.

Trial Trip of the Steamship Maristow.—A few days ago the trial trip of the new steel screw steamship Maristow took place on the Firth of Forth. The weather was propitious, although a strong breeze was blowing. Upon running a measured distance a mean speed of 11½ knots was shown on a double run, the engines working smoothly throughout. The Maristow is a screw steamer of the well-deck class, 263ft. in length by 37ft. beam by 19·5 depth moulded. Her engines are of the triple-expansion type, with cylinders 19in., 30in., and 51in. diameter by 39in. stroke, supplied with steam from two steel boilers, which work up to 160lb. pressure. All the latest improvements have been introduced in this steamer, including steam winches, steam steering-gear, &c., while her side-lights are protected by lighthouses on each side of the forecastle.

A Prepayment Gas Meter.—With the view of enabling the industrial classes to avail themselves of the advantages of gas lighting by paying for the gas in small quantities in advance as they require it for use, an ingenious prepayment gas meter has been devised by Mr. R. W. Brownhill. The apparatus is based upon the principle of the confectionery and other automatic supply stands now so familiar to the public. It consists of a small attachment which can be applied to any meter, and which will cause the gas to be delivered in definite quantities as paid for by pence dropped into a box. All that has to be done is to drop in a penny, and pull a small handle, when sufficient gas for the supply of an ordinary burner for six hours will be delivered from the meter. Any number of pennies may be placed in the box, one at a time, up to 143, the handle being pulled after each penny, which would insure 858 hours' gas to one burner, or a shorter supply to several. But the main object is to enable the masses to pay for their gas by a few pence in advance, which exactly suits their means, instead of finding themselves several shillings in debt at the end of each month or quarter. An important consideration in connetion with this class of users is the supersession of the dangerous paraffin lamp, which has been the cause of so many fatal fires among the labouring classes.

Utilisation of Alkali Waste.—At a meeting of the Liverpool Section of the Society of Chemical Industry, a paper was read by Mr. E. W. Parnell, F.C.S., on the Parnell and Simpson alkali and sulphur process, which is a method of manufacturing alkali and sulphur simultaneously from common salt and Leblanc alkali waste. This waste largely consists of lime and sulphur, but hitherto only a portion of one of these constituents has been recovered in a serviceable form, and that only after an expensive and laborious treatment. For the Parnell and Simpson process it is claimed that this refuse is simply employed as a substitute for lime in an ammonia alkali process, exactly corresponding with the ordinary ammonia process as now worked on an extensive scale in Cheshire and other places. The entire saving of lime by the new process would in itself be sufficient to make the process a highly valuable one; but this is not all, as the sulphur contained in the alkali waste is evovled at a certain stage in the form of vapour, and can be readily collected and rendered merchantable. This is effected without any interference with the course of manufacture. The ordinary ammonia alkali process has been hitherto the cheapest process of manufacturing alkali from salt. The new process, however, is said to possess all its advantages, and has, in addition, the entire saving of lime employed in the ordinary process, combined with the simultaneous recovery of the sulphur contained in the Leblanc waste.

The Chinese Silver Mines at Jeho.—The United States Consul at Tientsin, in a report just published, describes the only silver mines known to be worked in all China. These are situated at Jeho, about 150 miles north of the Great Wall, in Eastern Mongolia. The two mines are about ten miles apart, nearly 50 miles north of the prefectural city of Jeho. They are called respectively the Chimney Mountain and the Orphan Mountain, and have been worked for 30 years after Chinese methods. The ore is argentiferous lead or galena, and is found in thin streaks, scattered through veins which occur between porphyry and limestone. Both mines are in high hills which have been burrowed with native workings and stripped of all ore found above water-level near the base of the hills. For ten years past they have produced little, as the native miners had to stop when they reached water, as they had no means of removing it. In spite of their primitive way of working and their rude tools, these miners have accomplished very remarkable results. Long, tortuous galleries, large enough to admit a man on hands and knees, have been cut through the hardest rock in every direction, the ore and waste rock being laboriously carried to the surface in bags. They have also, by long experience, discovered for themselves the rudiments of the science of smelting and refining silver ores, and are able to produce pure silver with the simplest appliances. Of late years a royalty of 33 per cent of the gross yield has been paid to the Government, and the mines have passed from hand to hand with steady loss to the investors. Li Hung Chang took the matter up, and decided to employ a foreign expert to examine the mines. A report has been made by an American engineer that the prospects justified a further outlay for pumping and hoisting machinery, and for labour to open up the mines for a more extended survey. This has been done; new shafts have been opened, the water has been pumped out of the old ones, the native miners have been taught the use of foreign explosives and tools, and the results are favourable. In consequence the work, under foreign guidance and with improved methods, promises to be permanent and successful.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

December 24th.

18846 Checking Counter Mechanism, P. C. Illgen, and P. E. Kürsten, London. [Complete Specification.]
18853 Feed-water Heaters, G. B. Field, London.—[Complete Specification.]
18855 Exhaust Nozzles, J. H. McIndoe and W. Meredith, London.
18856 Printing Telegraphs, G. V. Sheffield and M. Lowenstein, London.
18858 Electro-chemical Generators, F. J. Brougham, London. (La Société Perreur-Lloyd and fils, France.)

December 27th.

18863 Vapour Engines, M. Blumrich, United States.
18870 Heating Tools, W. Percy, Cumberland.
18874 Ventilators, St. J. V. Day, Glasgow.
18879 Counting Frame, R. Gilfillan, Glasgow.
18890 Twisting Machines, G. L. Brownell, Glasgow.
18899 Devices, E. R. Hyde, London.—[Complete Specification.]
18903 Moulds, H. J. Smith, Glasgow.
18916 Rock Drills, T. H. Bell, A. L. Stevenson, and R. Clough, London.

December 28th.

18922 Electrical Switches, T. Wardell, Glasgow.
18928 Safety Lamps, W. Clifford, Sheffield.
18930 Automatic Work Detector, J. Blamires and W. Blamires, Huddersfield.
18933 Pulley Blocks, C. F. Batt, Manchester.—[Complete Specification.]
18945 Steam Jet, C. H. Rosher, Westminster.

December 29th.

18982 Steam Boiler, P. Roscow and M. Settle, Manchester
18889 Grates, T. J. Disturnal and W. J. Disturnal, Walsall.
19004 Couplings, E. Edwards, London. (E. Müller, Germany.)
19005 Regulators, R. Nicholls and J. F. Kelley, London.
19008 Rotary Engines, A. J. Boult, Middlesex. (C. F. Fogg, United States.)—[Complete Specification.]
19013 Gas-motor Engines, C. W. Pinkney, London.

December 31st.

19017 Automatic Brake, P. A. Atristain, London.—[Complete Specification.]
19018 Engines, G. E. Montagnon, London.
19026 Steam Trap, J. Williams and W. Williams, Monmouthshire,—[Complete Specification.]
19028 Handles, J. Sturrock, Dundee.
19041 Reducing Valves, T. Bentley and W. Calvert, London.
19042 Lever Motive Power, J. A. Walker, London.
19057 Preventing Smoke, E. Dobson, London.
19058 Electric Batteries, J. Y. Johnson, Middlesex. (F. Gendron, France.)
19059 Numbering Machines, J. M. Black, London.
19063 Piston Packing Rings, W. Thomson and J. M. Macgregor, Glasgow.
19068 Apparatus for Storing Energy, J. G. Lorrain, London.

1889.

Where Complete Specification accompanies Application an asterisk is suffixed.

January 1st.

1 Closing Valves, J. S. Tommis and A. E, Whitwham, Huddersfield.
8 Starting Valves, E. Worthington, Manchester.
10 Link Belts, C. Laycock and W. Laycock, jun., Bradford, Yorkshire.
12 Parallel Vices, T. Singleton, London.
14 Fans, Pumps, &c., H. W. Holden, Doncaster.
19 Railway Signalling, J. Malcolm, Glasgow.
23 Furnace Grates, G. Alexis-Godillot, London.*
26 Ships' Berths, E. Lawson, London.
30 Electric Telegraphy, M. W. Dewey, London.*
32 Grinding Knives, H. H. Lake, London. (R. Dutton, United States.)*
39 Percussion Fuses, A. Martin, London.
40 Spiral Springs, J. Oldham and O. Oldham, London.
46 Electric Generator, W. S. de L. Roberts and J. S. Mollison, London.*
48 Valve Gear, A. G. Brookes, London. (C. C. Worthington, United States.)
49 Ordnance Projectiles, C. E. Kelway, London.

January 2nd.

54 Liquid Elevators, J. Jackson, Chorlton-cum-Hardy.
58 Steam Boilers, R. Scott, Newcastle-on-Tyne.
62 Illuminating Lanterns, I. Sherwood, Birmingham.
65 Sieving Machines, G. C. Dymond, Liverpool. (O. Bilharz, Germany.)
67 Railway Sleepers, J. P. E. C. Stromeyer, Twickenham.
68 Supporting Rails, J. P. E. C. Stromeyer, Twickenham.
70 Firing Device, E. B. Müller, London
72 Apparatus for Hauling, J. F. Hyland, London.
78 Controlling Rudders of Ships, F. R. Lipscombe, London.
79 Steam Engines, E. S. Harpst, London.*
83 Apparatus for Distillatory, W. Lawrence, London.
85 Dynamo-electric Machines, A. Poleschko, London.

January 3rd.

93 Hydraulic Apparatus, W. A. Macfadyen, Manchester.
95 Securing Shuttle Tongues, G. Spencer, Bradford, Yorkshire.
97 Mounting Card, W. Walton, Manchester.
104 Hydraulic Jet, W. A. Macfadyen, Manchester.
108 Cleaning Apparatus, C. Herbert, Glasgow.
109 Shuttle Boxes, J. Pilling, Halifax.
110 Heating Buildings, J. Holden, Cheltenham.*
112 Electric Flashing Signal, J. Woods and H. W. Hatfield, London.
113 Measuring Machines, H. C. Braun and A. Ford-Lloyd, London.
118 Electric Brakes, W. P. Widdifield and A. H. Bowman, Manchester.*
121 Gas Motors, A. J. Boult, Middlesex. (E. Capitaine, Germany.)
122 Fire Grates, G. C. Dymond, Liverpool. (H. Piron, Belgium.)
123 Joint Keys, S. Danischewsky, Liverpool.
126 Dynamos, G. B. Luckhoff, London.
127 Hydraulic Machines, J. Fraser, London.
135 Arrangements for Lighting, I. A. Timmis, Westminster.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER.

JANUARY 25TH, 1889.

MINING EXPLOSIONS.

THE Hyde colliery explosion furnishes a melancholy comment on the recent self-congratulation consequent on the comparative freedom from such accidents during the past year. In 1888 there were 43 deaths from this cause, a quite sufficiently heavy loss, it is true, but still the lowest since returns were officially made for the first time in 1851. We had hoped that the stringent provisions of the Mines Regulation Act, in operation for the past thirteen months, would have practically prevented serious occurrences of the kind, and no doubt the Hyde explosion will make plain the absolute necessity of entire conscientiousness in carrying it into effect, and so possibly preventing future disaster.

In this case we have a pit hitherto looked upon as absolutely safe, so safe indeed that naked lights were freely used, and yet without warning, and after nearly half a century of immunity, a sudden outrush of gas took place, followed by a terrible explosion, and the usual—sadly usual—consequences to the poor fellows at work. In view of past experience, it seems abundantly proved that no mine can be regarded as absolutely free from danger of fire damp, and that a sudden outrush may occur even after long immunity has given a complete sense of security In many cases such a quantity of inflammable gas is evolved as to be quite beyond the control of the most effective modern ventilation.

In the Report of the Royal Commissioners upon Accidents in Mines, an instance is given where a heading was being driven through a hard portion of the seam, and was approaching a region of softer coal, when large masses of coal at the end of the heading were blown out, and gas rushed with such force into the workings as to overthrow men and tubs. Though 12,000 cubic feet of air per minute continued to pass the place where the outburst occurred, the neighbouring parts of the workings were not sufficiently free from gas for four days for work to be continued. It was estimated that considerably more than a million cubic feet of gas came off. In this case, fortunately, none were injured, but had open flames been in the vicinity, the consequences would have been fearful to contemplate.

After all, when the chemical and physical nature of coal is considered, and it is remembered that it is still in a state of chemical change or decomposition, attended with the evolution of the inflammable marsh gas, as well as carbonic acid, we can hardly be astonished at occasional outbursts.

Experiments recently made throw great light upon this point, and prove to some extent the nature of the process going on in a fiery coal seam. One of the Royal Commissioners made measurements of the pressure developed within the seam at the collieries of Elemore, Hetton, Eppleton, Boldon, and Harton. The depths of the places observed varied from 750ft. to 1,268ft. below the surface; holes were bored horizontally, or slanting slightly upwards, of lengths up to 47ft. Suitable arrangements were made to measure the pressure accumulating in these holes when completely closed up, but connected with a pressure gauge, and it was found that, although the volume of gases issuing from the surfaces was but small, yet pressures varying from 200lb. to 460lb. per square inch were repeatedly observed. Generally the pressure increased with the depth of hole, but variations occurred dependent on distance of passages and workings, as well as upon the continuity or discontinuity of the surrounding strata. The process seems, then, to be a slow decomposition of the coal and an accumulation within its pores of the gases evolved under pressures which may vary with physical conditions, such as compression and porosity of the coal and other substances; so long as an outlet is possible the gases produced pass off quietly, and are carried away in the air current. If by any combination of circumstances, however, a space exists sufficiently pressure-tight to retain the compressed gases, then considerable volumes may accumulate ready to discharge rapidly upon the breaking down of its containing walls from any cause. Some fall of rock or subsidence, or the approach of mining operations, may do this. A strong chamber, capable of resisting 400lb. per square inch, contains a very large quantity of compressed gas; a space of only five cubic feet at this pressure would contain gas which when liberated would occupy about 135 cubic feet, a volume quite capable of producing a highly destructive and fatal explosion.

In a wet mine, without inflammable coal dust, 4 per cent of fire-damp may produce a violently explosive mixture, and accordingly 135 cubic feet of gas is capable of rendering 3,375 cubic feet of the air in the mine violently explosive; and if the area of the passage at the working face be 30 square feet, 112ft. in length would be filled with explosive mixture. If fired by flame or a blown-out shot, it is needless to say that a disastrous explosion would result, in which the flame produced would expand, and burn all within its reach.

In a dry, dusty mine, with inflammable coal dust stirred up by a slight explosion, much more serious results would follow. It has been proved by the researches of Galloway, Mallard, and Le Chatelier, and the Commissioners that even so low a percentage as 2·5 marsh gas renders such an atmosphere highly explosive. It should be always remembered that a very few cubic feet of gas getting into a bay, say at the end of a working face, may produce an explosion capable of stirring up dust and firing gas lurking in places out of the ventilating current.

The strongest mixture of ordinary coal gas and air, if fired in a closed vessel at atmospheric pressure, produces a maximum pressure of 100lb. per square inch, and a flame temperature of 3,600 deg. Fahrenheit, or hotter than the cast iron running from a blast furnace. In a pit explosion, under some conditions of pressure and configuration of passage, a temperature not far short of this will be attained.

Under these circumstances it is easy to see how fatal even a comparatively slight explosion may become. The natural dread of death by scorching and explosion makes us feel more for accidents of this kind, but we should not forget that a greater number of deaths in mines are due to falls of the roof and sides; it is therefore difficult to say that in all circumstances safety lamps should be used, as it is sometimes of more importance to the miner to clearly see the walls and roof. The best and most feasible remedy, in our opinion, would be in the use of some form of safety lamp which, while quite safe, gives as good a light as a naked flame, and illuminates the roof as well. Inventors have long worked upon safety lamps, and with great success, but something still remains to be done to produce a lamp which will entirely remove the temptation to use naked lights.

ENGINEERS' ASSISTANTS.

In the relations existing between employer and assistant there is a striking difference between those employed professionally and those engaged commercially. In ordinary business establishments there is a certain routine of busy duty laid out, and this has to be carefully and conscientiously followed by the employé who aims at giving such satisfaction as may ensure the permanence of his occupation; but in the engineering profession much more is required, and this on account of the ever-changing conditions under which the advice of the civil or mechanical engineer is sought.

It is quite obvious that an engineer in fair practice cannot find time to work out the details of his own designs; his part is to determine the general arrangement of any work or scheme with the execution of which he is entrusted, and to superintend the efficient carrying out of details by skilled assistants, who complete his plans and place them before him in such form that he may conveniently examine and finally decide exactly what is required.

The engineer's assistant is therefore brought into very close relationship with his employer, into whose ideas he must thoroughly enter in order to be able to extend or modify them as occasion may arise during the drawing out of any particular plan. There is one marked characteristic about the confidential assistant, and such must all be considered who are entrusted with work of the character to which we refer—that is, his work is continuous; he cannot leave business thoughts behind him, as can the mercantile man; even when he crosses the office threshold his responsibility still keeps his work constantly in mind. The superiority of detail must necessarily depend in a very great degree upon the ability and diligence of the assistant, who will have greater facilities for determining the best course to pursue in working out minor points than can his chief, the multifarious nature of whose engagements will preclude his concentrating his attention upon them for a sufficient time. It is curious how, with a thoroughly experienced designer, the means to obviate each difficulty as it appears presents itself as it were spontaneously, and also how continuously improvements on old forms and old methods suggest themselves to the thoughtful man, so that to the last he is enriching his experience with new methods of operation. These remarks do not of course apply in any sense to those who take no real personal interest in their work beyond the emolument it affords them, but let us hope they are exceptions. Some such we know there are, but no more than in other professions.

A very little reflection shows in how great a degree an engineer is dependent on the character and abilities of his assistants for getting his work done in a manner which is satisfactory in itself, and which does not involve constant attention to details on his part; and this ability should be appreciated by the employer, not only in justice to those under him, but also in his own interest, for an occasional word of commendation or expression of special satisfaction is exceedingly grateful, and will stimulate the recipient in his endeavours to promote his chief's interest by assiduity and vigilance.

In regard to the assistants themselves, especially the younger ones, one pitfall should be very cautiously guarded against, and that is, over-rating their own importance. A man may in his own self-consciousness know that he is doing his part well, better perhaps than others in similar positions; but he must not forget that it is *only his part*, and not his employer's. Such remembrance may possibly save many heartburnings and false belief in unjust treatment, which can only impair his utility, and perhaps lead to his ultimate and serious loss of position.

It has been said that in the past not a few of the most successful engineers have owed much to a faculty for making the best use of those employed by them, and this is no doubt to some extent true. There is considerable generalship to be exercised in treating each man according to his disposition, to make him satisfied with the place to which he is appointed. To carry this out successfully requires an intimate knowledge of human nature, which all men do not possess.

These remarks are not made in any hypothetical manner, but are the outcome of a long experience and a very intimate knowledge of the systems in force in engineers' offices of all classes, both in London and the provinces, and it takes but a comparatively short time to find which kind of policy results in producing the best work. Under a harsh rule, it is true, a fixed standard may be insisted on for quality of drawings and mechanical work generally, but the same amount of intelligence will not be displayed as in those places where a courteous though firm demeanour characterises the principals, for the more willingly the work is done the better will it be in every respect, and, moreover, it will be executed with greater despatch and at a less cost.

From inevitable conditions it is evident that it is impossible for every assistant to attain to the position of a principal; hence there must be a body of men who are assistants to the end of their professional career. It seems strange, therefore, that no widely-spread association should have been called into existence in their interests; as it is, they seem to be in a position of isolation in regard to each other, which is somewhat difficult to account for.

Some years ago an endeavour was made to form an institution consisting entirely of engineers' assistants, and it was proposed that its operations should extend over the whole of England and Scotland. The promoters, however, met with very little encouragement, and so the matter fell into abeyance, and has not since been revived. This scheme differed from those of the numerous local engineering societies which are now to be found in all parts of the United Kingdom, inasmuch as the reading and discussing of papers was not to be a primary object; it would have become an association for intercommunication among the members on business matters, and would probably have inaugurated a relief fund for distressed members.

It is a certain fact that first-class assistants, should their particular situations fail them, have very great difficulty in obtaining fresh ones, and this is in a great measure due to the want of some special source of information regarding the varying requirements of the profession. It is true there are self-styled agencies, but nearly all of them are useless, if not fraudulent. Advertisements, too, are unsatisfactory.

There is a general opinion that engineering, in common with other professions, is overcrowded, but we do not think there exists a surplus of thoroughly qualified engineer assistants; of those of lower status there are undoubtedly too many. Under these circumstances, it would be advantageous if the bulk of practising engineers were to curtail the number of pupils they take, and the engineers with no practice were to cease taking pupils altogether, for there are men calling themselves engineers who accept pupils merely for the premium's sake, the unfortunate youths being then left to fritter away their time on imaginary work in the office, long lunch hours, or the demoralising influences of the public billiard-room.

In conclusion, we would remark that engineering, like other professions, offers a fair field and good prospects to those who possess the necessary ability, the necessary assiduity, and the requisite common sense; but to those who expect to find all difficulties smoothed, and an easy time generally, it is hopeless to promise fulfilment.

ELECTRIC LIGHTING OF TOWNS.

THE *Times*, in an interesting article on the development of electric lighting, states that "one of the signs of the impetus lately communicated to electric lighting enterprise in the metropolis is the correspondence which is occupying our columns on the comparative merits of licenses and provisional orders. These, it will be remembered, are the two alternative kinds of charter one or the other of which may be obtained by an electric-lighting company under the Act of 1882. They differ considerably in effect. The utmost duration of a license is seven years; of a provisional order—since the amending Act of last year—forty-two years. Moreover, the Board of Trade have uniformly laid down that a license is applicable to the lighting of small areas, whereas large areas can only be dealt with properly under the ampler powers conferred by provisional orders. No alteration in this respect is prescribed by the amending Act of 1888. Hitherto the license and the provisional order have lived side by side very amicably, for the apparent reason that there were no spoils to quarrel about. Electric lighting has for various reasons proved unprofitable to promoters. Since the passing of the Act of 1882 some fifty-nine provisional orders and five licenses have been granted to companies, and fifteen provisional orders and two licenses to local authorities; and early last year it was stated in Parliament that the Board of Trade were not aware of any cases in which the powers thus obtained were being exercised. But within the last year or two electric lighting in this country has raised its head anew. How far the revival is due to the increased experience of electricians, how far to the success with which electric lighting has been worked in America, how far to last year's relaxation of the Act of 1882, or how far to generally stimulated trade, we do not profess to judge. We are inclined to think that the revival of electric lighting produced the Act of 1888 rather than the Act revived electric lighting. However this may be, better days seem to be at hand. Some companies have been carrying on operations as best they could without either license or provisional order; several are about to apply for licenses; and two, anticipating the rest, have given the statutory notice of their intention to apply for provisional orders embracing the whole of the metropolis. The applicants for licenses only are indignant at this last piece of greediness, and thus the controversy of which we have spoken has naturally developed itself. We desire to recognise the soundness of the principle which pervades Mr. Hammond's letter, that principle being the necessity of guarding against the creation of great monopolies. Taught by bitter experience, Londoners have every reason to be jealous of nascent undertakings for supplying them with light and water. But we may fairly consider that, in regard to electric lighting, public interests were sufficiently preserved by the Act of 1882, the safeguards in which were so stringent that they had to be relaxed in 1888. There are, in fact, two sides to the question. We do not want oppressive monopolies, but we cannot afford to throttle enterprise by stipulations which discourage investors. Lord Crawford declares that if the Board of Trade were to grant no provisional orders, but restrict itself to granting licenses pending the development of electrical knowledge, this would have just the same damping effect as the short tenure of twenty-one years and the inequitable terms of preemption which rendered the Electric Lighting Act of 1882 inoperative, and had to be altered by the Act of 1888. The requisite capital, according to Lord Crawford, could not be raised, for investors see no security and no prospect of adequate profits in the precarious tenure afforded by a license. To go back to a short tenure of not more than seven years, just after Parliament has been driven to affirm the necessity of granting to the companies longer leases of life, is a retrograde step. Such is Lord Crawford's view. It is almost impossible to lay down any hard and fast rule on the question. We can merely place the two principles—one directed against monopoly, the other against trammels upon enterprise—side by side, and observe that due weight must be given to each. We have full confidence that when it comes to particular cases the Board of Trade will use its discretion wisely. We should be sorry to see the entirety of the metropolis parcelled out among two or three companies on the principle of 'first come, first served.' We should be hardly less sorry if the Board of Trade, by any pedantic rules, checked for another interval the progress of electric lighting."

FAST OCEAN STEAMING.—The remarkably fast passage of the Castle liner Roslin Castle, which was noted at the time of her arrival at Cape Town, proves to have been completed in a much shorter steaming time than any previously recorded voyage between England and the Cape. Leaving Dartmouth at 4 p.m. on the 7th of December, the Roslin Castle reached Cape Town at 1 p.m. on Wednesday, the 26th of December, having called at Lisbon, Madeira, and St. Helena. The entire distance, 6,102 knots, was covered in 18 days 21 hours, the net steaming time being 17 days 18 hours 30 minutes; average speed 14·35 knots.

THE LATE MR. J. J. COLEMAN, F.R.S.E., INVENTOR OF THE COLD-AIR MACHINE.

A FEW weeks ago there died near Glasgow the inventor of the system of mechanical refrigeration widely known as the Bell-Coleman. By this system most of the foreign meat arriving in this country is carried safely across the sea in vessels fitted with special cold chambers and the necessary machinery.

The principle of the cold-air machinery is very simple. When air at atmospheric pressure is taken into a pump cylinder, and then compressed into a reservoir to a pressure above atmosphere, heat is evolved; if the heat be retained—that is, if it be prevented from escaping—and the hot air be expanded behind a piston, then the air becomes lowered again to its original temperature. If, however, the air after or during compression is cooled by water, and then expanded in a cylinder doing work on a piston, it thereby loses heat, and when discharged from the cylinder at or near atmospheric pressure it is very cold. It falls to a temperature very much below its initial one. The cold-air machine then, in its simplest form, consists of a steam cylinder, an air-compressing pump with suitable coolers, and an expansion cylinder for expanding the compressed air to atmosphere again.

The refrigerating chamber in the vessel is constructed with double walls and doors packed with some non-conductor, such as sawdust; in this chamber the meat is hung up, and the air is constantly circulated through the machine, the same air being taken into the machine and discharged back again when cool. There are thermometers placed in such positions that the engineer in charge can read them at intervals, and the revolutions of the machine are adjusted to preserve the meat at a temperature close upon, but not below, freezing. There are many difficulties of detail in the designing of such machines, but perhaps the most serious with which Mr. Coleman had to contend was the formation of snow within the expansion cylinder. This he overcame by exposing the air after compression and cooling by water, but before expansion, to the temperature of the cold chamber in a series of pipes. The water existing in the state of vapour was thereby greatly reduced, most of it being deposited in these pipes and drained off; the air was, in fact, dried by cooling. This point was the principal one claimed in Mr. Coleman's patents, and that it is a valuable one is very evident from the difficulties encountered by other inventors in endeavouring to attain the same object.

The principle of the compression, cooling, and expansion of air to produce cold is very old, previous attempts, attended with partial success, having been made by the late Dr. Gorrie, Sir C. W. Siemens, and also by Dr. A. C. Kirk, the well-known Clyde engineer, whose work in triple-expansion engines has so much aided progress. To Mr. Coleman, however, belongs the great credit of first successfully overcoming all difficulties. We give the following short account of his career, as well worthy of study by the practical engineer.

The son of a Lincolnshire chemist and druggist, Mr. Coleman was left fatherless when he was about ten years of age, and in the course of the next few years he became connected with a business of the same kind as his father's in the town of Halifax. Being studious, and of a scientific turn of mind, he entered several classes in the Mechanics' Institution of that town, attaining such great proficiency in chemistry and other branches of science that he received a number of high awards of merit. When he was about 22 years of age he stood so high in his scientific attainments that, at the Oxford meeting of the British Association (1860), he communicated two papers to the Chemistry Section. One of them, which dealt with some important relationships of the atomic weights and volumes of the chemical elements, was honoured with a place in the "Proceedings" of the association for that year. This circumstance seems to have influenced him in becoming a teacher of science, as he afterwards held the position for several years as science tutor in three leading educational establishments, one of which was the famous Training College at Chester, which at that time had the Rev. Dr. Rigg as its principal—a distinguished educationist.

About the time of which we speak the important invention of the late Dr. James Young, the father of the paraffin industry, had become such a pronounced success that many persons in other parts of the country determined to follow his example as manufacturers of mineral oil. In Flintshire, and but a short distance from Chester, a rich bituminous mineral, known as "curly cannel," was discovered, and when it was found to yield to suitable treatment all the products obtained from the Boghead coal or Torbanehill mineral which James Young used at Bathgate for a number of years, the "oil fever" broke out in that county in a remarkable manner. Mr. Coleman, as a skilled chemist and general scientific expert, was tempted across the Dee into Flintshire to erect and manage a works for the manufacture of mineral oils. The skill of the deceased soon travelled to Glasgow, and the directors of Young's Paraffin and Mineral Oil Co. (Limited) were induced to offer him a post in their service as an expert to carry out original experimental investigations, in the hope that one or more of their so-called waste products might be turned to profitable account, and that certain of their marketable products might be made more profitable. He accepted the post, and he was not long in showing his employers that they had made a good choice, and that, in short, he was the "right man in the right place." Brief reference may here be made to two points only. In his experimental investigations he was enabled to show that the uncondensed gases produced in the distillation of the bituminous shale were capable of yielding, to great pressure and low temperature, highly volatile liquid hydro-carbons, having great solvent powers on various substances, and serviceable in producing illuminating gas where ordinary coal gas was not obtainable. He also turned his attention to the improvement of those preparations which were then being sent out for lubricating purposes, and in both cases he was remarkably successful.

In dealing with the uncondensed hydro-carbon gases from the shale retorts he devised a machine which developed the required low temperature and the great mechanical compression. This invention led to a close intimacy springing up between himself and Sir William Thomson, who has always been keenly alive in his appreciation of "new departures" in physics and mechanics. This intimacy again led to Mr. Coleman being consulted by Mr. James Bell, the well-known shipowner and importer of fresh meat from the United States by the Anchor Line steamers. For some time the method of refrigerating fresh meat in the holds of steamers while crossing the Atlantic was to circulate through the meat chambers air that had passed over extensive surfaces of block ice—a method which was very expensive and occasionally very inefficient. Mr. Coleman was requestod to set his active and highly scientific mind to work to try if he could not devise some thoroughly efficient system of mechanical refrigeration. He eagerly entered into the spirit of Mr. Bell's suggestion, and in order that he might devote his undivided attention to the solution of the problem put to him he quitted the service of Young's Paraffin Company (Limited), carrying with him, however, the good wishes of the directors. What may be regarded as a "new industry," that of providing the teeming thousands of our home population with fresh meat from North and South America, and from our Australian and New Zealand colonies, at comparatively moderate prices, is of such recent origin and growth that it is scarcely necessary to enlarge upon it. Suffice it to say that Mr. Coleman was not long in solving the new problem of mechanical refrigeration. Some ten years ago or thereby his first machine, which was practically perfect, was made in the Anchor Line Engine-works, and very soon thereafter the Circassia, Anchoria, Bolivia, and Devonia were fitted with Bell-Coleman dry-air mechanical refrigerators; and at one time as many as twelve steamers belonging to the fleet of Messrs. Henderson Brothers were carrying fresh meats from the States to Glasgow, Liverpool, and London. In a very few years shipowners were quite on the *qui vive* in regard to this question of fresh meat importation, and the demand for refrigerating machines became very great.

About four years ago Messrs. Haslam and Co., of Derby, bought up the Bell-Coleman patent rights, and Mr. Coleman, having made a moderate competency, retired from active business pursuits. He settled down at a delightful spot at Bearsden, and built in connection with his residence a spacious laboratory, which was eventually equipped in a manner unequalled by any other private laboratory north of the Tweed. Here it was his intention to carry on original experimental investigations with the view of enlarging the boundaries of chemical and physical science, and so long as his constitutionally frail health would allow him he did some excellent work, the results of which were in most cases communicated to various learned societies. A portion of the work—a highly important portion—was done conjointly with his intimate friend Professor McKendrick. He was for nearly twenty years an active and efficient member of the Philosophical Society of Glasgow, in whose "Proceedings" there were numerous valuable papers to which his name is attached. To the Institution of Engineers and Shipbuilders in Scotland, with which he was also connected for about the same period, he likewise contributed papers, as also to the Royal Society of Edinburgh, the British Association, and the Society of Chemical Industry (of whose Scottish branch he was the president at his death). Perhaps the most important of his informal papers was the one which he contributed, five or six years ago, to the Institution of Civil Engineers on "Dry-air Refrigerating Machinery and its Application." This brought him one of the highest awards in the gifts of the institution.

BOWERS' SEPARATOR FOR STEAM BOILERS.

One of the chief difficulties which steam users have to encounter arises from the formation of scale and deposit in their boilers, the removal of which necessitates periodical stoppages, to the loss of time and money. It is well known that the cause of this formation of scale and deposit arises from the various impurities introduced along with the feed-water, and left behind after evaporation.

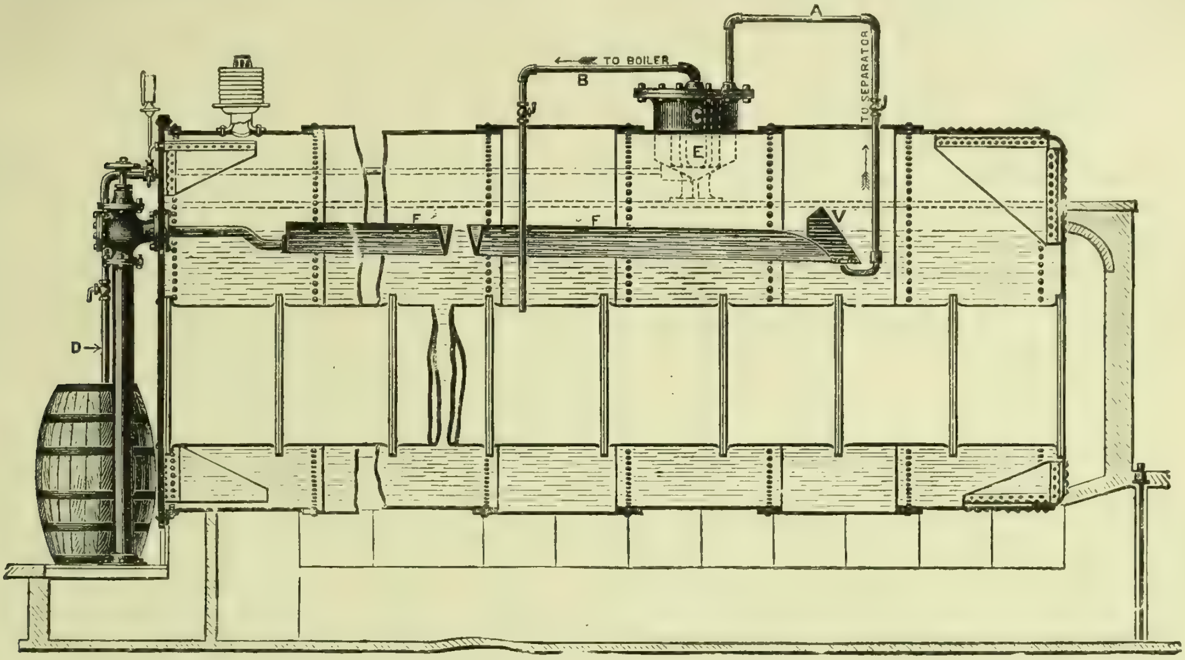


Fig. 1.

These troublesome substances may be roughly classed under two heads—those held in suspension, and those in solution : the former, as sand, mud, decayed vegetation, &c., being visible; the latter, as the carbonate of lime and magnesia, sulphate of lime and potash, silica, and other substances, are invisible till they are precipitated. It may be safely said that no water fed into boilers is free from some of the above impurities, although in a few cases, as in Glasgow water, the total solids amount to under four grains per gallon. But while the matter held in suspension is deposited rapidly on entering the boiler, in consequence of its higher specific gravity, some of that held in solution is precipitated through the elevation of temperature, a considerable proportion being completely precipitated on reaching 290 deg. Fahr., corresponding to a pressure of 60lb. per square inch. This is especially true of waters containing mainly carbonate and sulphate of lime. The lighter impurities remain suspended for a time near the surface of the water, and are carried by the currents which set backwards from the fire towards the quieter and cooler spaces of the boiler. Now, it is for the removal of these deposits as soon as they begin to be formed, and for their automatic conveyance out of the boiler, that Bowers' Patent Separator has been devised, and we are informed that, although only two years before the public, there are now over 200 at work within the United Kingdom alone.

The following is a description of the apparatus. To intercept the suspended and precipitated impurities of the water before they have time to settle themselves and remove them out of the boiler, a sheet-iron scum-plate V and a trough F is used (fig. 1), the scum-plate being fixed diametrically across the boiler, and at the water level, shaped like the letter V, the centre or apex communicating with a pipe A leading to the separator C, which stands outside and above the boiler. The trough F has a converging mouthpiece secured to the scum-plate V, whilst its other end is attached to the feed-pipe of the boiler, its object being to convey the heavier impurities of the feed-water to the scum-plate V, and which, without this device, would at once sink to the bottom of the boiler, and remain there. Thus the impurities of the water, of whatever specific gravity, whether light, such as the salts of lime and magnesia, or heavy, as river and canal mud or sand, are by the above means collected and conveyed to the separator C, a cylindrical vessel of cast iron, fitted internally with a sheet-iron scroll E, hanging downwards from the top, arranged from the circumference to the centre of the vessel. (See fig. 2.) The water conveyed from the boiler enters the separator at A, and is caused to flow in a circuitous manner by the scroll, thus giving it ample time to deposit its impurities to the bottom, which is shaped to facilitate deposition.

On reaching the centre of the scroll the water returns to the boiler by the pipe B, to a considerable extent freed from its impurities; thus a circulation is formed from the boiler through the separator back into the boiler again, the impurities being left in the separator, from which they are blown out from time to time by the blow-off D. The circulation of this water, once commenced, will continue without intermission as long as steam is kept up in the boiler, producing a perfect automatic conveyance for the impurities of the water. In illustration of this, an

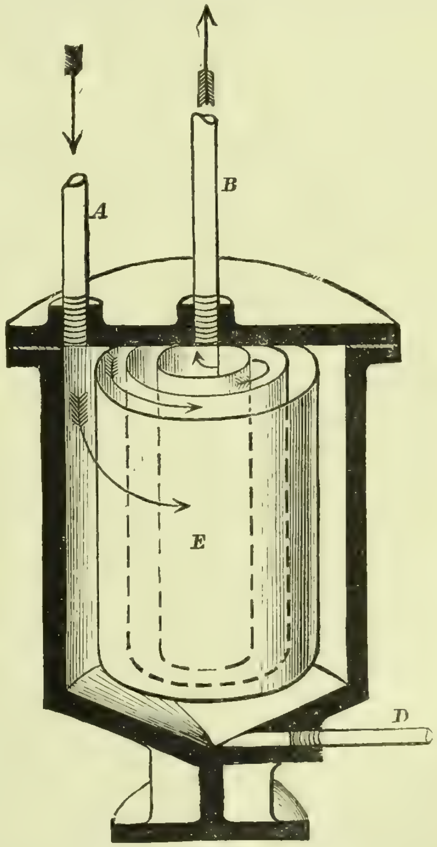


Fig. 2.

ordinary Cornish boiler, 5ft. by 20ft., with an internal flue 2ft. 6in. diameter, and 12in. of steam space as a minimum, containing 1,344 gallons of water, we are informed, will pass the whole of its contents through the separator in about four hours, the size of pipes being 1½in., and the difference of temperature between flow and return pipes being 10 deg. Fahr., giving a velocity of 73ft. per minute. The amount of deposit removed out of the boiler will, as a matter of course, vary in proportion to the impurity of the feed-water, and also to some extent upon their chemical nature; but the average weight calculated from a number of boilers, fed with water of different densities, all using Bowers' separator, has been found to be 8 cwt. per month. In one case of a Lancashire boiler, where the water used was heavily charged with lime and magnesia, as large a quantity as 12 cwt. was taken out in a single fortnight. A great advantage obtained by the use of this apparatus is the avoidance of damage to furnace tubes and lower plates of externally-fired boilers arising from the pressure of a large percentage of impurities in the water.

Bowers' separator is supplied by Messrs. G. W. Allen and Co., Brazennose Street, Manchester, to whom those desirous of inspecting the apparatus at work may be referred. In our opinion the separator is exceedingly ingenious, and is an important contribution to the solution, in many cases, of an exceedingly difficult engineering problem. Waters exist, of course, which cannot be dealt with in this way, but for many waters the apparatus is well adapted and most efficient.

ACCURACY IN MECHANICAL CONSTRUCTION

At a meeting of the Manchester Association of Engineers, on Saturday, 12th January, the President (Samuel Dixon, Esq.) delivered his inaugural address, on a subject of particular importance and interest to practical men of every grade in engineering. The subject was, "Accuracy in Mechanical Construction." Mr. Dixon, in his able and thoughtful essay, shows that the present race of Manchester men are in no danger of forgetting the noble traditions of their past. He said:

Twelve months ago, gentlemen, you may remember, I gave an address here on "Modern Machine Tools," in which I sketched to some extent the history of that important family of mechanical constructions. To-night I do not purpose travelling over so wide a field, but have decided to address to you a few observations on the question of "Accuracy in Mechanical Construction," and although I cannot hope to present to you any startling or novel view, yet I trust that a general review of this question may not be unprofitable.

I would, gentlemen, in the first instance consider for a moment the very meaning of the term accuracy, for it is one upon which very different conceptions are held, and I would then consider the chief elements entering into or necessary for the attainment of accuracy in mechanical constructions.

It is very easily seen that this term of accuracy is a relative one only, and depends upon our powers to estimate how near a piece of work approximates to actual perfection, for it is well known that there is no such thing as *absolute* perfection.

Intimately mixed with this question of accuracy is that of measurement, for of our powers to detect differences comes our true appreciation of the term accuracy.

To have acquired this power of detecting and measuring differences of the highest degree of refinement, is to have acquired a very considerable knowledge of the objects under comparison and of the errors entering into such measurements. To the joiner measuring a plank with a rule, and using his thumb as a marker (giving origin, I think, to the term "rule of thumb"), an approximation having an error of 1 in 30 is sufficient. To the workman using a rule and scriber, an approximation having an error less than 1 in 1,000 can be attained; but to the skilled workman using standard gauges, as in turning, a difference of 1 in 10,000 is detected and appreciated, whilst in the highest degrees of measurement with the machine invented by the late Sir Joseph Whitworth, the difference, we know, of the one millionth part of an inch can be measured. This extreme degree of accuracy, in the measurement of length, is about equal to that acquired by the chemist in measuring the weight of a substance, for this is commonly done, having an error less than 1 in 500,000 of the load, whilst in highly refined instruments it has reached that of 1 in one million parts. These degrees of refinement are, however, even rude compared with the precision with which *time* can be measured; for, with the present instruments, an error of less than 1 in eight million parts can be measured, a degree of precision which almost baffles the mind in its comprehension.

This precision in our powers of measurement is the very keynote of that remarkable development of the scientific system which has become the great characteristic of the 19th century. The dawn of this system was seen in the discovery of the great law of gravitation by Newton, and although deduced from very simple elements, its certainty has become so great that calculations of the greatest magnitude are based upon it. The simple observation of a falling stone had not for centuries yielded anything more than the simple fact that it always fell to the ground; but immediately the true scientific spirit comes to work and measures all the elements of the problem, such as the time it takes to fall through a given distance, the velocity it has acquired at the end of a given time, and the relation of its mass to these elements, &c., the true law is at once discovered by comparing a number of observations.

I know of no more beautiful instance of this power of measurement at the present day than was revealed by that terrific eruption of the volcano at Krakatao, in 1883, the results of which have recently been given to the world by the Royal Society. Here was a totally unexpected phenomenon for which no one could have been prepared; yet such to-day is the mighty army of observers scattered all over the world, each with his instruments of the highest precision, that the consequences of that event could, on a comparison of observations, be perfectly traced in all parts of the world, and the progress of the mighty waves set up in our atmosphere, and also in the sea, be traced completely round our globe.

These are but instances of that wonderful development of scientific method in this century which has been the basis of all true work, and I think we engineers may also say that its influence has been largely felt and even fostered in our ranks; yet great as this influence has been in the past, I am convinced that in the immediate future it will be far more powerfully felt.

I think, myself, that though the guiding spirit of all true engineering work must ever be based upon experience, as in the past, yet I feel that a *scientific* interpretation rather than an *instinctive* one must be the guiding hand in the future.

The question of mechanical accuracy was, I believe, first most urgently felt in connection with astronomical work, on account of the enormous errors introduced into the calculations by an extremely small error in the instruments.

In general engineering work, however, we have had in the past a noble army of men striving to attain greater precision on every hand, but prominent amongst these must ever stand that remarkable character, which has left such a permanent mark upon our engineering work—I refer, of course, to the late Sir Joseph Whitworth. In considering the question of accuracy, it is well not to mix it in our minds with that important element of design; for a construction may be of the very highest degree of accuracy and yet very indifferent in design, so that I would not consider the general question, but only that power to produce perfectly a piece of mechanism *precisely* as the designer intended it. This is what is understood by accuracy of mechanical construction. If we consider for a moment any piece of mechanism, no matter how highly complicated, and begin, as it were, to analyse it, we find that although in general aspect it may be very complicated, yet if we separate the various parts and classify them, we find it built up of extremely few and simple geometric forms, but it is the infinite variety of ways in which these can be combined, varying as they do also in magnitude, which give these constructions their complicated aspect.

In addition to the various surfaces necessary to produce the required mechanical motions, there are found a large number due to necessities of construction, for these constructions are made up of pieces joined together; and if we study them further, we find in good designs that there is always some definite relation between these articulations of the innumerable pieces and those cardinal central lines of the structure which go to make up the geometry of the machine. If these relations be not accurately preserved at every point, and errors be allowed to creep in, we all know that the result is one of those disastrous structures sometimes met with, which to rectify is almost impossible, necessitating as it would the re-construction and adjustment of the whole.

The fewness of geometric forms in any structure is evidence, we all know, of the highest design, for simplicity is the strongest evidence of experience, whilst the complicated and fantastic forms so easily drawn are strikingly significant of the amateur.

The variety of forms entering into our mechanical constructions is of course limited to those which can be produced with accuracy and despatch. Of these we have—

1st.—The true plane or flat surface.
2nd.—The true cylindrical form, which may, of course, be either external or internal, the one being simply the counterpart of the other.
3rd.—The true screw.
4th.—The cone intimately related to the cylinder, and of necessity external or internal.
5th.—The sphere, which again has its counterpart, as in the ball and socket joint.
6th.—Irregular forms, some of necessity, as in cams, others as matters of taste in design.

The relative importance also of these various forms depends very largely on our power to produce them rapidly. Let us consider these forms separately.

The True Plane.—This was one of the problems which presented itself to the early engineers as a difficult task, requiring considerable skill in the use of the chisel and file; and although it is to-day one of the easiest form to produce by machines, yet it is curious to reflect that even in our boasted perfection of mechanical skill we have to take refuge in hand labour whenever we wish to attain the highest degree of perfection. Although this fact is well known, yet it does not seem to be sufficiently known, for only a few weeks ago I had the problem presented to me by a prominent engineer that he required a machine for producing *absolutely* true surfaces, as in the various slides of lathes, without the slightest necessity for hand labour upon them, and although one does not wish to close the door and say it is *impossible*, yet such was my conviction I could only reply in those terms. The high importance of the true plane is very easily seen even from a cursory examination of any great mechanical structure, especially any one having any claim to precision, and in considering this one is led to think of that classic achievement of Sir Joseph Whitworth, who, about the year 1840, first showed to the world how to produce a true plane.

I have often read with the greatest interest the description he gave of his work in a paper read before the British Association at Glasgow, in 1840, on "Plane Metallic Surfaces, or True Planes," in which he showed the importance of scraping in the production of a true plane, compared with the methods previously in existence. With reference to the part which the introduction of this insignificant looking tool, the scraper, was likely to play, Mr. Whitworth in the same paper used the following prophetic words—that "a higher degree of excellence will be gradually established, the influence of which will be felt throughout all mechanical operations, while to the mechanic himself new fields will be open, in which he will find ample scope for the exercise of his faculties, both manual and mental."

Looking back now over the work of the intervening 50 years, one cannot but be struck with the clearness with which he foresaw the important step which this process was about to accomplish, and the far-reaching results which would arise from the introduction of this little instrument. In the same paper he also showed not only how to make one true surface by comparison with another or standard surface, but also showed how to produce a standard plate itself, giving details of the process which cannot to this day be improved upon.

Among machine tools the true plane becomes of extreme importance, and in the planing machine this is perhaps best seen, for not only does the accuracy of the work depend upon the truth of the main slides of the table, but the inaccuracies of the surfaces of the cross slides are exactly reproduced upon the work. In shaping and slotting machines we easily see the controlling influence of the true plane; but it does not stop here, for in all cases where it is necessary to guide a tool or a piece of work in straight lines, it is necessary to resort to the true plane as the sole basis of such control—in fact, we have scarcely a single machine in which the primary accuracy does not depend upon some of its slides. In the milling machine this accuracy is of even greater importance, for owing to the peculiar strains brought upon the slides by the action of the cutter it needs the highest degree of accuracy to prevent vibrations being set up, which are well known to be fatal to good work.

Before leaving the consideration of the true plane I would refer for a moment to an extremely delicate little instrument called a spherometer, used in Sir Howard Grubb's works, of Dublin, for the measurement of the accuracy of surfaces, for although it is there used to measure the accuracy of those large spherical surfaces of lenses used in telescopes, it is equally capable of measuring the truth of a plane surface. It consists of a tripod, the feet of which are hardened steel points, and arranged equi-distant from each other. In the centre is a fine-pointed steel screw, having 50 threads to the inch, with a micrometer head having 100 divisions, so that each division represents an advancement of $\frac{1}{5000}$th of an inch; but even more delicate forms are constructed. During a recent visit to Dublin, Sir Howard Grubb very kindly showed the action of this instrument, which in the hands of such a skilled operator, is capable, I believe, of easily measuring variations of $\frac{1}{50000}$ or even so fine as $\frac{1}{100000}$th of an inch. When the central screw is advanced until all the four steel points have equal pressure the instrument may be moved to any other part of the surface, and if an elevation amounting to $\frac{1}{100000}$th part of an inch be discovered, it will spin round on the centre point which rests on the elevation. So delicate was this little appliance, that the elevation of a glass surface caused by the heat from a touch of the hand was easily shown.

THE TRUE CYLINDER.

We now come to the consideration of the next most important form in mechanical construction, that of the true cylinder, and here it is perhaps desirable to consider the production of external and internal cylinders separately.

The capacity to produce external cylindrical forms seems to have existed in remote ages, having its origin doubtless in the potter's wheel, and though we can only regard these as approximations, being entirely produced by hand tools, yet they seem to have been perfect compared with the internal cylinders produced, for in Watt's time it was well known that his chief difficulty lay in the boring of his steam cylinders. We, at the end of this 19th centuary, can hardly realise the conditions which would allow of a man like Watt rejoicing that the cylinders did not then vary more in diameter than the thickness of a half-crown. The cylindrical is by far the most general form, arising from the simplicity and economy with which it can be produced. Its relative importance is well seen in any work by noting the number of machines, such as lathes, boring and drilling machines, producing cylindrical work, compared with those producing any other form, or again by measuring the areas of cylindrical surfaces in any machine. A very obvious advantage in the production of cylindrical surfaces is that the cutting can always be continuous, whereas in that of plane surfaces, except in milling machines, it is intermittent.

It was in the production of standard cylindrical gauges that Sir Joseph Whitworth first showed to the world the extreme precision which such a form admits of, and in his address to the Institution of Mechanical Engineers, in 1857, he showed that the difference of $\frac{1}{10000}$th part of an inch in diameter is a very appreciable quantity, representing to the touch, in standard gauges, the difference between a perfect fit and a sliding fit, and although all constructions do not of course demand this extreme accuracy, yet in every case its importance is very great. There is only one way of doing work right and a thousand ways of doing it wrong, yet in mechanical constructions it is often easier and cheaper to work on accurate lines than otherwise. In many workshops even at the present day this is ignored, and the production of a shaft or stud consists in bringing it down very approximately to the size with a tool, and then reducing the remainder with a file, a practice which ought not to prevail. To produce such a surface direct from the tool depends very largely on the skill of the workman, but more largely on the accuracy and stability of the machine he is using, and noting this desirability, let us see upon what it really does depend. Let us take, for instance, a simple slide lathe. Here it is easy to see first of all that not only must the line of centres of the headstocks be identical in *one* but in *any* position of the movable headstock. Again, as one of the centres revolves it becomes absolutely necessary that the spindle and its bearings should be perfectly true, for every irregularity here is reproduced in a magnified form upon the work, and further, it is necessary that the line of centres shall always remain perfectly parallel with the true planes guiding the motion of the tool and the position of the loose headstock.

Looking upon these essential features, one is led, notwithstanding their simplicity, to the reflection as to how many of the lathes daily employed really possess these essential points. How many turners can trust the lathe upon which they are working? Who does not know of the lathe which "slides in" or "slides out," or "bores a bit taper" or "runs off" in surfacing? necessitating the constant adjustment of the tool by the workman, and producing a series of cones, and not a cylinder at all. What often strikes me is the remarkable skill with which some men can produce good work on some of those constructions which pass by the name of lathes, and I often wonder why so many continue to pay so heavily throughout the whole lifetime of a lathe for this extraordinary skill on the part of the workman to avoid the initial errors of the lathe itself; and does it not seem a strange sight, that of a workman struggling for 20 years to counteract the initial inaccuracies of the lathe put into his hand.

(To be continued.)

ROAD LOCOMOTION.

At the opening meeting of the Association of Birmingham Students, connected with the Institution of Civil Engineers, Mr. Robert Green read an interesting paper upon "Road Locomotion." As Mr. Green has had special facilities for acquiring information upon the practical part of the subject, we propose giving the more important portions of the paper at some length.

In the first part he said that the advantages of easy, economical, and rapid locomotion were abundantly evident in widening the available area over which the population of great cities could be comfortably distributed. A double rate of transit meant opening up four times the available area, treble rate nine times, and so on.

The first essential to rapid travelling was a good road. Of this the Romans were fully aware, and in their time England was intersected by two grand trunk roads running at right angles to each other—one from north to south, the other from east to west. From these main lines there were branches in every direction.

Passing on to more recent times, it was stated that in 1625 hackney coaches were first introduced, and in 1676 the first turnpike road was opened, and toll was first levied. This road intersected the counties of Hereford, Cambridge, and Huntingdon.

In 1763 there was but one stage coach between Edinburgh and London, which started once a month from each city, took a fortnight to perform the single journey, and carried an average of twenty-five passengers monthly.

Arthur Young, who travelled in Lancashire about 1770, has left in his tour a graphic account of the deplorable state of the roads in that district, and mentions ruts four feet deep as no uncommon occurrence even in the summer.

Till the close of the last century the internal transport of England was entirely accomplished by wagon, a method not only slow, but expensive. The charge for carriage by wagon from London to Leeds was £13 per ton, from Liverpool and Manchester £20 per ton. The reader did not dwell upon the development of railways, merely remarking that, though considered expensive, they had greatly reduced the cost of transport. He proceeded to treat of road locomotion, and more particularly of street tramways, and recalled the fact that in 1857 George Francis Train visited this country to advocate the use of tramways on a system previously applied in the United States. His schemes were received indifferently, and three years passed before he succeeded in obtaining permission to lay down a line in Birkenhead. In 1860, and in that town, the first street tramway in England was opened for traffic, followed in 1861 by a similar undertaking in one of the suburbs of London.

The system did not become successful till 1868, when the first Act of Parliament dealing with the matter was obtained. In 1870 a General Tramways Act was passed, which allowed of their construction on public roads and highways. From that time they have continued, with but slight interruption, to develop in a rapid and remarkable manner.

In 1875 steam was first permitted on tramways, subject to strict regulations by the Board of Trade, so strict indeed as to interfere seriously with its legitimate extension. After eight years' experience those restrictions were modified, and accordingly since 1883 steam has been much used. The use of horses on tramways was, in the writer's opinion, a cruel practice, as evident from the fact that their average life was only four and a half years. A horse of average power, working for eight or ten hours per day, could transport on its back about 2 cwt. for about 25 miles, in a two-wheeled cart about 20 cwt., and in a tramway car about 90 cwt. Two horses could work a car weighing, with its load, 9 tons upon an incline of 1 in 25, at about six miles per hour; but this was cruel service, and it was not astonishing to find that 77 per cent of the gross receipts of tramways so worked were absorbed by horses and expenses connected with them.

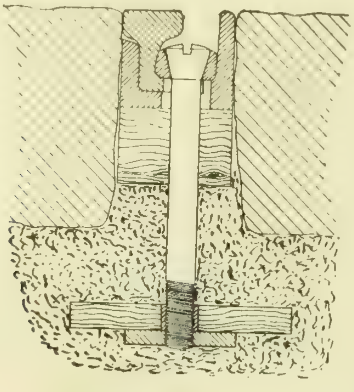


Fig. 1.

Motive Power.

Some form of mechanical motor was undoubtedly preferable, and various motors had been proposed, including steam, compressed air, electric motor, and cable. Steam so far was the most extensively used, and on the Birmingham and other lines the engines constructed by Messrs. Kitson and Co., Leeds, the Falcon Co., Loughborough, and Wilkinson, Wigan, and Merryweather, Greenwich, had given great satisfaction.

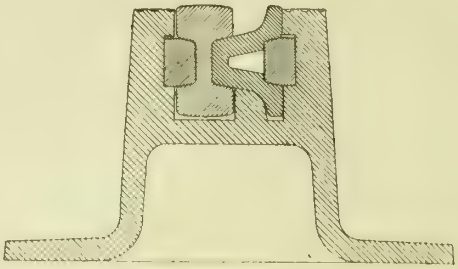


Fig. 2.

Kitson's engines, as used on the Central Tramways line, Birmingham, weigh, with water and coal, from 9 to 10 tons, draw a large car holding 60 passengers, and cost about £750 each. The working parts were protected from the dirt and dust of the streets very completely by suitable casing and doors arranged to allow of easy inspection and repair.

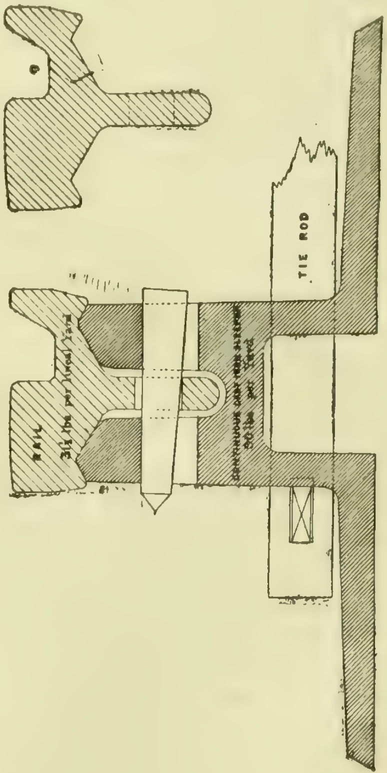


Fig. 3.

The engines of the Falcon Co. are also used on this line. The principal details were—

Diameter of cylinder, 8in.
Stroke, 14in.
Diameter of wheels (coupled), 2ft. 6in.
Tractive force per lb. of effective pressure per square inch of cylinder area, 30lb.
Boiler barrel, outside, 2ft. 9in. diameter.

In drawing two loaded cars, weighing together 18½ tons, at the rate of six miles per hour, on a mean gradient of 1 in 25, the engine indicated 40 H.P. The fuel consumed averaged from 8lb. to 9lb. of coke per mile. Usually the exhaust steam passed into the smoke box, was superheated before discharged, and thereby made invisible on reaching the air; but in cold or damp weather it passed through a series of copper tubes above the engine, cooled by air, and returned to the feed-pump as hot water. In Kitson's engine two-thirds was always condensed in this way, and the remaining steam sent into the chimney to improve the draught for the fire.

Complaints were occasionally made of emitting steam, but they were confined to the colder months of the year, as in the warmer months the absorbing power of the atmosphere is greater.

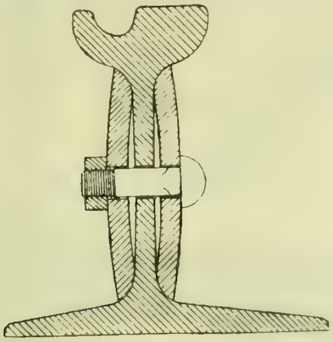


Fig. 4.

Each engine was provided with a governor, set to shut off steam and apply the brake to all four wheels at any speed exceeding 10 miles per hour; this it was found was tampered with occasionally. Each bunker capacity was at least 8 cubic feet. The weekly consumption of an engine (Kitson's), worked in that time 432 miles, was—

41 cwt. coke,
2,000 gallons water,
17 pints oil for lubrication,
1 pint paraffin oil for cleaning,
6 pints colza oil for lighting,
7lb. cotton waste.

The life of engine wheel tires on these lines was 23,000 to 25,000 miles—somewhat short, but the gradients were heavy.

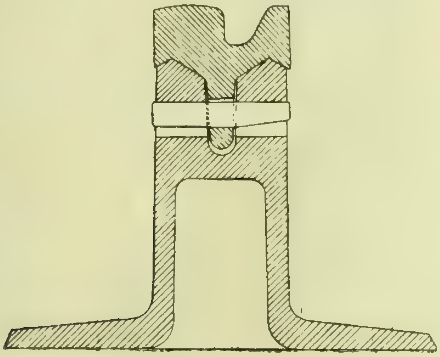


Fig. 5.

Compressed air was little used, and the reader had no personal experience, but he mentioned the systems of Pardy, Scott-Moncrieff, Colonel Beaumont, and Meraski. He then gave details of the Franq fireless locomotive for tramways, and said that in it there was no fire, but merely a reservoir containing about two tons of highly-heated water. The pressure at first was 250lb. per square inch, but fell at the end of a ten-mile journey to about 20lb. It had then to be re-charged up to the original pressure. The reservoir was a strong, plain, cylindrical one, mounted on two saddles. One engine was constructed for the Dutch-Indian Tramway Company, for Bavaria, of the following dimensions:—

Diameter of cylinders	9in.
Stroke	12in.
Diameter of wheels	2ft. 7½in.
Wheel base	4ft. 3in.
Length of reservoir	8ft. 3in.
Water contained	440 gallons
Steam space	20 cubic feet
Highest steam pressure ...	240lb. per square inch
Lowest " " ...	20lb. " "

It runs 12 miles with one charge on a level road with a tram of a total weight of 10 tons. The weight of the engine is 10½ tons in working order, and eight tons when empty.

The electrical motor, he said, was now on its trial in Birmingham, with accumulators upon the engine, and he felt confident that it had a great future before it. Several electric tramways had been worked; the earliest was that between Portrush and Bushmills, in the north of Ireland, opened for traffic in October, 1883 (W. Siemens). In the same year Mr. Magnus Volk opened a short piece in Brighton, constructed along the foreshore, and upon which a single car was run daily.

There was a short length in operation on the pier at Ryde, and on a larger scale there was a tramway along the Promenade at Blackpool—two miles long—constructed by Mr. Holroyd Smith. In November, 1884, the line between Bessbrook, and Newry (Ireland) was commenced, and in October, 1885, was opened for traffic. The total length was 3 miles 2·4 chains. Since then it has been in daily operation, conveying goods as well as passengers.

Cable tramways were of American origin, and were first introduced in San Francisco in 1873. The first example in England was that at Highgate, London. In Birmingham, a provisional order was obtained in 1885 for a line between Colmore Row and Hockley. It was commenced in April, 1887, and opened for traffic in March, 1888, since which it has worked satisfactorily and is very popular. The system has undoubtedly many advantages, more especially for heavy gradients; it is practically free from noise, and quite free from smoke or fumes. It gave great uniformity of speed, and fewer inconveniences to householders on the line of route than any other system yet perfected.

Permanent Way.

Within the last few years (he said) the permanent way of tramways had been much improved, and now all the details were the result of great and continued experience. The many sections of rails proposed, tried, abandoned, or modified, showed the care and energy devoted to this part of the subject. Several forms of section are illustrated by figs. 1, 2, 3, 4, and 5; these are only a few selected from almost every conceivable section. Fig. 1 is an obsolete form of rail; fig. 2 is the Channel rail; fig. 3 is "Barker's" rail, showing details; fig. 5 is also a "Barker's" rail, but with an improved form of wedge to give greater bearing surface; fig. 4 is a rolled Girder rail used in London and Sunderland.

It might be taken as an indisputable fact that if two similar metal rolling surfaces, such as tram rails, be laid, one on a bed of wood or other elastic material, and the other on a rigid iron girder, the life of that laid on the elastic bed would be longer than that of the one laid on the rigid bed, and the rolling stock which ran over the elastic structure would last longer than the stock run over the rigid structure. The difference felt when driving on granite or on wood paving was an illustration in point familiar to everyone. It had, however, been found in practice that this elasticity had given rise to so many difficulties in the maintenance of the permanent way that many companies had chosen the least of the two evils by abandoning the wooden or more elastic sub-structures, and had accepted in preference the somewhat increased expense of prime cost and renewals entailed by rigid steel girders. The "Girder" or "Gowan's" section of rail (see fig. 6) has during the past two or three years been extensively used not only in this country but upon the Continent with very great success. It was a strong combination of rail and sleeper in itself.

(*To be continued.*)

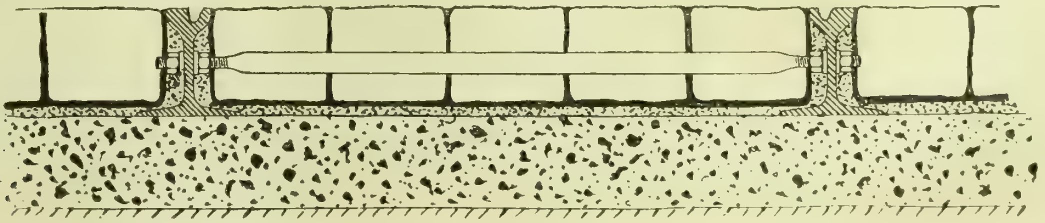
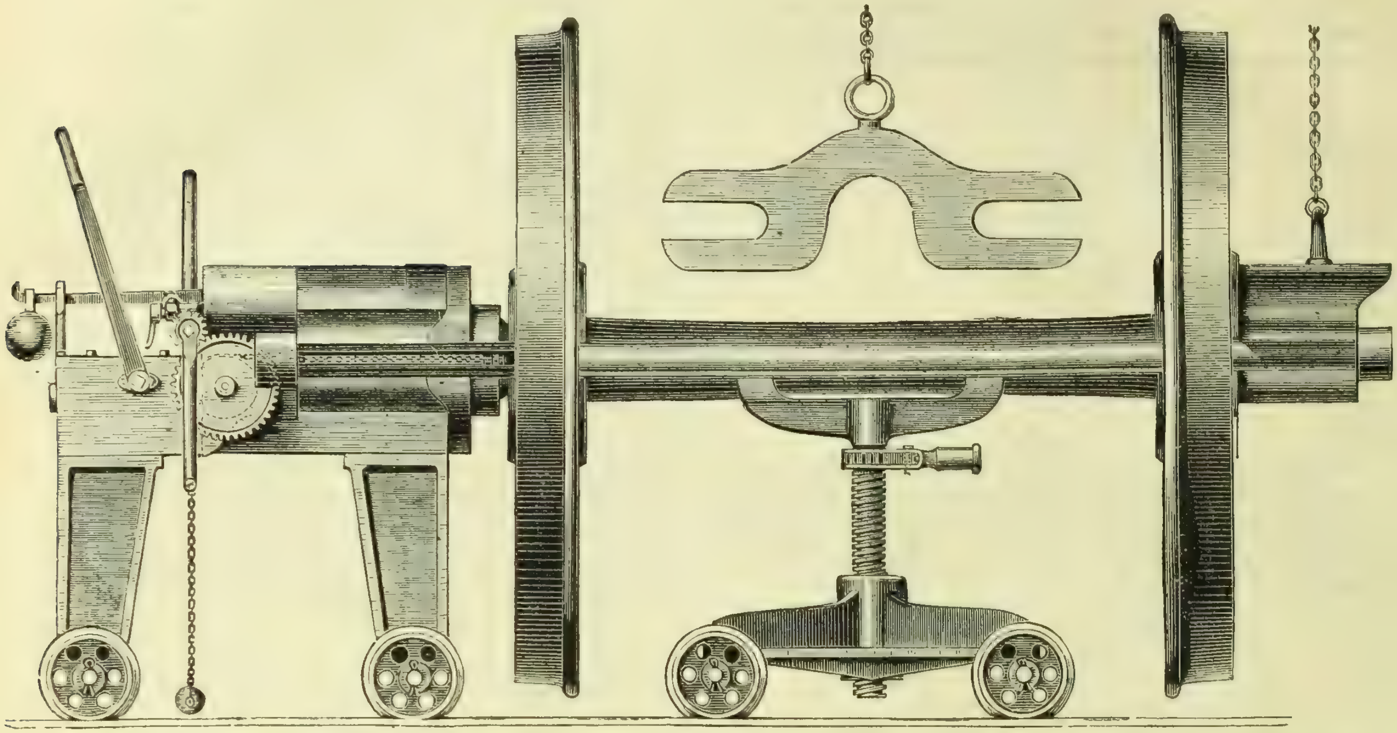


Fig.

IMPROVED HYDRAULIC WHEEL PRESS.

CONSTRUCTED BY MESSRS. YOUNGS, ENGINEERS, RYLAND STREET, BIRMINGHAM.



IMPROVED HYDRAULIC TOOLS.

We illustrate, on this and the next page, several hydraulic tools of improved modern type, as constructed by Messrs. Youngs, engineers, Ryland Street, Birmingham. They are a powerful hydraulic wheel press for forcing wheels on their axles, a very efficient and reliable form of hydraulic jack, and a hydraulic punching bear. The wheel press consists of a suitably proportioned cylinder and ram, a windlass drawback gear, a pair of gun-metal pumps working in a cast-iron cistern and fitted with stop and safety valves, the whole combination being mounted upon a frame running easily upon four wheels. To enable the carriage and engine wheels to be properly adjusted and dealt with, a screw elevator is used, also mounted upon four wheels. In the illustration the press is shown in position for action, with massive crosshead outside the distant wheel, but attached to the press by tension bars. Another view of the crosshead is seen between the wheels. When attached in the manner just described, it is only necessary to work the pumps by hand, and both wheels are slowly and steadily forced on to their axles, with a pressure which cannot exceed a safe load as set by the safety valve weight. The wheels may be forced off when required by the same machine.

Although hydraulic lifting jacks and punching bears are now in very common and extensive use, yet we think the sections we give this week will interest our readers. In the lifting jack section, A is the reservoir, B the working lever, C the pump piston, D the pump cylinder, E the inlet valve to the pump having a gauze covering, F is the ram cylinder, G the screw hole for recharging the reservoir, H the ram, J the ram guiding key, and K the discharge screw to allow lowering. The action is too familiar to require description. We may state, however, that the small discharge hole shown in the ram cylinder above the key J serves to allow the water to escape when the jack has been raised to its full height. The hydraulic bear acts in a precisely similar manner, and the lettering indicates similar parts. In filling these tools it is better to use rain or distilled water in which about ¼oz. of soda has been dissolved; this arrests rust or corrosion. When there is danger of freezing it is better to use equal parts of glycerine and water. These hydraulic machines are exceedingly handy and reliable tools.

WESTINGHOUSE BRAKE ON THE GOTHARD RAILWAY.*

Since the end of March, 1888, the introduction of the Westinghouse brake on the Gothard Railway has been definitely decided on. Hitherto the ordinary vacuum brake has been employed on this line, and the directors in adopting the automatic pressure brake have only yielded to the representations of the Railway Department of the Swiss Government, which was very desirous of having a uniform system of brake on all the railways.

For the long steep gradients occurring on the Gothard Railway the ordinary arrangement of the automatic Westinghouse brake was not considered perfectly satisfactory, as the pistons are not tight enough to allow a lengthened application of the brake without renewing the supply of air to the reservoirs from time to time, and it is somewhat difficult to regulate the action of the brake in this way, while besides, in case of its automatic application, the train has to be stopped while the blocks are released separately on each vehicle.

To remedy these defects, a double line of pipes in connection with an additional valve, as used on the Paris-Lyons-Mediterranean Railway, was adopted. By means of this valve, designed by Mr. Henry, chief engineer of the above-named line, the brakes can be controlled independently of the auxiliary reservoirs and triple valves, direct from the main reservoirs without interfering with the automatic action, while when the latter comes into play all the brakes can be simultaneously released by the driver.

On the 14th and 15th of March trial trips were made to test the efficiency of the new brake with satisfactory results, which, however, as regards regularity of speed in descending long gradients were not superior to those obtained with the vacuum brake. The train consisted of a locomotive, tender, and ten vehicles, weighing together 183·03 tonnes (179·37 tons), to 53 per cent of which the Westinghouse brake was fitted, or including all, brakes could be applied to 71 per cent of the total load. The trial took place over maximum gradients of 1 in 38, and on the latter gradient with all the brakes in operation, reversed engines and the use of sand on the rails, the train was brought to a stop in 10½ seconds when running at a speed of 45 kilometres (28 miles) per hour in a distance of 83 metres (272 feet).

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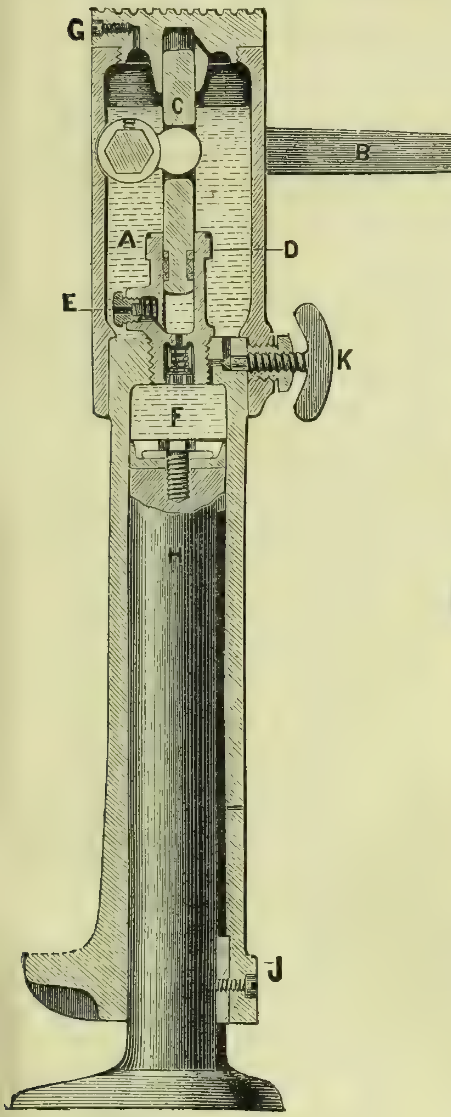
* Foreign Abstracts, Proc. Inst. C.E.

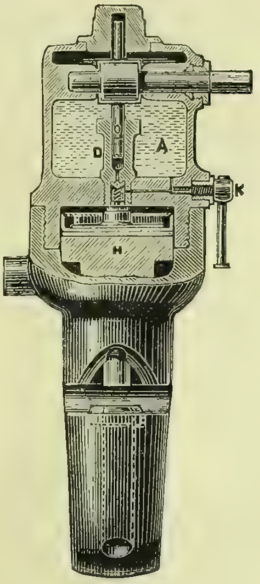
MATERIALS OF ENGINEERING.—XI.

Alloys of Copper.

The blending of metals to form alloys is an enigmatical process, from whatever aspect it is regarded. Apart from previous knowledge, it seems impossible to predicate beforehand what the result of any given mixtures may be. In some cases true chemical compounds are formed, in others mere mechanical mixtures. A third class appears to consist both of compound and mixture in the same alloy, while a fourth class, that in which the disproportion in the elements present is very great, cannot be properly explained. Most alloys, as the term is usually understood, appear to belong to the third class, the union of elementary bodies in their combining proportions forming new materials, characterised by properties differing from those of their constituents, while the excess of one element is found in a nearly pure condition between the crystals of the alloy. Thus, as a very familiar example, in common brass, portions of tin or lead are often seen by the naked eye scattered throughout the alloy, imparting to it a patchy appearance. On the other hand, there are a large number of materials which are not usually termed alloys, in which it is impossible that true chemical combination can have taken place, owing to the very minute quantity in which one of the alloying elements is present, notwithstanding that the qualities of the resulting product is affected so much as to constitute practically a new material. Thus the mechanical interspersion of graphite among the crystals of cast iron alters the aspect, fusing point, and strength of the iron, making it in all respects different from the iron from which carbon is entirely absent. Though the grey cast iron is not usually termed an alloy, yet, regarding its physical qualities, it is as much entitled to be so called as gun metal or bell metal, which are in the main true chemical compounds of copper and tin.



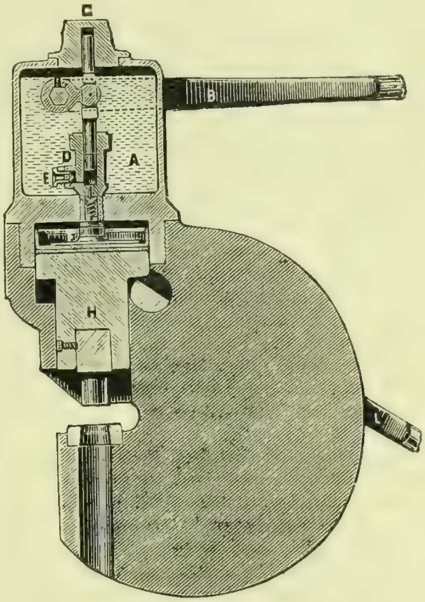
Hydraulic Jack.



Punching Bear.
Transverse Vertical Section.

We are not surprised at the large number of alloys of copper used in engineering when we bear in mind how trifling an alteration in the proportions of the elements employed will modify physical characteristics. Those who have read Mr. Austin's Cantor lectures, recently reprinted in *The Practical Engineer*, will have marvelled at the extremely small additions of foreign ingredients which will suffice to change the characteristics of a metal. Thus, while pure gold, when alloyed with copper in the proportion of 9 parts in the hundred of the latter, will have a tenacity of 18 tons per square inch, it will have that tenacity reduced to 5 tons by the addition of one two-thousandth of its mass of lead, and its golden colour will be changed to an orange brown. Pure bismuth crystallises in broad mirror-like planes, and reflects light; but if the one two-thousandth part of tellurium be added thereto, a minutely crystalline structure is produced which scatters light. The influence of foreign matters on the tenacity and ductility of copper were touched on in the last article, and since chemical union in combining proportions will not satisfactorily account for these results, Mr. Austin seeks to connect them with the periodic law of the elements, and shows that those elements whose atomic volumes are more nearly identical form by their union the least fragile compound.

The differences in the physical characteristics of the metals offer no bar to their union in alloys if the operation is properly performed. Various devices have to be employed when the fusing points are widely different, and when one element is more susceptible of oxidation than another, and when the difference in their specific gravities is considerable. In the mixture of alloys whose constituents have widely different melting points, it is a difficulty to ensure homogeneity. Hence precautions are necessary, such as melting the metal whose fusing point is highest first, then adding the metal whose fusing point is low, stirring the whole. Pouring rapidly, and pouring "dead," that is when the alloy is near the point of solidification, is also adopted. The practice often is to make an alloy of the more fusible metal along with a small quantity of the less fusible, and then add that in measured quantities to another portion of the alloy. Thus, the compound "temper" is employed in mixing the softer copper alloys; 32 parts of tin are added to 16 parts of copper to form an alloy, and this "temper," as it is called, is added afterwards to tin, to form the precise grade of metal required.



Punching Bear—Sectional Elevation.

The density of an alloy may be greater or less than the mean density of the elements in its composition. The strength is usually greater than the mean of its constituents. Alloys are more fusible than the mean temperature of the fusibility of their constituents. The most infusible metals are easily melted when alloyed with others, and if the more fusible elements are gradually eliminated, the melting point is gradually raised. Alloys are generally harder than the mean hardness of their constituents. Alloying tends, in some cases, to increased ductility, in others to brittleness. Some alloys give out heat, others absorb heat during their union. J. H.

THE CHANNEL TUNNEL.*

By Col. H. Montague Hozier.

When I request you to-night to bear with me for a short time, while I endeavour to discuss the question of direct railway communication between our country and the Continent, I must at once say that I do not propose, and I am not capable to advance, any arguments of an engineering or scientific character. I purpose merely to seek to examine this matter from a common-sense point of view. I wish to weigh those arguments which should guide ordinary opinion as to whether such communication would be advantageous or disadvantageous to us as a nation. On the mass of individual opinion public opinion is built, and it is public opinion which must eventually determine whether railway communication with the Continent shall be established, or whether we shall remain for ever, even more than in the days of Horace—

> Toto divisos orbe Britannos.

It appears to me that this question is essentially commercial and not military. If the commercial necessities of a country require such a communication, it must be the duty of the army and navy to provide for the security of our island, even under altered circumstances and new conditions. There was a certain increased risk of invasion incurred when steam navigation was introduced, and also when railways were established and developed, since both allowed troops to be concentrated and carried more rapidly than under previous conditions. Some military men objected strongly to the construction of railways; but the great Duke of Wellington swept away the objections, which had no influence on his clear and vigorous intellect; and during the fifty years that railways have endured no practical disadvantage has arisen from them. No one would now dream of proposing to prohibit by act of Parliament that British subjects should own steamships, or that steamships should be forbidden to approach our shores, or that railways should not be allowed on account of the infinitesimal risk of danger which they still present. The commercial advantages of steam communication surpass so enormously the infinitely small risk it presents, that the risk is forgotten, while the commercial advantages are daily more and more appreciated.

It seems to me that the question of railway communication between England and the Continent is much in the same condition as the question of internal railway communication was fifty years ago. There is an opposition—a strong opposition—to its establishment, and we must respect the opinions and views of those who still oppose it; but so soon as the enormous commercial advantages which must accrue to this country by its establishment are appreciated, the opposition will die away, and in a short time the fact that there was an opposition will be entirely forgotten.

Nor must we lose sight of the fact that our commercial prosperity is the first and most important element to be considered. Even from a strictly military point of view, it is our commercial energy and our commercial power which gives us the wealth that enables us to equip fleets and to recruit armies. Without the commerce which provides the most important of the sinews of war, we in England should be powerless as a military nation, instead of holding a position in the forefront of the councils of the world. It is therefore most important to consider whether our commercial supremacy is threatened, and if so, by what means it can be most readily strengthened. I propose to discuss the matter in the following order :—

1. Whether for the sake of the maintenance of our commercial supremacy direct railway communication with the Continent is desirable.
2. If it be so, how that communication can be best obtained.
3. Whether any sufficient reasons of national importance exist to justify the Government of the country, as guardian of the common weal, in opposing the establishment of such communication.

The great Napoleon taunted the English with being a nation of shopkeepers. We now recognise that we are a nation of shopkeepers, and we glory in being so. It is on the fact that we have been the shopkeepers, the warehousemen, the carriers, and the manufacturers of the world that our national wealth, and hence our national greatness, depend. To every interest in this island our commercial prosperity is of the most vital importance. This is self-evident as far as the manufacturer, and merchant, and all professions dependent or allied with the manufacturer and the merchant are concerned. A little consideration, too, shows that the landowner, agriculturist, and every sort and condition of class, is equally involved in the matter of our commercial prosperity. Without the wealth which the merchant and the manufacturer collect and produce, the land and the produce of other classes would find reduced or doubtful markets. For many years after the beginning of this century England was commercially omnipotent, and had no rivals. Now the case is very different. The steam engines formerly built in this country for continental markets are now made in Belgium or Germany; the construction of harbours, canals, and other engineering works are entrusted to continental firms. Manufactories of every description have been established, and are every day more extensively developed in every European country. On the other hand, although our commerce has not entirely stood still, yet it has increased far less proportionately than that of many continental countries.

Our commerce may be broadly divided into—

(*a*) The products which we manufacture and export in our character as manufacturers.

(*b*) The products which we import and distribute as warehousemen and distributors.

(*c*) Our great carrying trade.

With regard to the direct exports of manufactures, although there has been no actual falling off in the values of the amounts which we have exported, yet our exports have not increased in anything like the proportion to our population, which the exports of most continental countries have to theirs. While our total exports increased in value between 1865 and 1875 about 27 per cent, those from Belgium increased about 95·83 per cent, and from Holland about 192·51 per cent.

Our distributing trade—that is, the products which we import and distribute—has very considerably diminished. From 1805 to 1886 the population increased over 23 per cent; our total exports increased by 24 per cent: but the exports of produce brought here to be distributed only increased 10 per cent. An ingenious method has been discovered by Mr. Giffen of reducing values in different years to a common denominator. From this it seems that our foreign and colonial exports, which in 1873 were in value £56,000,000, fell in 1883 to £23,000,000, a fall of £20,000,000 lost to this country. About twenty years ago the whole of the silk of Asia was brought to England in a raw state, and was thence distributed to the Continent. In 1875 the raw silk coming to England for exportation was 2,300,000lb.; in 1885 it had fallen to 300,000lb. This is a sample of a certain class of goods. Between 1865 and 1885 the imports from the Australian colonies into the United Kingdom increased 56 per cent, into France 11,000 per cent, into Belgium 5,400 per cent, and into Germany 6,600 per cent. Now, it might reasonably be urged that the Suez Canal has been the cause of these changes—that goods from the East, which formerly came to England to be warehoused and distributed, are now sent through the Suez Canal on account of the facility of communication with continental ports on the Mediterranean direct to continental countries, and it cannot be denied that the Suez Canal may have done something to divert trade from this country. Telegraphic communication, which allows large stocks not to be retained, may also have done something; yet if the Suez Canal has been the cause of this diversion of the trade of England, it only shows that facility of communication with markets is of enormous advantage. Goods coming through that canal are not delivered at the place of manufacture, but have to go to ports where they are put on railways and sent to the factories by direct railway communication. But if we grant that the Suez Canal has done a great deal to divert trade in Oriental articles, such as silk, the Suez Canal cannot be responsible for the diversion of the distributing trade from America. In 1875, 2,300,000 cwt. of cotton came to this country from America for export abroad; in 1885 the amount of cotton brought from America to the United Kingdom for foreign exportation had fallen to 1,800,000 cwt. The diversion of the United States trade cannot be due to the Suez Canal. A great deal of this trade goes to the northern ports of France, or in the case of Belgium, Holland, Germany, to the North Sea ports. Formerly these ports traded only with England; bulk was broken at English ports, and goods were trans-shipped in small vessels. Now bulk is not broken; the large steamers run direct to the continental ports, and the trade which used to give employment to our merchants, our warehousemen, lightermen, docks, dock labourers, and stevedores passes by our shores and goes straight to our foreign competitors.

I do not wish to weary you with dry arrays of figures, but this fact may be clearly seen by the following considerations :—

The value of goods imported from the United States into the United Kingdom increased in the 15 years following 1870 by about 60 per cent, while that of the goods imported into Belgium from the United States increased 280 per cent, and into Holland

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* Paper read before Society of Arts, Wednesday, January 16, 1889.

161 per cent. Coffee, too, exported from the United Kingdom to continental countries, for which the Suez Canal cannot be to blame, in 1875 was 1,170,000 cwt., but in the year 1885 fell to 700,000 cwt. On the other hand, certain imports into continental ports have increased very largely. The wool imported into Antwerp in 1865 was 115,558 bales; in 1885 it was 200,618 bales. From the River Plate, which cannot be affected by the Suez Canal, the import of wool into Dunkirk in 1865 was *nil*, but in 1885 it was 138,866. The coffee imported into London in 1875 was 79,700 tons; in 1885 it had fallen to 51,780 tons. The import of coffee into Havre, which in 1875 was 45,650 tons, had risen in 1885 to 100,890 tons. Thus, while the import of coffee into London fell by about 28,000 tons, that into Havre increased by about 55,000 tons. These figures, and many others, prove conclusively that articles of this nature have been diverted by being sent direct to continental ports, where they can be put on railways, and sent directly to the place of manufacture.

The manufacturers of England are allowing the raw material to be sent to their rivals chiefly, as it seems to me, because they will not give their customers easy access to their markets, and obtain facilities for the prompt delivery of their goods. The great manufactures of the world are surely and not slowly being transferred from England to settle in Belgium, France, and other countries, and our financial business is following them. The course of finance is undoubtedly following the course of trade. It is indisputable that an enormous amount of financial business that used to be done in London and England is now being transferred to Antwerp, Havre, and other places, because goods are consigned direct to these parts. Those who study the correct records of late commercial history must feel that we are daily committing one of the greatest errors that a nation of shopkeepers can commit in maintaining a difficult access to our factories and warehouses on the part of our customers. Few can study without surprise the returns of the travellers who pass from Italy to France, from Spain to France, from France to Germany, and from Russia to Germany, and the comparatively small number of passages made between the Continent and England. It is only natural that continental customers should prefer to make their purchases on the Continent of Europe rather than cross the Channel and come to England. What would any sane man think of a large shopkeeper in this country who provided every facility for his customers, spacious and clear entrances to his stores, well-covered porticos, easy access to his counters, and prompt delivery of his goods? It would immediately be remarked that that man was entering on a course which would probably lead him to wealth. What would the same critic think of another shopkeeper who said to his customers, "I will supply you with the best goods at the cheapest rates, but I insist as a preliminary to your entering my shop that you should be tossed about for two hours in a diabolical machine? Your ears will be offended with the creaking of machinery, your nose with the smell of oil, and a number of people around you will be visibly and painfully ill." Would it not be believed that this shopkeeper was taking the most happy measures to reduce himself to bankruptcy? Common sense dictates that facilities of communication between purchasers and markets must be of enormous commercial importance. Yet our manufacturers and our merchants insist upon their continental customers undergoing an ordeal from which it is not unnatural that the continental customers are only too ready to recoil. Within our island we appreciate facility of communication, and neglect no opportunity of increasing it. Bridges are being thrown across the Forth and the Tay to connect the small population north of those estuaries with their fellow-countrymen in the south. Tunnels have been driven under the Mersey and the Severn; Manchester is constructing a ship canal. Everywhere railways are developed except to connect England with the Continent, and to open our markets to the most numerous of our customers. In other countries the same is seen. Great bridges have been thrown over the Mississippi and the Ohio. Tunnels have been driven through the Alps under Mont Cenis and the St. Gothard. The Alps were almost as formidable a strategical obstacle between Italy and France as is the English Channel between England and France, but the Italians had no fear in allowing tunnels to be constructed.

(To be continued.)

COLLIERY ACCIDENT.—A singular cage accident is reported from the Bolton Colliery, near Sunderland. A boiler exploded in the engine-house, releasing the machinery. The cage was precipitated to the bottom of the shaft, with the result that one of its occupants was killed.

PRACTICAL RULES FOR SPIRAL SPRINGS.

As the question of formulæ for spiral springs so often occurs in practice, the following notes may be useful to readers generally.

It is found when testing springs that their fault, if any, generally lies in the direction of softness, thus producing, under pressure, permanent set. A temper such that a smooth file will just touch the angle for marking purposes is generally the right one. The writer, after testing scores, has found this to be invariably the case, and a properly tempered spring should successfully bear the test of having its coils brought close together (when the space between the coils equals not more than two-thirds the section of the wire of which the spring is made) without any permanent set whatever.

In coiling spiral springs of square section it is frequently the case that the coils have an altered section diametrically, the outside being thinner, while the inside is found to be considerably thicker, than the original section, due to the compressive and tensile actions that take place on the inside and outside diameters. This always happens in springs that are made without proper appliances, and it is therefore recommended that springs for any important work be procured from some spring maker who makes springs a specialty. A correctly proportioned spiral spring for safety valve should admit of being compressed through a distance equal to half the diameter of the valve with the working load. If made stronger, the accumulated load, when the valve is lifted either by the steam pressure or the lifting gear, becomes excessive, and thus prevents the valve opening freely to discharge the surplus steam in the boiler before it has risen several pounds per square inch higher than is desirable. Too great attention cannot be paid to this point, and the spring should consequently be designed to give a compression of at least a quarter of an inch for every inch in the diameter of the valve, in addition to the initial compression due to the load, thus allowing an escape area around the valve equal to the valve area, without causing an excessive amount of strain to be thrown on the lifting gear, weigh shaft, and levers.

Formula for springs :—
Let A = area of valve.
„ C = 11,000 for square and 8,000 for round steel.
„ D = diameter of spring, centre to centre of coil.
„ E = compression or extension of one coil.
„ P = pressure per square inch.
„ d = diameter of steel, or side of square in inches.
„ d_1 = diameter of steel, or side of square in 16ths of an inch.

Then

$$d = \sqrt[3]{\frac{A \times P \times D}{C}}$$

$$\text{Let } E = \frac{D^3 \times A \times P}{d_1^4 \times 30} \text{ for square steel,}$$

$$\text{Then } E = \frac{D^3 \times A \times P}{d_1^4 \times 228} \text{ for round steel.}$$

MANUFACTURE OF GAS FROM PETROLEUM OIL.*

AFTER having referred to the systems of air-carburation, and the need for motive-power, with the liability of the gasoline or petroleum oil to be separated into two parts, by the action of refrigeration, Mr. Gautier shows how the conditions of the problem are reversed in his automatic system of continuous production of clear gas, in which the gas is vaporised, and the current of vapour so produced is utilised for the induction of air, and mixture with it. The liquid is conducted from the reservoir into a small vaporiser, or boiler of sheet steel, about 3in. in diameter, sufficient for supplying forty burners. The complete volatilisation of the gasoline, without residue, is effected by a burner which is supplied from the gasholder. The gasoline vapour passing off by a small tube draws air on the principle of an injector, in the course of its passage to the gasholder in which the mixture is stored, and from which the supply for the burners is drawn. Over-production is checked automatically by means of two levers which are struck and moved by the crown of the gasholder when it approaches the limit of its rise; one of them regulating the supply of gasoline, the other the supply of air.

This gas does not cause any smell. It is a little heavier than air. Volume for volume, it yields double the light, and twice the heat from ordinary coal gas.

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* Foreign Abstracts, Proc. Inst. C.E.

AN ENGINEER'S LIFE AT SEA.—XXII.

BY A SEA-GOING ENGINEER.

Examination and Training of Engineers.

When at sea, every "junior" should always have an eye to the examinations yet to come. The "ticket" is not given in order to put a man into a certain post that he may then learn its duties. These duties are supposed to be already well known to the applicant, and the certificate is intended to be simply a recognition of the fact. A "third," before going up, should know well all the various duties of a "second," and feel confident that he could take his place in case of accident or sickness. Of course, the examiners are aware that he is without the experience given by practice, but for this due allowance is made. While, however, an incompetent "second" may be kept straight by his chief, the latter has no one to perform the same office for him, and so the examination for chief is more strict than that for "second," and the knowledge expected takes a wider range.

In "trying" for chief, the engineer must know the principal rules for the strength of boiler plates, stayed or unstayed, under a bursting or a collapsing strain; the ultimate strength of iron and steel, and what allowance must be made for riveting and for the factor of safety. He must know which plates vary directly in strength according to their thickness, and which vary according to the square of the thickness. He must know something about the twisting strains on shafts, and the strength of beams variously loaded and supported, as well as the strength of bolts and cotters. He should also be familiar with all the calculations he is likely to meet with in practice, such as the safety valve loads, and the horse power of engines as obtained from indicator diagrams. Besides the strength, he should know the weight of all the materials he has to deal with, including the weight of fresh and salt water, and the stowage room to be allowed for coal. He will also be none the worse for knowing the chief constituents of coal, iron, steel, or brass, and he should be familiar with the composition of salt water, and understand clearly what it is that the salimometer has to tell him. He should, for instance, be prepared to explain how to make a salimometer, or how to get the saltness of water from its boiling temperature without a salimometer at all. He should also make a special study of the proportions of his engines and boilers, so that with a given area of fire-grate he can tell the size and proportion of every part; what consumption of coal he should have; what weight of water should be evaporated, and what power developed. He should also verify formulæ and rules by actual measurement of his engines, and make new rules for himself, which he can afterwards compare with other engines, and thus learn what is the practice of various makers. All such information is certain to be of use to him in his career, though not all actually essential for passing. If, however, his highest aim is only to know enough to get through, with nothing over, he will probably fail. Examiners have an unfortunate habit of asking just those questions which are not expected, and it is safe to regard them as trying to find out, not what a man knows, but precisely what he does not know. A "second" should remember that all the information required to pass as chief must be acquired while he is still acting as "second," unless he should be fortunate enough to be chief of an under-powered boat while only holding a "second's" certificate. He should also remember that it is only by taking interest in his present work, and by proving himself an active and efficient "second," that he can hope for either a certificate or a situation as chief. If he thinks himself to be a better man than the chief, he can afford to be forbearing in the knowledge that his turn is sure to come before long, and all promotion at sea usually comes unexpectedly. He should also remember that if he cannot obey he is unfit to rule, and that if he does not serve well he can hardly expect others to serve him better. This may seem to have little to do with his training for examination, but the connection between his moral and mechanical qualifications is a close and intricate one, and is by no means overlooked by the examiner when he comes up for his "verbal."

A "second" will find that the apparently simple duty of estimating the coal required on board is by no means so easy as it looks. Every chief should measure his bunkers for himself, and know how much coal a foot of vertical height represents at any given distance from the top or bottom of the bunker. It is worth noting that bunkers should only be measured to the lower edge of the deck beam, as even if the trimmers can throw the coal to fill up to the deck, yet it will settle down again. This may seem a small matter, but nothing connected with the coal can be safely overlooked. The amount also used in port and in getting up steam, or in lying under banked fires, is easily underestimated, and such may lead to serious error. In getting coal on board, especially in a foreign port, the chief should appoint a reliable man to the sole duty of seeing that the coal is properly trimmed. Without this he cannot know how much coal he has on board during the voyage. Again, if coal has to be got in a foreign port, the chief has to use all his wits to see that he gets the amount he has ordered. Through shortness in this respect one steamer got into Gibraltar with only coal for another hour's steaming on board, and owing to an empty space in the middle of an otherwise full bunker another steamer had to get coal at Holyhead in order to carry her up to Liverpool. Such matters may to a "second" seem to be trifles, but they often entail considerable anxiety on a chief. His anxiety he will probably find to be well grounded if the coal agent offers him a present, for, owing to the keen competition among coal agents and consequent cutting down of prices, he may feel sure that he has been cheated in his supply, and must look out for trouble ahead. Experience confirms this.

In connection with the duties of a chief, there should be a clear understanding with the "second" in the matter of work. Some chiefs in small steamers have to help with the overhauling in port. This, unless absolutely necessary, is rarely satisfactory. No "second" wants to be needlessly interfered with, but on the other hand a chief must not even appear to shirk work. Perhaps the best plan with a new "second" is for the chief to put the matter directly to him by stating that he is ready to assist in any way, but that if the "second" desires it he will keep out of the engine-room as much as possible, and only exercise a general supervision. In nearly every case the "second" will choose the latter alternative. Of course the chief, if he is fit for his position, must exercise a real supervision, but it will be none the less effective if unobstrusive, and the same insight which lets him know if he has a good "second" will show him that it is best to give such a man a practically free hand. Even with an unsatisfactory "second" the less needless interference the better, for his freedom, if skilfully guided, will get much more useful work out of him than if his self-respect is lessened by harassing interference and control.

Again, it is sometimes not easy for a "second" to feel respect for a fair-weather chief, who struts about in the pride of authority when all is going well, but who in a serious breakdown or in bad weather collapses into a helpless object, who has to be kindly but politely urged to leave the engine-room till the work is completed. It is, however, worth remembering that for every such unworthy chief there is at least one corresponding unworthy "second," who is on his way to the same position, and also that in addition to this there is a large extra number of equally inefficient "seconds" who will never attain to the rank of chief at all. Though an inferior man may occasionally attain to a superior position, and may stop there for a time, yet the weakness of a chief in one or two points may, on the other hand, be more than counterbalanced by his strength in other and equally important points, and the "second," before deciding that the chief and he should change places, should consider that all the balance of probability is in favour of the chief being a better man than himself, whether he chooses to think so or not.

BELT AND ROPE GEARING.—III.

The Power of Belts.

The amount of power transmitted by a belt is equal to the product of the resistance (at the circumference of the driven pulley) and the velocity at which the belt travels. When the resistance is estimated in pounds and the velocity in feet *per minute*, the product of the two will be a measure of the work done in foot pounds *per minute*; and 33,000 foot pounds per minute being equivalent to one horse power, it follows, therefore, that

$$\text{Horse power H.P.} = \frac{\text{resistance} \times \text{velocity in feet per minute}}{33{,}000} \qquad (12)$$

From this we may obtain the value of resistance R, in terms of the power and the velocity (in feet *per minute*), that is to say

$$R = \frac{33{,}000 \times \text{H.P.}}{\text{velocity in feet per minute}} \qquad (13)$$

If the velocity be taken in feet *per second* v, then

$$R = \frac{550 \times \text{H.P.}}{v}\,; \qquad (14)$$

Now, the resistance R is equal to the difference of the two tensions T and t, so that

$$R = T - t \qquad (15)$$

and as $T = r \times t$ (see formula 8), by substituting this value of T in formula 15, we obtain $R = (r \times t) - t$; or $R = t\,(r - 1)$; and it follows that $t = \frac{1}{r-1} \times R$ (16)

If the symbol k be taken to represent the fraction $\frac{1}{r-1}$; then

$$t = k \times R \qquad (17)$$

It will be seen that the value of this co-efficient k depends entirely upon the values assigned to μ, the co-efficient of friction, and also to the amount of arc embraced by the belt.

Diagram 2 has been constructed for the purpose of enabling the various values which the co-efficient k will have under the various conditions which may exist, to be found without calculation.

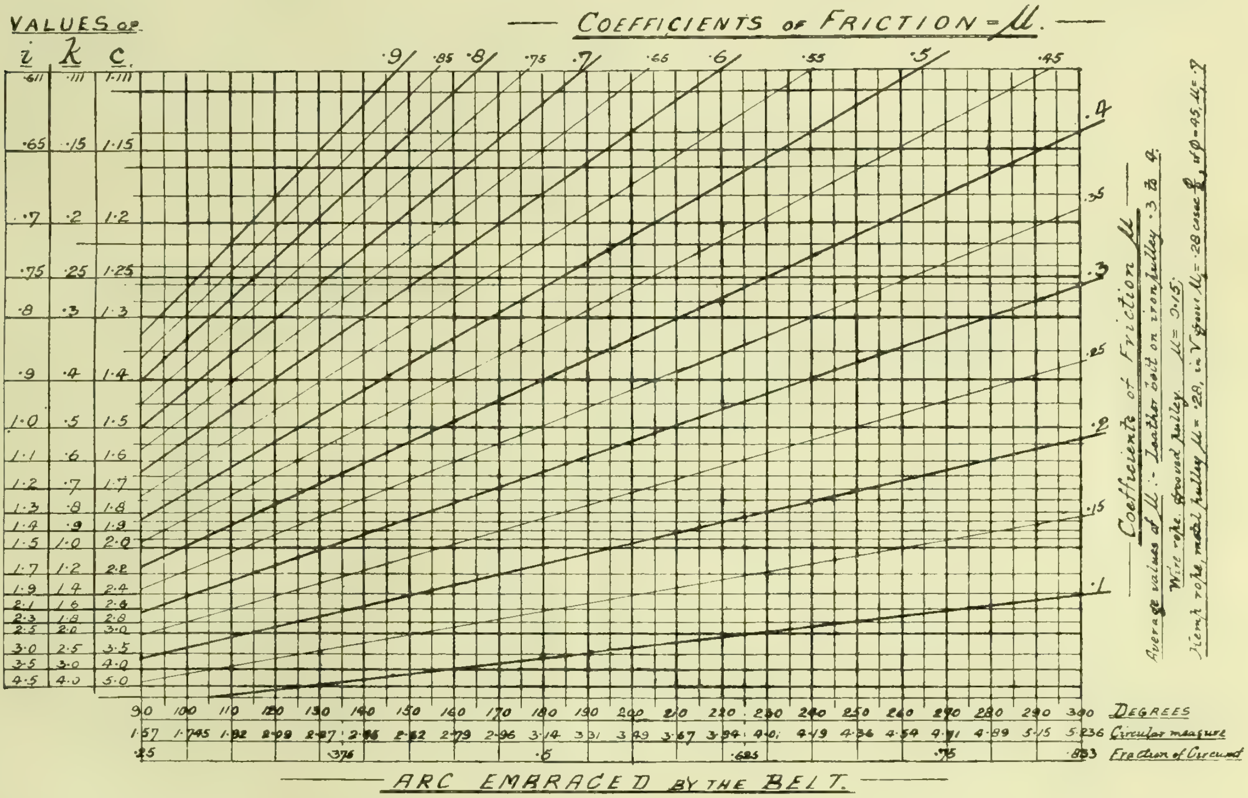
Proceeding a little further with our investigation, it follows that as $T = r$ times t, we may write

$$T = \frac{r}{r-1} \times R; \qquad (18)$$

and if c be used in place of the fractional co-efficient $\frac{r}{r-1}$ we have

$$T = c \times R \qquad (19)$$

the value of the co-efficient c being obtained by reference to Diagram 2 also,



Graphic Diagram No. 2.—Giving the values of the co-efficient k.

Now $R = \frac{T}{c}$

Therefore $\frac{T}{c} = \frac{550 \times \text{H.P.}}{v}$ and it follows from this

that

$$T = \frac{550 \times \text{H.P.} \times c}{v} \qquad (20)$$

and as the tension T on the belt is equal to the sectional area of the same multiplied by the stress per unit area; that is, T = area of belt × stress per square inch, we obtain—

$$\text{Sectional area of belt} = \frac{T}{\text{Stress }(s)} \qquad (21)$$

By substituting the value of T, as given in formula (20), we get

$$\text{Area A} = \frac{550}{s} \times \frac{\text{H.P.}}{v} \times c \qquad (22)$$

and if s be taken as 300lb. per square inch, then

$$\text{Area A} = 1{\cdot}83 \times \frac{\text{H.P.}}{v} \times c \qquad (23)$$

Formula (23) gives the sectional area of belt theoretically necessary for the transmission of a given horse power under certain conditions of working, and where the speed is *abnormally* low.

Since $v = \frac{\text{dia. in inches} \times 3{\cdot}1416 \times \text{revolutions per minute}}{12 \times 60}$ $= {\cdot}004363 \times \text{dia. in inches} \times \text{revolutions per minute}$. Therefore, by substitution, $T = \frac{550 \times \text{H.P.} \times c}{{\cdot}004363 \times \text{dia.} \times \text{revolutions}}$ and since $A = \frac{T}{S}$ we have

$$A = \frac{126050 \times \text{H.P.} \times c}{S \times \text{dia.} \times \text{revolutions}} \qquad (24)$$

and therefore

$$A = 420 \times \frac{\text{H.P.}}{D \times n} \times c \qquad (25)$$

From this we may obtain the sectional area necessary under *similar* conditions of working, as mentioned in connection with formula (23), but in this case obtained in terms of the horse power transmitted and the *diameter and revolutions* of the driving pulley. Note: See formula (39), and column 2, Table II.

Initial Tension.

The "initial" tension that would be required under these *same* conditions may be found thus:—

$$\text{The initial tension } I = \frac{T + t}{2} \qquad \text{(formula 3)}$$

and as $T = \frac{r}{r-1} \cdot R$, and $t = \frac{1}{r-1} \cdot R$, it follows that

$$I = \frac{\frac{r}{r-1} \cdot R + \frac{1}{r-1} \cdot R}{2}; \text{ or}$$

$$I = R \times \left(\frac{1}{2} \cdot \frac{r+1}{r-1}\right), \text{ and on}$$

putting i for the co-efficient $\left(\frac{1}{2} \cdot \frac{r+1}{r-1}\right)$ (see diagram 2)

we get

$$I = R \times i \qquad (26)$$

and further, on substituting the value of R in terms of the horse power and the velocity, we may write

$$I = \frac{550 \times \text{H.P.} \times i}{v} \qquad (27)$$

It would appear, from a glance at this equation, that any *increase* of velocity would be accompanied by a *proportionate* diminution in the *initial* tension necessary; but, as will be seen presently, there are certain elements which affect very materially the truth of this assumption.

Consumption of Water in Glasgow.—The average consumption of water in Glasgow during the whole of last year was 40,000,000 gallons per day, or nearly 50 gallons per head per day.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STEAM-ENGINE EFFICIENCY.

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To the Editor of "The Practical Engineer."

Sir,—The engines are too large for their load, and the boiler pressure is too high for the dimensions of the cylinders. For the 100lb. boiler pressure the cylinders should not be less than 4 to 1, and as they are now over large, they would be more so if the low-pressure cylinder was increased to above ratio. The I.H.P. is given as 132, and high-pressure is stated to be doing twice the work of low-pressure, so I assume that it at present stands thus:

H.P. 16in. dia., 4ft. str., 58 revo. = 464ft. = 2·82 const. × 35·2lb. M.E.P. = 99·2 I.H.P.
L.P. 28in. dia., 4ft. str., 58 revo. = 464ft. = 8·65 const. × 4·0lb. M.E.P. = 34·6
133·8

Ratio of cylinders, 3 06 to 1.

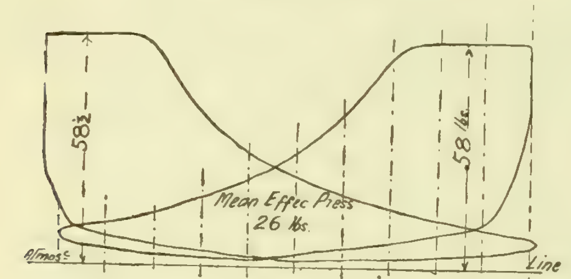
The scale not being given on the diagrams, the mean effective pressures are assumed.

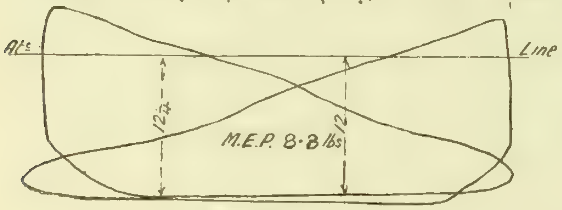
To make the best of the cylinders as they stand, the M.E.P. in high-pressure should be 23·5lb., and in low-pressure 7·7lb., thus:

H.P. 16in. dia., 4ft. str., 58 revo. = 464ft. = 2·82 const. × 23·5lb. M.E.P. = 66·2 I.H.P.
L.P. 28in. dia., 4ft. str., 58 revo. = 464ft. = 8·65 const. × 7·7lb. M.E.P. = 66·4
132·6

giving equal loads for both cylinders.

Scale, 48lb. = 1in.





Scale, 16lb. = 1in.

The diagrams enclosed are from an almost similar engine, and although they are not an illustration of perfection, yet they are what I should advise you to produce from your engine by dropping your boiler pressure down to 60lb., cutting off at about 2½ tenths in high-pressure, and lapping low-pressure slide valve, so as to cut off at 4½ tenths.

I cannot give sketch of actual lap required, as the stroke or travel of valve is not given.

Your engines being too large, with a too high boiler pressure, necessitate a too early cut-off in high-pressure cylinder, which sets up severe initial condensation of steam at each inlet. Again, the vacuum shown in high-pressure cylinder is an extremely wasteful feature; there should not be less than 5lb. back pressure instead.

An economical two-cylinder engine, with cylinders and pressure proportionate, should not cut off much earlier than 4 tenths stroke, and supposing this was the case with these present engines, another drawback presents itself, viz., the Corliss gear, which is not adapted for late cut-off.

The Corliss motion will not trip later than half stroke; consequently there is only 1-tenth stroke range left for governing speed of engine.

However, assuming that 16in. and 28in. cylinders must remain, and that boiler pressure cannot be lowered for other reasons, then the best that can be done under existing circumstances is to lap the low-pressure slide valve to cut off at about 3 tenths stroke. This will increase the M.E.P. of low-pressure diagram and diminish M.E.P. of high-pressure diagram, giving a more equal distribution of power in cylinders, and putting back pressure on the high-pressure piston.

I have within the last three months had two cases where firms have put down new boilers at 90lb. and 100lb. pressure (engines remaining as before), under the impression that increased pressure certainly meant increased economy, with the result that consumptions have gone up 15 per cent to 20 per cent, and have finally had to reduce boiler pressures, with the result of a saving in fuel. The increased pressure has been adopted without their ever having ascertained whether it would "fit," so to speak, the existing dimensions and proportions of their cylinders.—Yours, &c., Draughtsman.

To the Editor of "The Practical Engineer."

Sir,—I would suggest that "L. C. D." make the following alteration to the Corliss valves of the non-condensing cylinder, which I think would be an improvement.

As shown by the indicator diagrams which he gives, the compression in this cylinder is not of very much consequence, owing to the low back pressure due to the ratio of expansion at which the engine is working; and if he is likely to keep at this ratio of expansion, by altering the valves so that the compression commences at about fifteen inches from the end of the stroke, he would reduce the mean pressure in the cylinder, which would also make the powers developed by the two cylinders more equal, and at the same time he would fill the clearance spaces with steam of a higher pressure, and would thus save steam at each stroke. Should "L. C. D." adopt the plan of your correspondent, "R. Bramall," of reducing the cut-off in the low-pressure cylinder, then the compression given above would require modifying.—Yours, &c., Orion.

To the Editor of "The Practical Engineer."

Sir,—Replying, thanking "R. Bramall" and "W. A." for their information, I beg to say, in reply to "R. Bramall," that it was through no fault of mine that the scales were not given with diagrams. As you, Mr. Editor, must know, the diagrams were marked with the scales, high-pressure $\frac{1}{48}$in., and low-pressure $\frac{1}{12}$in. I also gave travel of valve as 8⅓in., but for some reason you did not publish them. The eccentric rod is 13ft. 3in. long. I may also say that the boiler is keenly fired, and therefore shortening bars would not do at all. Would lengthening them, say to 7ft., not improve it? In reply to "W. A.'s" questions, I may say the boiler is not altogether free from scale, but there is not so much that this can be the cause of such a large coal consumption; and having no economisers, the feed-water enters boiler at a temperature of about 100 deg. Fahr.—Yours, &c., L. C. D.

[The scale was not given because drawings were reduced in reproducing. It could easily be obtained from pressures marked upon the diagram.—Ed.]

QUERIES AND REPLIES.

10. P. E. Reader, Paisley, will feel obliged for a sketch and description from any reader of the principle of Higginson's speed regulator as applied to governors.

Answer.—The following is a short account of my governor compensator: Suppose a governor of ordinary construction, such as the Watt or Porter, to be rotating in its normal or mid-position at, say, 50 revolutions per minute. Suppose the steam pressure falls, or the load increases, so that the engine runs slower, and the governor balls fall. This slowing the ordinary governor cannot entirely prevent, and the engine runs slower, say 49 revolutions, as long as the steam is down. If, now, the engineer were to weight his governor by any suitable means, such as the balance weight, which is fitted to most governors, he could bring back the speed of his engine to 50 revolutions if he were to add the correct amount of weight. If, on the other hand, the steam had risen, or the load, or part of the load, had been taken off the engine, it would have increased in speed, and the governor would have risen above its mid-position. If the engineer were again to alter the weight on his governor, this time taking weight off, he could again bring back the speed to 50 revolutions, as before. The amount of increase or decrease of weight required to adjust the speed obviously depends on the size and construction of the governor, and is a matter of calculation or of trial. This increase and decrease of load I effect by placing on the rockshaft of the governor a two-armed lever, supporting on its opposite ends two vessels containing mercury, connected at the bottom by a tube. As the governor rises and falls, the vessels do so also, and, being on opposite sides of the fulcrum, when one rises the other falls. The mercury, of course, runs from the higher to the lower vessel to adjust its level, and in so doing increases or decreases the weight on the governor. The amount of mercury used and the leverage of the arms varies, of course, in each case.—J. Higginson.

12. Knocking in Engine Cylinder.—Some two years ago, I had the cylinder of one of my engines bored out, a horizontal condensing engine with cylinder 20in. diameter, 3ft. stroke, and a speed of 90 revolutions per minute. Since that time there has always been a noise in the cylinder at intervals, sometimes at one end, sometimes at both. At other times the engine will run quite smoothly and noiselessly for hours. I have several times had the piston out, and found all good and in satisfactory working order. It is a sort of clicking noise such as is sometimes heard in starting an engine without first heating it up, but it is not due to water, as I have relief valves at each end of cylinder, a syphon in the steam pipes, with steam trap, &c. If any of your practical readers have had any similar experience, and will inform me how I may stop the clicking noise referred to, I shall be obliged.—Bowling.

Answer.—Some time ago I had a similar experience with an air compressing pump; the piston was single acting, 9in. diameter and 15in. stroke, pressure of compression 90lb. per square inch, and speed 140 revolutions per minute. At times the piston would run with perfect quietness, and then commence making a peculiar clicking noise. I observed that this always came when the pressure was increased to 120lb., and disappeared at lower pressure. I had the piston out many times, and at last found that the metal under the rings was porous. I may say that the piston was a hollow trunk open to the air, and had six cast-iron Ramsbottom rings. The porous metal in the grooves allowed the air under the rings to escape, and the pressure from the cylinders at once collapsed the rings, getting between the surface of the cylinder and the ring faces, the return spring, when the pressure went off, made the peculiar clicking with every stroke. It disappeared entirely when I had a new piston of good metal put in. Is there no leak under the rings to exhaust side of piston through the metal?—Ed.

2. Varnish for Papier-mache Goods.—Would some reader kindly inform me how to make the black varnish that papier-mache goods are coated with? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished?—J. T. L.

3. **Slide Valve of Hydraulic Engine.**—Will some reader kindly inform me which is the best form of slide valve to adopt? The engine makes 20 strokes per minute, and the pressure is 1,000lb. per square inch. I should be glad also to learn what kind of stop valve is generally used for hydraulic cranes.

7. **Blacklead Pencil Making Machinery.**—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery?—B. B.

9. **Grinding Optical Glasses.**—Will some kind reader inform me how to grind optical glasses? Is there a book published on the sublect, and, if so, what is the price, and who is the publisher?

11. **Compounding Engine.**—Could any reader kindly inform me of the best rule to apply for compounding a vertical engine, 12in. cylinder by 24in. stroke? The steam pressure is 60lb., and the high-pressure cylinder to cut of at ⅝ths of the stroke. Is there any rule stating at what part of the stroke the low-pressure cylinder should be cut off, and how much should the area of the casing of the low-pressure cylinder be in order to act as a receiver?—C. E.

TO CORRESPONDENTS.

G. H. F., London.—The sand-blast patents are, we believe, controlled by Messrs. Hookham, of Bartholomew Street, Birmingham. They will, doubtless, re-cut your files by the sand-blast process.

Walter.—In air-compression cylinders it is customary to avoid the use of ports altogether. The cylinder covers are generally constructed to carry both air inlet valves and discharge valves. The air inlet valves, which are generally of the conical seated type, are made as large and numerous as possible, and open direct to the air. The discharge valves are also lift valves, opening within a portion of the cylinder cover, which is practically part of the compressed-air reservoir. You will find details of air compressors in descriptions published in a paper read by the late Mr. Coleman, Inst.C.E., on "Mechanical Refrigerating," dated 1882. We believe that Prof. Robinson has also published a work on this subject. The air inlet areas are generally made larger than steam port areas, but in practice it has been found that air flows more freely than steam, and there is less resistance for a given rate of movement.

J. T.—Certificates for competency in the management of engines and boilers are granted by the Glasgow and West of Scotland Engine-keepers' Association, but they are limited to those at work in the district. We are not aware of any other engine-keepers' association. "Wilson on Steam Boilers," published by Crosby, Lockwood, and Co., is a well-known work, which may suit your purpose.

MISCELLANEA.

Discovery of Salt at Barrow.—For some months past boring operations have been carried out on Walney Island, Barrow, with a view of ascertaining if coal was lying in the neighbourhood. The first borehole was unsuccessful, but in the second hole a splendid bed of salt has been found at the depth of about 300ft. Its extent has not been fully ascertained, but it is reported to be about 70ft. thick. Half of the bed is said to be in a crystallised state. The discovery has occasioned considerable excitement in the town.

Locomotives on Different Railways.—Some interesting statistics as to the engine power of different railways are given by a London correspondent. For instance, the London and North-Western Railway has 2,543 engines, the Midland 1,777, the Great Western 1,600, the North-Eastern 1,506, the Great Northern 829, the Great Eastern 710, the Caledondian 690, the London and South-Western 533, the London, Brighton, and South Coast 410, and the South-Eastern 334, whilst the London, Chatham, and Dover has only 180, the Metropolitan 67, and the District 54.

The Railway Race to Scotland.—A number of new engines of extraordinary weight and power are being constructed in the locomotive works of the London and North-Western Railway Company, at Crewe, in view, it is stated, of the renewal of the race to Scotland in May. The engines are from a new design, with triple boilers, and are being built specially to stand the strain of great speed and increased drawing power. The high rate of speed obtained in the race last season almost shook the locomotives to pieces. The engines now being constructed are about 20 tons heavier.

The Cheshire Salt Trade.—At the new private salt works in course of construction at Winsford for Mr. John Garner, the sinkers in the brine shaft struck a stream of brine, which quickly rose to a depth of 24ft. The men have been engaged cutting the shaft for three months, during which time they have sunk it no less than 210ft. It is the deepest shaft in the Cheshire salt district. Mr. Garner is constructing his new premises on the site of the old works of the Cheshire Amalgamated Salt Company, which he has purchased. Now that rich brine has been discovered, the reconstruction of the old works will be rapidly pushed forward. Mr. Garner's works are promoted in opposition to the Salt Union, which had successfully absorbed every existing manufactory in the Cheshire salt district.

A Novel Canal.—Mr. Arthur Picard, of Leeds, has patented a novel system for canal construction. He proposes to make the water in the canal do the work of the carrier. He divides his canal in the middle, thus forming two distinct waterways, and by a screw, pump, or other method he makes the water into a current, which carries the boats along the canal in one direction on the one side, and in the other direction on the other side of the division. The boats are to be capable of being put on wheels and run along tramways to receive their cargoes. The idea is ingenious, but quite impracticable, as the inventor seems to have quite omitted the consideration of amount of motive power required, and also the impossibility of steering when a vessel is merely drifted along.

The Electric Light in the House of Commons.—An extension of the system of electric lighting is in progress in the House of Commons. Hitherto the only portions of the building illuminated by electricity have been the division lobbies and upper corridors, the library, reading-room, tearoom, smokeroom, and a limited number of other apartments; but when the House reassembles it will be found that gas has also been superseded in the cloakrooms and entrance lobbies, and on the main staircase. It is understood that this is the first step towards the general adoption of the electric light at St. Stephen's, and that before long the oil-lamps used in the committee-rooms will be abolished, and electricity substituted for gas in the public corridors and waiting-halls, as well as in the members' lobby.

Development of Electricity.—It is stated that the Admiralty have definitely adopted into service the engine-room telegraph and electric signalling system known as Willis's patent, which will replace the mechanical system now in use. The Willis's arrangement was subjected to the roughest practical test before its adoption, both on land and at sea, and was the only invention which met every requirement and successfully stood every condition of service. All new ships and vessels refitted will be supplied with these instruments. In appearance and in handling the new electric telegraph is much the same as the old mechanical system. Its greatest advantage is that the engineer, on receiving an order, at once sends the signal back to the officer on the bridge, who is thus assured that his order has been correctly transmitted and understood. The new system will tend largely towards reducing the risk of collisions at sea.

Proposed Ship Canal across Scotland.—The agitation in favour of canals and waterways, which has been waged in England for some time back, has at last extended to Scotland. Such agitations are contagious, and it is not, therefore, surprising to hear the revival of an old suggestion from the north on the subject. The proposal is to improve the present existing canal between the Clyde and the Forth, so that ships might be able to pass through. The canal was constructed a century ago, and is 35 miles long, extending from Bowling on the Clyde to Grangemouth on the Forth—the line being almost due east and west—and there is a branch of 2¾ miles to Port Dundas in the north of Glasgow. It rises 156ft., and has 39 locks. At the present time only very small craft can be passed through, not only because of the short locks, but also owing to the depth of water being but about 9ft. It is proposed that it should be made suitable for deep seagoing ships. There are no great engineering difficulties in the way. The cost is variously estimated between £1,500,000 to £2,000,000 sterling.

Improvement in Fire Stoves.—An important improvement in heating apparatus is being exhibited in Birmingham. It is intended to supersede either the coal fire or an ordinary gas stove, and is named the "Backus" patent heater. The aim of the inventor has been to give the maximum amount of heat at the minimum of cost. The fuel used is gas or oil, applied by an ingeniously-constructed burner or lamp. An intense heat is produced without smoke or smell, perfect combustion being attained; but, in addition to the heat thus obtained, by means of an arrangement of tubing, upon which the flame impinges, a quantity of water is made into steam, which passes into an ornamental chamber, which forms the whole upper part of the stove. The steam at the remotest part of the stove condenses, and the water runs back to be re-converted into steam. The invention, it is stated, will overcome all the objections usually advanced against gas and oil stoves.

Gas Mains as Electrical Conduits.—The problem of conveying telephone and electric lighting wires underground in large cities has received a partial solution in New York, where, for the last few years, a telephone conductor has been run inside a gas main, between the gasworks of the Consolidated Gas Company, at 99th and 111th streets. The conductor enters the gaspipe by a stuffing box, made gas-tight by plaster of Paris. The wire is carried by glass insulators fixed to the roof of the pipe. The length of the circuit is over half a mile, and it has been in continual use. Owing to the success of this experiment a series of new mains have recently been supplied with telephone cables serving for the use of the gas company. Telephone currents are, of course, very weak; and it would be unsafe to run electric lighting wires in mains charged with gas. But the experiment tends to show that the disused mains of a gas company might profitably be employed for running the wires of an electric lighting company underground.

A Dynamite Projectile.—At the invitation of Mr. Snyder, an American inventor, a number of gentlemen inspected at Anderton's Hotel, London, a new projectile. It is in the form of a shell charged with dynamite, and can be fired from any ordinary cannon without explosion until it strikes the object at which it is aimed. Such a result would be impossible if the missile were placed upon the usual cartridge, as the effect of the discharge would almost certainly burst the shot and destroy the gun. To obviate this difficulty, Mr. Snyder uses a slow-burning ammunition, and has an ingeniously designed plug of indiarubber to act as a buffer between the powder and the receptacle in which the dynamite is stored. When placed in the gun, indeed, the shell may be described as in two pieces—the base, containing the plug, being so arranged as to fit like a cap on to the shell proper. This cap receives the first force of the exploding ammunition, presses the yielding indiarubber against a case containing the dynamite, and so drives it forward "by a harmless push, instead of a dangerous blow." According to the statement of Mr. Snyder, this is the main feature of an invention which, he thinks, will alter the whole condition of warfare.

The Graphophone.—The "Tainter" graphophone, which formed an interesting object at the conversazione of the West Bromwich Institute on the 4th instant, was exhibited to a number of visitors at the Cobden Hotel, Birmingham, on the following day. The instrument, which is somewhat akin to the Edison phonograph, is to enable a record to be made on wax-covered cylinders of spoken sounds in such a way that by a reversed process the sound may be again produced, although with much less intensity. A treadle motor revolves the cylinder, while a delicate graving needle cuts upon it a very minute spiral line, varying in depth with the vibrations of a diaphram actuated by sounds spoken over a bell-mouth. By substituting for the engraving arrangement a fine steel point connected with a kind of telephone, with tubes to the ears, the engraved record is re-translated into sounds. The machine has been so far perfected as to be extremely useful, especially for dictating correspondence either for the cylinder to be sent through the post, or for the letters to be re-translated by a clerk; and the company have arranged to let out machines and to sell the cylinders, which are not costly.

The Tower Bridge.—Good progress has recently been made with the new Tower Bridge over the river Thames, of which the contractors are Mr. John Jackson (who is a native of Newcastle) and Armstrong, Mitchell, and Co. The northern approach at Little Tower Hill, together with the north river pier, are very near completion. Each of the river piers, founded in the London clay at a level of 60ft. below high-water mark, has a base about 200ft. long by 96ft. broad. Eight out of the 12 large caissons in connection with the southern river pier are sunk, and the southern abutment has been commenced. It may be added that the total length of the bridge will be 940ft.; the length, with approaches, 2,640ft.; and the opening span 200ft. It is estimated that 31,000,000 bricks will be used in the bridge and approaches, with 19,500 tons of cement, 235,000 cubic feet of granite and other stone, and 10,500 tons of iron and steel. There will be two steam pumping engines for hydraulic machinery of 360 horse power each, eight hydraulic engines, and six accumulators. Each opening span will be 50ft. wide by 100ft. long, and the weight of each leaf of opening span will be 700 tons, with the roadway and counterbalance weights.

Board of Trade Inquiry.—The official report of an inquiry held under the authority of the Board of Trade with reference to the explosion of a boiler on October 29 last, at the works of Mr. G. Thompson, Railway Arches, Deptford, has just been issued. Charles Thompson, brother of the owner, was killed by the explosion. The report at some length describes the boiler, which was made in 1867, and states that the plate and tubes had become quite unfit to withstand the working pressure, or, indeed, any useful pressure, with safety, being quite worn out. A number of persons were at work in the building, and escaped uninjured, in consequence, no doubt, of the roof of the shed offering little resistance to the upward flight of the funnel and smoke box casing, and thus leaving a free escape for the issue of steam and water. The report, in conclusion, states: "The boiler was of great age, and it is to be feared, in common with many of the boilers used in small workshops, has passed from owner to owner, with little regard to the question of condition or safety, so long as it supplied steam to the engine without giving out. The explosion appears to have resulted from the boiler having been kept at work long after it was worn out."

A New Canadian Line of Steamers.—It is said that the firms of Anderson, Anderson, and Co., and F. Green and Co., of London, managing proprietors of the Orient Line, have renewed their offer to the Dominion Government to carry the Canadian mails. They offer to build three express steamers of 7,500 tons apiece, to steam not less than 20 knots an hour, and to make the passage between Halifax and Plymouth in five days, and to Rimouski in five or six hours longer time. The steamers will be the most expensive that can be built at this time, and will, in beauty and convenience, surpass the Umbria and the Etruria, the ocean greyhounds of the Cunard Line. In their offer the above-named firms show that while in 1882 4,086 cabin passengers were brought to Montreal, this number had fallen off in 1885 to 2,744, and only had increased in the last year because some of the lines carried passengers to Montreal for the same price as to Quebec. This state of affairs, they claim, was caused because the steamers landing in New York are so much more convenient, and they will try to remedy it by their new line, which will be an entirely independent one. The firms offer to have the vessels ready within 18 months after the contract is awarded.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

January 4th.

138 Multiplying Gear, T. Fraser, Glasgow.
142 Lubricating Rolls, T. Rowbotham, Stockport.
148 Preventing Incrustation, R. Cosslett, Bristol.
149 Working Scrap Metal, J. W. Summers, Stalybridge.
160 Coating for Iron, P. Evans, Liverpool.
164 Gas Meters, W. E. Price, London.
167 Lubricating Piston Rods, J. Kerr, Liverpool.
178 Converting Waste Steam, C. Wells, Middlesex.*
179 Electric Lights, C. Wells, Middlesex.
183 Hydraulic Apparatus, H. D. Pearsall and J. W. Gordon, Middlesex.
187 Metallic Alloys, P. M. Parsons, London.
190 Oil Stoves, E. A. Rippingille and J. D. Rippingille, Middlesex.
193 Hose Couplers, O. B. Grant, London.*
195 Tunnelling Apparatus, J. H. Greathead, London.
196 Oil Motor Engines, J. Southall, of the firm of Hardy and Padmore, London.
198 Hydraulic Lift, A. A. Vuigner, London.
199 Machinery for Finishing Pile Fabrics, S. C. Lister and J. Reixach, London.

January 5th.

206 Grinding Mill, J. S. Chenhall and J. W. Chenhall, Devonshire.
210 Apparatus for Kiers, W. Bracewell, Chorley, Lancashire.
211 Rolling Machines, D. E. Kempster, London.*
214 Salt Apparatus, R. Hodgson, Birmingham.
217 Calculating Machines, A. W. Patching, Manchester.
224 Fire-extinguishing Sprinklers, W. Mayall and T. Thomasson, London.
228 Thrashing Machines, T. Bee, London.
229 Oil Cups, P. Jensen, London. (W. F. Mattes, United States.)*
238 Electric Machines, J. D. Gibbs and E. Fesquet, London.
242 Automatic Apparatus, A. M. Parker, London.
247 Utilisation of Exhaust Steam, P. A. Thomas, London.
248 Artificial Fuel, R. Clark and J. W. T. Stephens, Cardiff.

January 7th.

253 Wind Engines, T. Adair and W. Adair, Down.
256 Treating Gold, Silver, &c., L. P. H. J. Mauclaire, London.
260 Loom Dobbies, E. Bottomley, J. J. Grimshaw, I. Brook, and D. Grimshaw, Bradford
262 Furniture Spring Making Machines, Gottfried von Susskind, Berlin.
264 Stereotype Plates, A. Sauvée, London.
267 Bolts and Nuts, J. Day and F. W. Day, London.
268 Locomotive Engines, R. H. Lapage, London.
282 Conduits for Electric Mains, F. Coates, London.

January 8th.

316 Furnaces for Steam Generators, J. Davies, Manchester.
321 Rock Drills, G. Lawson, Glasgow.
323 Governors for Steam Engines, D. P. Davis, London.*
325 Lubricators for Car Axles, T. Saunders, London.
333 Treatment of Sea-water, J. A. Wanklyn, London.
339 Manufacture of Steel, R. A. Hadfield, London.
342 Dynamo-electric Machines, W. M. Mordey, London.
343 Rotary Engines, H. E. Newton, Middlesex. (Joseph Thorne, United States.
344 Steam Boilers, T. Gourlay, London.
355 Machinery for Working Stone, F. Trier, Westminster.
360 Sewing Machines, J. S. Wallace, London.
361 Welding and Forging Metal by Electricity, H. H. Lake. London. (E. Thomson, United States.)*
364 Steam Boilers, J. Anthony and J. Anthony, jun., London.
370 Weldless Chains, H. Rongier, London.
371 Lifting Jacks, J. M. Smith, London.
375 Electric Glow Lamps, A. Bernstein, London.*
377 Riveting Metal Plates, H. H. Lake, London. (E. Thomson, United States.)*

January 9th.

383 Cycle Brakes, H. T. Bassett, Wolverhampton.
384 Steam Boilers, R. W. B. Sanderson, Manchester. (J. O'Brien and S. J. Weaver, United States.)
385 Preventing Collisions between Railway Trains, J. A. Wilson and F. M. Young, Dundee.
387 Gas Economiser, J. D. Hall, Liverpool.
391 Packing for Steam Engines, G. Alwyn, Brighton.
403 Smoke Preventer, E. Pignot and F. Durand, London.
405 Hydraulic Force Pumps, J. F. L. Crosland, Manchester.
409 Bricks Machines, N. Proctor, A. Middleton, C. E. Fraser, and H. M. Carter London.
423 Centreing Axles and Shafts, J. Fletcher, Middlesex.
426 Force Pumps, J. Jackson, London.*
427 Axle Boxes, W. Pilkington, C. T. Bishop, and A. Brownsword, London.
435 Dynamo-electric Machines, J. H. Holmes, Newcastle-on-Tyne.
436 Coupling Link, S. Pltt, London. (R McLeod, New Zealand.)

January 10th.

441 Starting Gas Engines, J. M. C. Paton, Manchester.
455 Looms, E. Hollingworth, Huddersfield. (W. Mattio, United States.)
458 Steel and Iron Tubes, W. Gaskell and C. G. Till, New Wandsworth.
463 Ball Valve, M. Syer, Peckham.
478 Packing of Pumps, J. Kirkman. Liverpool.
483 Producing Light from Oil, E. E. de Facien, London.
485 Electric Generators, H. E. Newton, Middlesex. (D. Piédrahita, France.)
492 Screw-keys, J. D. Morrison, London,
495 Combination Nail and Screw, F. Carter, G. J. Randall, W. H. Talbot, and J. Webber, London.
496 Slide-rest Lathes, R. Price and W. H. Winnall, London.
497 Railway and Tramway Wheels, J. H. Timms, London.

January 11th.

510 Wedges, R. S. Wood, Manchester.
517 Wood-planing Machines, S. S. Hazeland, Cornwall.
520 Securing Metal Wheels, J. Hemming, Birmingham.
528 Cutting Metals, W. W. Hulse, London.
536 Cleaning of Boiler Tubes, C. Baddeley, Camden Town.*
541 Compressing Fluids, J. Frick. London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10, can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from either of our offices on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER.

FEBRUARY 1ST, 1889.

ACTUAL AND IDEAL HEAT ENGINES.

THE practical problem of obtaining mechanical power or work by the agency of heat has long occupied the minds and exercised the constructive abilities of engineers. It has existed as a problem much present in men's imagination long prior to definite knowledge on the mutual relationships of heat and mechanical work, indeed long prior to the formulation of definite surmises concerning the possibility of connection.

Thermo-dynamics, the science treating of the inter-dependence of heat and work, is a very recent growth, and has not as yet had a long enough life to greatly influence the development and practical improvement of steam or other forms of heat engines. We cannot but believe that now a thorough understanding of its principles and laws will greatly assist the practical engineer, and accordingly we propose shortly to discuss several matters bearing on it, and to point out several errors not uncommonly committed by theorists on the one hand and by practical engineers on the other.

Two great laws have been absolutely and conclusively established, known as the First and Second Laws of Thermodynamics. The first law was surmised by Mayer, of Heilbronn, and proved to demonstration by Dr. Joule, of Manchester. It demonstrated the equivalence of heat and mechanical energy, and may be stated—Heat and mechanical energy are mutually convertible, and heat requires for its production and produces by its disappearance mechanical energy in the proportion of 772 foot pounds for each Fahrenheit heat unit, a heat unit being the amount of heat necessary to heat one pound weight of water through 1 deg. F. This law is easily comprehended, and is now very generally understood and applied among practical men.

The second law is equally important, indeed more important to engineers, but it is not by any means so simple, and has been much abused in its application to heat engines, both by physicists and engineers. It asserts that under existing conditions it is impossible to convert the whole of any given quantity of heat into work, and that the proportion which can be converted into work follows a certain ratio determined by the absolute temperature of the source of heat and the lowest surrounding temperatures. That is, we cannot invent any form of engine in which it is even theoretically possible to convert the whole heat given to it into mechanical energy, and all, even ideally perfect engines—engines without practical losses or deductions—only convert a fraction of the heat supplied to them into available mechanical work. The reasoning supplying the basis of this law has been worked out by Rankine and Sir William Thomson from an ideal engine first described by Carnot in 1824. We do not purpose here following out the proof, but intend merely to state the result, and point out how its conclusions have been erroneously applied. The fraction of the total heat supplied to a heat engine which is converted into work by the engine is its efficiency, and the second law numerically stated takes the form of the now familiar formula,

$\text{Efficiency} = \frac{T - T^1}{T}$ where T is the absolute temperature of the source of heat, and T^1 the lowest temperature used in the engine. This formula gives the maximum efficiency which can be theoretically imagined from an ideally perfect heat engine, and it should be remembered that there are only two conceivable forms of ideally perfect heat engines. They are—First, an engine in which all the heat received by the working fluid is received at the highest temperature, and all the heat discharged is discharged at the lowest temperature; second, an engine having a perfect regenerator capable of reducing the working fluid to the lowest temperature without loss, and of raising it to the highest temperature without loss.

An engine complying with the first set of conditions is most easily conceived as a hot-air engine, and its mode or cycle of operations would be as follows: Suppose it to have a single air cylinder, and the piston to be some distance from the end of its stroke, the air contained to be at the lowest available temperature; then if the piston be moved in and compress the air into the clearance at end of the cylinder without loss of heat, the temperature will rise to a certain point, which is T. If the piston now moves out, and heat be added from any source, in any conceivable way, to keep the temperature constantly at T until the whole heat necessary is supplied, then the piston moves on till the air is expanded, doing work, and falls to T^1. Suppose the piston is now at the outer end of its stroke, and it is returned, compressing the air, while the temperature is kept at T^1 by cooling in some way till it reaches the starting point. When it does this it is ready to go through its cycle of operations again. Such an engine, if it were possible to avoid practical losses, would give the highest efficiency conceivable between the limits of temperature, and its efficiency could be calculated from the formula $\frac{T - T^1}{T}$. The second form of perfect engine we do not purpose describing at present.

Now, a great deal of difficulty has arisen between practical engineers and physicists, due to the indiscriminate use of this method of calculation, and it appears to us that much good would arise from a proper understanding. Physicists sometimes, though not always, forget that range of temperature is not the sole measure of efficiency in engines, and that practical engines are never perfect in cycle. All actual engines have theoretically imperfect cycles of operation. In the steam engine, for example, even if practical losses of heat could be entirely suppressed, the efficiency or proportion of heat converted into work would not be represented by the formula $\frac{T - T^1}{T}$, but by an expression giving a considerably lower result. If an ideal steam engine could be constructed, the whole heat due to the combustion of the fuel would be transmitted to the water in the boiler and formed into steam, without loss in any way, either from hot air leaving the furnace, or heat leaving the boiler or pipes by conduction or radiation; the steam would arrive at the cylinder perfectly dry, and there would be no condensation at admission due to cooling, or loss of pressure from clearance spaces. It would be expanded, without loss or gain to or from the cylinder walls, down to the temperature of the condenser, and would then be condensed. The valves would act without resistance, either in lowering the boiler pressure or by causing back pressure during the exhaust. Such an engine, we all know, is an impossibility, because of unavoidable losses due to the necessity of dealing with practicable materials, and to the difficulty of simultaneously accomplishing two self-contradictory requirements. All actual engines are attempts to reconcile the contradictory requirements of theory with the difficulties of realisation in metal; but even if a perfect steam engine were produced, it would not be a perfect heat engine. There is a gap in the steam-engine cycle which would require bridging over. In such an engine the steam would not be condensed by cooling below the final temperature of expansion, but would be condensed at the final temperature of expansion by compression, and the condensation stopped at such a point that the mixture of steam and water, when compressed mechanically, without allowing loss of heat, would rise at the end of the stroke to the full temperature of the boiler, and then be forced into the boiler. This alteration is, of course, quite impracticable, and if attempted would only increase the already considerable practical losses, but the formula $\frac{T - T^1}{T}$ cannot apply unless it be done. We have examined the ideal and the practicable forms of other heat engines, and find the same fact. In no actual heat engine, as constructed and at work, is the ideal cycle ever a perfect one. All heat engines of which we have any knowledge, even if perfectly carried out, or without losses of any kind, in practice have efficiencies lower than $\frac{T - T^1}{T}$.

In air engines, and gas engines also—which are but forms of air engines—the efficiency of the cycles of operation are easily calculated, and it has been conclusively proved that for each cycle there is an efficiency peculiar to itself, which is never attained in practice, but which is the ideal towards which it is the business of the engineer to approach as closely as he may. These efficiencies vary widely and quite independently of the maximum temperature. In one cycle, when a mixture of gas and air is compressed to a certain volume, ignited at that volume, and subsequently expanded to the original volume, represented in practice by the well known Otto engine, the theoretical efficiency is entirely independent of the increase of the temperature of explosion above the temperature of compression. An increase of 1 deg. F. would give the same efficiency as an increase of 1,000 deg. F.; that is, if a conversion of 0·3 of the heat at 1 deg. F. was possible, then 0·3 of the heat at 1,000 deg. F. would also be possible, and no more. In other cycles the increase of maximum temperature theoretically causes an actual loss of efficiency. These facts are well established; but they do not contradict the second law, as in no case is the ideal efficiency so great as $\frac{T - T^1}{T}$, but they caution us on the point of using discrimination in applying general formulæ.

The statement we hear so often, that the efficiency of an engine is dependent only on the range of temperatures between which it acts, and is independent of the nature of the working fluid, is quite untrue when applied to actual engines having imperfect heat cycles. It is quite untrue of the steam-engine cycle, and quite untrue of air-engine cycles; in both cases a change of working fluid would quite alter theoretical efficiency. The statement is true of perfect cycles, but not of imperfect.

In conclusion, we would impress upon engineers the absolute necessity of a knowledge of thermo-dynamics if it is wished to carry improvement in heat-engines much further. So much has been already done, and so great is the practical perfection attained, that careful and minute study of first principles, as well as a great knowledge of constructive detail, are now required in order to overcome remaining difficulties. We would also point out to scientists and theoretical students of thermo-dynamics the necessity of great care in the application of absolutely true generalisations, which may be quite misleading in cases where the conditions are not satisfied. The practical engineer may now learn much from the scientist, but the scientist will always find food for study in the engineer's achievements, generally made by direct experiment and without knowledge of the laws underlying the attained results.

RAILWAY LOADS.

It having been found that the speed maintained in the "railway race to Scotland" was such as the existing engines were unsuited to withstand, it appears that new ones are being built especially designed to resist the increased strains and vibrations due to greatly augmented velocities, and it is stated that the new engines will exceed their predecessors in weight by about twenty tons. It is to the effects of this increase of weight that we purpose directing attention in the present article.

In dealing with such alterations, the commercial question, remunerativeness, will obviously come to the front, and therefore it becomes necessary to consider not only the additional cost of the machine itself, but also what other expenses may be involved on account of the additional weight imposed upon the permanent way and works.

Taking the weight of an express engine of the first class at seventy tons, including tender, the proposed addition of weight would amount to nearly thirty per cent, which is a very notable increase, and probably its effect upon the works carrying the railway would be greater than is inferred by the mere increment itself regarded as a percentage, on account of the mode of its distribution. We will, however, for our present purposes assume that the effective load is actually augmented by thirty per cent.

In the first place, it is to be anticipated that the existing permanent way will not be sufficiently heavy to resist the wear and tear which will be entailed upon it, and therefore in this department there will be required the expenditure of more capital, and the renewals will be correspondingly heavier; in this there will be no particular inconvenience beyond the cost of a stronger permanent way.

In dealing with the iron bridges on the line there will be inconvenience and difficulty in providing for an increased load, such alterations as are necessary having to be made without interfering with the traffic, and therefore under circumstances enhancing considerably the cost of the work. The practice in England in designing iron and steel bridges is to proportion their parts to resist the stresses due to a load consisting of a string of the heaviest locomotives used on the system for which they are intended, and by such a load are they generally tested by the Government inspectors; therefore it is to be concluded that the works must be maintained at such a standard of strength that at no time shall a load come upon them capable of producing stresses exceeding those laid down by the Board of Trade.

In the ordinary course bridges are so designed that there is some margin of strength over that specified, even when placed under the maximum load; but it is hardly probable that this will reach more than ten per cent, or at the outside fifteen per cent, above that due to theoretical stresses; but this margin is intended to allow for special occurrences and for deterioration, and is not intended to be entirely absorbed by prospective increase in the weight of rolling stock; but even if it were, there is not sufficient to allow of an increase of thirty per cent in the running load. Some engineers, it is true, have adopted very low working stresses, three tons per sectional square inch having been made the standard working stress in some cases, but where this is done it is to be presumed that a low quality of iron is used; therefore to maintain the factor of safety which has first been fixed upon unimpaired, there will be as much reason in this case to increase the strength when rolling loads are augmented as in any other.

Under the ordinary traffic, it is well known that railway structures are but seldom subjected to the action of the maximum loads for which they are designed, except in the cases of very short girders, whose lengths do not exceed that of an engine and tender, and which, therefore, are under their maximum load every time an engine of the heaviest type passes over them.

Roughly speaking, the additional load thus brought on a bridge 100ft. span would call for an additional weight of iron to the amount of 8 or 10 tons for a double line of way; and when we come to consider the number of bridges that would require strengthening, we obtain some idea of the magnitude of the outlay called for in order to allow of an increased speed for only one or two trains a day. These matters must, of course, be taken into consideration in arranging the fares by such special trains, and looking at it all round, it certainly seems highly improbable that such a course will yield satisfactory financial results.

Judging from past and present, it is not easy to fix a limit to the increasing tendency towards heavier loads, and therefore the designers of our railways should be careful so to lay out their lines as to admit in the largest degree of the use of masonry and brick in the bridge works. These materials forming structures of which the forms and sizes are determined upon principles of stability rather than strength—there always being a very great excess of the latter—the loads upon them may be very materially increased without any danger; and furthermore, their tendency to deterioration is almost inappreciable, provided that in the first instance the foundations are solid and sufficient. Furthermore, the running load being much less in proportion to the weight of masonry than to that of metal bridges, equal increments of load will have much less effect on structures in the former than on those in the latter material. There is another advantage masonry work has over the iron, and that is that it can be strengthened more easily should such a course become necessary.

The increased concentrated loads on driving wheels will necessarily have a very marked effect on the arrangement of iron bridge floors, as well as the main girders, so that it is not easy to see how the strength of these structures is to be increased without entire re-construction. We have made these remarks to direct attention to the general conditions attendant upon the attainment of increased speed, because, while the interest is centred upon one particular constructive department, it may be diverted from others which are equally involved in the main question.

STATE OF THE SKILLED LABOUR MARKET.

THE following memorandum has been prepared for the *Board of Trade Journal* by its Labour Correspondent:—

There are generally special causes in operation at the commencement of the month of January which, as a rule, make this the dullest period in the whole year, so far as the labour market is concerned. Lengthened holiday suspensions, bad weather, and short days, all tend to keep employment down to its minimum, and the number of members thrown on the out-of-work benefit of the trade unions is by these more or less temporary causes much increased. This year, fortunately, the demand for labour has been so vigorous that these causes of depression have had in the aggregate but very slight effect, and the proportion of those thrown out of work is only fractional.

Twenty-one societies have this month reported, and show a total membership of 248,782, of which 8,198 were unemployed at the end of December, as against 7,826 in the previous month, an increase of only 372. In January of last year the total of unemployed upon a much less membership was 13,711, so that the advance made during the 12 months has been considerable. The proportions for the same comparative periods are—January, 1888, 6·9; December, 1888, 3·1; January, 1889, 3·3. In the January of 1887 the proportion was 9·9. The building trade is entirely responsible for the trifling falling-off above referred to, for had it not been for a considerable increase of unemployed in that industry there would have been a general improvement to record. The hard and broken weather of the latter part of December seriously interfered with building operations, and many men were thus thrown out of work. Consequently in this line of business the proportion of unemployed has gone up from 3·3 to 6, which is, however, much better than last year, when it was 8·4. In all the other branches of trade the increase is either so slight as to be immaterial, or there is an absolute decrease in the numbers out of work. In the shipbuilding and boiler-making trade the demand for labour is so well sustained that during the month the percentage of men out of work has gone down from 4·7 to 3·3, and from the amount of tonnage on the stocks work seems likely to continue brisk for some time to come. The engineering, ironfounding, and other branches of the iron trade are also well employed, though holiday stoppages have just perceptibly increased the number of members on benefit. The cotton trade shows some improvement, and fewer members are now on the books as being out of work. The coal trade all round is specially prosperous, and its condition contrasts most favourably with that of a year ago. In Northumberland not a single miner is reported out of work, and employment is said to be more constant than at any time since 1873. For the first quarter of the new year, at all events, there seems no probability of any serious check to this prosperous condition of the labour market.

HOWAT'S PATENT MINERS' SAFETY LAMP.

About the year 1816, Sir Humphrey Davy made those admirable researches of his which resulted in the invention of the safety lamp, and at the same time gave to the world a mass of carefully ascertained data upon the nature of flame, the mode of gaseous explosions, and the conditions of their origin and propagation. Since his time much study and experiment have been devoted by many men to the further elucidation and understanding of the subject. Great progress has been made, and many reliable facts are now part of our accurate scientific knowledge.

So far, however, as the laws of the extinction or the prevention of the spread of flame in an explosive gaseous mixture are concerned, no radical advance has been made. We depend now, as then, upon the conducting power of wire gauze for safety when a miner's lamp becomes accidentally immersed in an explosive atmosphere.

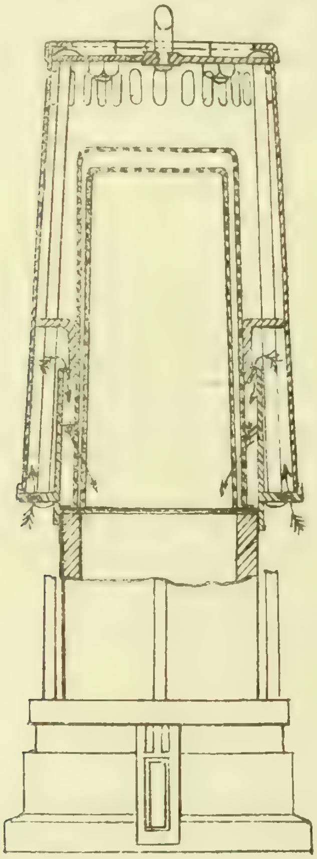

Fig. 1.

Many changes in the working and especially the ventilation of our mines have been made, causing a corresponding necessity for change in the arrangements of lamps intended to be safe, the principal being in the velocity of the air currents. It was very early observed that an ordinary Davy lamp when placed in a current of inflammable mixture became much heated, and finally caused explosion.

Much experiment has resulted, and many lamps have been designed to overcome this danger. All the new lamps, however, may be classed under three well-known types of which they are merely modifications. Those types are (1) Davy, (2) Stephenson, and (3) Clanny.

In the Davy the flame is entirely surrounded by a wire gauze cylinder. In the Stephenson there is a glass cylinder having a metal perforated ring at the bottom to supply air, and a perforated metal plate at the top to discharge the products of combustion. In the Clanny a short glass cylinder surrounds the flame, surmounted by a cylindrical cap of gauze, through the lower part of which the air supply enters, and through the upper part the products of combustion are discharged.

It was found in time that all these lamps were safer if protected in some way from the air current, and accordingly the Davy lamp was put into a tin lantern with glass windows, and became known as the Davy in case, or the tin-can Davy. In some cases the Davy was surrounded with a glass cylinder, and was then called the Jack lamp, or Jack Davy.

The Stephenson was shielded in various ways, and the Clanny was also shielded. These modifications greatly improved the safety of the lamps, and in time the three best known forms became the Davy in case, the Mueseler, and the Marsaut lamps, the last two being of the Clanny type, having air supply entering above the glass, and products passing away through the upper part of the gauze. The Mueseler has an internal funnel to carry off the burnt gases, and is the official lamp of the Belgian Government. The Marsaut differs from the Clanny in the fact that it has two or three gauzes slipped one within the other, and it is perfectly shielded by an outer shield; the air inlets, too, are placed in a ring of metal forming the base of the shield.

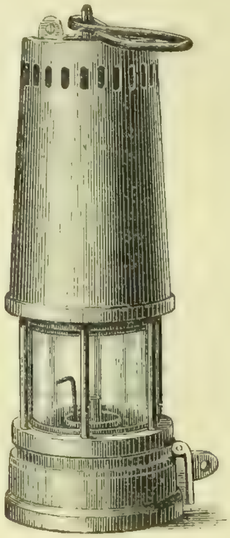

Fig. 2.

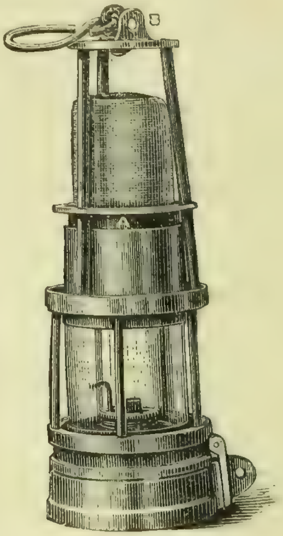

Fig. 3.

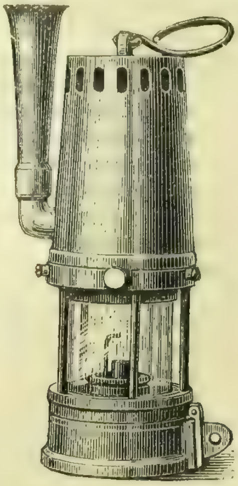

Fig. 4.

The Royal Commission on Explosions in Mines, in their report two years ago, mention four lamps as combining in a pre-eminent degree the qualities of safety, simplicity, and illuminating power. They were the Mueseler, Marsaut, Gray, and Evan Thomas. Of these four the Marsaut is perhaps the most generally and favourably known in this country. The Mueseler gives but little light in a bad atmosphere, and is, moreover, very easily extinguished in handling, a very slight departure from an erect position causing such a change in the flow of current as to return the burnt gases to the flame and so put it out; otherwise, in its latest and improved form it is a valuable and safe lamp.

The Marsaut lamp stands rougher usage, and may be freely handled and moved about without danger of extinction; at the same time it is very safe, and stands the test of a current of explosive mixture moving at the rate of about 3,000ft. per minute without causing ignition. In an atmosphere somewhat heavily charged with carbonic acid it loses its illuminating power very rapidly, because of the difficulty of a sufficient air supply from above the glass. Mr. Howat, of Manchester, has studied this and other forms of lamp most carefully for many years, and has invented an important improvement in the Marsaut form which greatly increases its illuminating power, more especially when burning in a bad atmosphere.

We show in fig. 1 a section of the lamp, and illustrate its general appearance in figs. 2 and 3, with the outer shield in position and with it removed. Mr. Howat observed that in the ordinary Marsaut lamp a large portion of the air entering between the shield and the gauze passed upwards and out with the products of combustion without passing through the gauze at all, and he added to it a ring of metal, fitting tightly between the gauze and the outer shield. This ring he calls a deflector, and its function is to prevent the flow of air outside the gauze, and to cause all air entering at the bottom holes to pass through the gauze and into the interior of the lamp. As we have recently seen experiments made with this lamp which prove its power of retaining illuminating intensity in a bad atmosphere, we feel sure that our illustrations will interest our readers.

The addition of a deflector ring to the Marsaut lamp seems but a small deviation, but it has nevertheless a most important effect on the action. In fig. 1 the arrows indicate the course of the entering air, and in figs. 2 and 3 the lamp is shown with and without shield.

From what we have seen, Mr. Howat's lamp appears to us to retain all the good points of the Marsaut lamp and to give a greatly increased light. One of the recommendations of the Royal Commission has also been carried out, which gives increased safety. The inner collar seen in fig. 1 is carried up nearly to the deflector ring, and it prevents any currents striking the lamp obliquely from prejudicially affecting the action of the gauze. We are informed that there are over 30,000 of these deflector lamps in use now, which shows how greatly miners appreciate increased light.

Fig. 4 is a form of lamp designed by Mr. Howat for gas testing, and it also contains the new feature, the deflecting ring, but the airholes admitting below the deflector can be closed by means of an adjustable collar, and then all the supply must come through the conical funnel seen in the illustration at the side of the shield. In testing for the presence of gas in the pit, the mouth of the funnel is brought near the roof, and a sample is thus taken into the lamp and reaches the flame from any portion of the air. The arrangement is exceedingly sensitive, and a very small quantity of gas causes quite a perceptible lengthening of the flame.

ACCURACY IN MECHANICAL CONSTRUCTION

(Concluded from page 55.)

Look at the question again from a commercial point of view, where the outlay of a few pounds in the first instance would obviate it. Let us put it into figures. If we put the time lost owing to inaccuracies and imperfections of a lathe to be only 10 per cent, which is a low estimate, and take 30s. per week only as the workman's rate, we have 3s. per week or £7 16s. as the loss paid per year, which is equivalent to paying interest on the sum of £156, so that in medium-sized lathes the difference in first cost is a mere bagatelle compared with the capital sum it represents in the difference of production. So far I have referred mainly to common cylindrical objects, such as shafts, studs, &c., but there remains also those cylindrical forms of extreme precision such as are frequently required in machine tools and other constructions, and which can be produced only by grinding, but of these I will not treat at length, as they usually form a branch of that special but important work for the rectification of hardened surfaces by means of emery.

So far I have referred mainly to *external* cylindrical parts, but if we turn to the counterpart or *internal* cylinder, we see that the elements of accuracy are here those same primary elements of the true cylinder in the machine producing the work.

It is, in fact, perfectly obvious that the accuracy of the internal cylinder can never be greater, but it is entirely dependent upon the accuracy of the bars and bearings producing it; but in most cases it is much less, for the hole produced is often twice the diameter of the bar producing it, and the errors are magnified therefore in the same proportion. The next simple and extremely useful form is that of the *cone*, in the production of which the same cardinal principles hold as for the true cylinder. This is now, however, best produced by a combination of motion in two directions, the old practice of displacing and disturbing the accuracy of the movable headstock being the least satisfactory method of producing a true cone.

The Screw.

We now come to the next important form in our constructions, that of the screw, with its counterpart, the nut; and here in passing one cannot but again pay a tribute of recognition to the name of Whitworth for the immense service rendered to mechanical science in connection with this form. The production of true screws follows, of course, very largely the conditions necessary for the production of plain cylindrical forms, except that the true screw can only be produced economically from another equally true screw, so that whatever errors exist in the parent screw are reproduced upon the work, and often in an exaggerated form; hence the importance of a true standard screw. This may seem a degree of refinement not often required, but to anyone who has had to divide objects into equal divisions perfectly interchangeable at any part of their length, this importance will have been painfully evident. If we examine one of the screws which often pass muster as guide or standard screws, we frequently find that, although perhaps measuring accurately in pitch over a number of feet, it is, when minutely examined, full of inaccuracies in different parts of its length. Although these are not easily detected, it is possible to show that in one part the pitch may be lagging behind and in another in advance of the true pitch. I do not here refer to microscopical inaccuracies, but to those which are appreciable and of importance in mechanical constructions.

In astronomical and high-class philosophical instrument work we find an extremely high degree of accuracy obtained in screw-cutting. Take, for instance, the question of temperature in screw-cutting, which we, in our heavy work, cannot neglect. For these purposes it is necessary to guard against the small amount of heat generated in cutting a screw having say 50 threads to the inch, and so important does it become to have both the master and the work at the same temperature, that the finest screws are made by immersing the lath bodily with its work in a bath of oil kept at a constant temperature. In addition to the screws produced from a master, as in a screw-cutting lathe, there is, of course, that great family of screws produced by dies prepared from master taps, in which the inaccuracies of the master are at least faithfully reproduced, and in this connection one cannot but admire their French name, which recognises their intimate relation to the work, for they are termed "mother" taps.

A few years ago there was a considerable agitation for the adoption of the metric system in our measurements.

This agitation was, I think, conducted very largely by those who had little or no conception of the Herculean task which it was proposed to give to engineers, especially whose standards, based upon the inch, are interwoven with at least three-fourths of the drawings and machines in existence. Although one cannot but admire the strictly scientific metric system, there are peculiar features of our English inch and subdivisions which are by no means to be overlooked, and I rather agree with a prominent American engineer who contends that the subdivisions of the inch by two gives rise to a better gradation of sizes for the workshop than the metric. The effect of this is, I think, best seen among bolts, for if we put down the numbers, say 5, 10, 15, 20, 25, &c., which are the cardinal numbers of the metric system, and attempt to interpolate suitable intermediate sizes for mechanical constructions, we soon realise the difficulty.

I would also here mention the opinion of a prominent Continental engineer, acquainted with the English system, who said that he decidedly *preferred* the English subdivisions, for in drawings they lent themselves naturally to the scales of half-size, and the extremely useful scales of quarter-size and eighth-size, whilst with the metric the first natural scales were one-fifth and one-tenth, neither of which are good for designing. The importance of the English standard sizes of threads, and the rapidity with which they are spreading, is well seen by anyone whose duty, like my own, is frequently to prepare tenders to the specifications of Continental engineers, for it is very curious to note that in whatever language the specification be drawn in, the general dimensions throughout may be given in millimetres, but wherever screwing dies accompany the machines, the dimensions now almost always change to the English fractional measures, the two dots being used to express inches often when no words are introduced. This, however, is a digression.

In this connection I would refer to that historic attempt at a change of measurement, in which even the French themselves broke down. At the time the metre was adopted and revolution was in the air, they decided to alter the recognised divisions of the circle, so that instead of 360 deg., and the usual subdivisions of minutes and seconds, the circle should be divided into 100 parts or degrees, and each of these into 100 minutes, and again 100 seconds to each minute. This seems a very innocent and simple proposal, very like the proposed change of standard for engineers, but owing to the immense number of mathematical tables and calculations which had previously been calculated upon the original system, the project had to be abandoned. If the existing mathematical tables, voluminous though they be, proved an insuperable difficulty even in France, what shall be said of the proposed change to English engineers, in which these difficulties are a thousand fold.

We come now to those irregular forms which are demanded sometimes of necessity, as in the case of cams, and sometimes as a matter of taste as to appearance, and which are often indulged in by men who know or care little about the cost of production. These forms until recent years have been extremely costly, but with the introduction of the milling machine their accurate production has become possible. Here again, however, their production depends upon that of some standard form which the milling machine is simply the means of reproducing. In addition to the chief forms entering into constructions, I have already referred to the importance of the subdivision of standard measurements of length, but besides these there are the angular measurements necessitating the subdivision of the circle into *any* number of equal parts. This is of the utmost importance to engineers, for upon it the accuracy of that great family of toothed wheels entirely depends.

To divide the circle into *any* number of equal parts has been a problem for mathematicians for ages past, but in the present day it has become an exceedingly important one, for it becomes absolutely necessary to face the general problem of how to divide the circle, not into given numbers but into *any* number of equal parts, and although this can now be satisfactorily accomplished, its accuracy is ultimately found to depend upon that of a master wheel. In cases of extreme accuracy required in astronomical instruments the practice of Sir Howard Grubb, to whom I am personally indebted for the details, is most interesting. In the cutting of wheels he begins by first dividing the blank to be cut with the extremely delicate dividing engine used for the great circles of telescopes, and having cut these fine lines on the rim, he places the blank in a comparatively strong wheel-cutting machine, using the master wheel only for turning round, and not for dividing. Fixed to the machine is a small microscope with cross wires, so that the fine lines of the divisions on the blank can be accurately brought round in succession and made to coincide accurately with the crossed lines of the microscope. The relative importance of a true master wheel is easily seen if we compare the diameter with the diameter of the wheels to be produced. Now, any error of the master wheel is, of course, magnified in wheels of larger diameter made from it, and if to its inaccuracies be added those due to the dividing apparatus, of whatever form it may be, I think it is highly creditable to engineers that some of those immense toothed wheels now employed in heavy mill gearing have attained such great perfection.

One of the finest master wheels I know of in this country is one made by the late Mr. Bodmer. It has 360 teeth, and is about 6ft. diameter, though I am not aware of the means he took to eliminate the errors and ensure its extreme accuracy.

At the present day the practice of making large wheel patterns is discontinued and superseded by the wheel-moulding machine, and whilst rejecting the inaccuracies found in old wood patterns, need we not look very sharply after these new machines, which are the parents of all our wheels, for they are working in the foundry under very unfavourable circumstances.

One sees also sometimes a master wheel of about 3ft. diameter being employed to mould a wheel perhaps five or six times its diameter. I think the nature of the result in such cases cannot be doubtful.

Reviewing these chief elements which determine the accuracy of our work as a whole, we see that the production of these forms is very largely a question of initial accuracy in the machines producing them. There remains, however, the next chief step to consider, and that is the combination of these forms into a perfectly accurate machine. Here we are compelled to resort very largely to the skill of the workman, for it is one thing to bore a perfectly true hole, but it is quite another to determine exactly where that hole should be bored. It is at this point where a workman's knowledge of practical geometry comes in, and although he may not know it by any such name, yet I cannot but bear testimony to the great knowledge which many workmen possess of an extremely practical form of geometry, gained by experience with scribing blocks, straight edges, trammels, and squares. In spite of all this knowledge, I fear it is in the setting of work for the machines that our greatest inaccuracies creep in; therefore anything which tends to diminish this risk, as well as to facilitate the rapid setting of work, is undoubtedly of great advantage. For this work, the men usually employed are termed "machine men," and are graded at a lower rate than fitters; but I often think much more frequently depends upon these men than upon the fitters.

We have so far considered all these forms on the assumption that, if once made, they would preserve their accuracy under all conditions. This, it should be pointed out, is a very fallacious view. Let us take only the numerous cast-iron portions. These to the untrained eye are often regarded as being perfectly *rigid*, but a little experience soon shows that there is no such thing in nature as perfect rigidity, for all solid bodies are more or less elastic, the difference being only one of degree. We, of course, know indiarubber to be almost perfectly elastic, so that if we mentally picture our constructions as made of indiarubber, we then get a clearer conception of the strains which come upon them, not only from the weight of their own parts, but also from the work which they are intended to perform. I need not, I think, trouble to specify the many precautions which arise from such considerations further than to point out the importance of accurate erection, even when constructed, for few heavy machines are entirely independent of the foundations they rest upon.

Returning to the review of the elements of accuracy, in which we see that their production almost entirely depends on the accuracy of the machines producing, and looking broadly at the facts, do we not find a remarkable analogy in these to what obtains in the animal world, where the weakness and shortcomings of the parents are transmitted to the offspring, even for generations? Do we not therefore see that in that great family of constructions, called machine tools, we have the parents of all our constructions reproducing in their offspring during their long life all those inaccuracies and failings which were originally left in them by their makers.

Does it not, therefore, seem almost a crime to leave initial seeds of inaccuracies in these constructions, which, by perpetuating themselves for all times, must earn for themselves the curses of generations unborn? In comparison with the animal world there is, however, this notable difference. The selection of parents in the animal world is controlled almost entirely by those principles of natural selection so ably enunciated by Darwin, but in the mechanical world we have the power to determine not only which shall be the parents of our own mechanical progeny, but also that these parents shall themselves be perfect.

These considerations, gentlemen, lead me to an important element, which is that of the commercial question, for of this, much as we may love our purely mechanical pursuits, we cannot remain ignorant. I think in no district in the world is the question of accuracy in mechanical construction better understood than in this county of Lancashire, and I doubt if any equal area in the world possesses such a reputation for first-class work.

Some years ago, in a town in the South of England, an engineer somewhat sneeringly remarked to me, when upholding the reputation of Lancashire work, "that he did not know there was anything in the climate of Manchester which should make their constructions better than others." It was quite true he did not know the condition of things in Manchester, but I am sorry to say it was not the only thing he did not know. He might with equal pertinence have said that he did not know it was good for cotton. What he overlooked was that noted fact that better workmen are to be found in Lancashire than in any equal area of the world.

In the past, gentlemen, Manchester has been, and to-day undoubtedly is, the centre and home of those breeders or constructors of that notable high-class stock of mechanical progenitors which have worthily earned their reputation in all parts of the world, and if one should wonder at the notion of locality having anything to do with a particular trade, one might extend one's wondering as to how it is that almost all the imperfect progenitors of mechanical construction should be the offspring of a particular county whose name they bear. In various parts of the world one meets these, having their origin certainly branded on their forehead, yet such are the struggles of that demon of quality, low price, that they continue to be sent out to countries in which the reputation of English work has been extremely high, so that, I think, we engineers of Lancashire have a perfect right to brand them wherever they are found.

A few months ago, in a foreign town, I was shown by an American engineer a number of machines which he had a malicious delight in pointing out were of English construction, and which were not at work, simply from the fact that they were unworkable, whilst alongside these were a number of first-class American machines in full work. I am sorry to say I could not deny that they were of English make, but such was their quality that he might just as well have pointed to any mongrel cur in the street as a type of the English bloodhound.

Never, gentlemen, in the history of our country was it more important that we should send out first-class accurate work than it is to-day, and I do feel a peculiar pleasure in addressing you this evening, for I know I am appealing to a body of Lancashire men who have done more than any equal number of my countrymen to maintain that high reputation of English work.

Seeing, therefore, gentlemen, the importance of accuracy in mechanical construction, I would appeal to you, and especially to the younger engineers here present, that we should make a most determined effort to maintain aloft that noble standard, that reputation for accuracy, which our predecessors have so worthily handed to us.

ROAD LOCOMOTION.

(Concluded from page 57.)

Originally this well-known form of rail was spiked to cross sleepers, but their vibration or slight movements loosened the paving sets to such an extent that they have been abandoned, and concrete 5in. or 6in. in depth substituted the full width of the tramway track, as in fig. 6 (p. 57). Since abandoning the wooden sleepers the base of the rail has been widened, and when well bedded it makes a very solid and rigid road. The bottom flange supports the granite sets next to the rail; thus it is practically impossible for the sets to be forced below the head, thereby maintaining a level surface. It is certainly rather heavy, a 7in. section weighing 98lb. per lineal yard, and a 6in. rail 92lb.

It may probably be argued that a grave objection to this form of rail was that whenever the head or rolling surface was slightly worn away the whole tramway track practically had to be taken up in order to renew it.

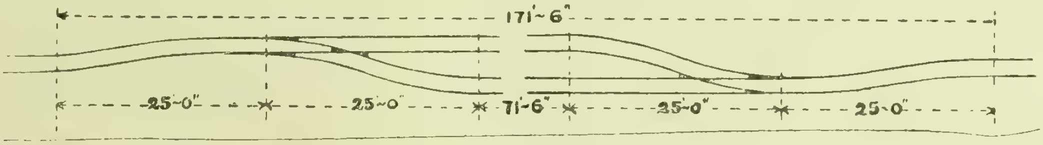

Fig. 7.

The "Channel" and "Barker's" rail (figs. 2, 3, and 5, pages 56 and 57) were designed with a view to the more economical replacement of the rail when renewals were required.

The "Channel" rail was found to make an excellent road when new, but after one or two years' work, or even less, according to the traffic, the defect very quickly became visible. The rail settled down on the timber sleeper, and the timber itself was compressed, so that the rail in a very short time was ⅛in. or ¼in. lower than when first laid.

In the reader's opinion "Barker's" rail, as keyed, was not adapted for steam tramways, inasmuch as the rails spring to an extent varying with the size of the holes for the keys which fasten the rails to the cast-iron chair, and once the springing commenced, the keys were rapidly loosened or cut, and a hammering action was set up. When the keys have worked loose there was no method of re-tightening them, except by taking up the paving. Upon a certain line this was found to be so expensive—tightening up the steel wedges and replacing those which had given—that the directors of the company had a portion taken up and relaid with the "Girder" rail. The groove must be narrow, so that the ordinary street traffic may pass over it with safety. In Birmingham the width of the groove is only ⅞in.

One very great advantage of the girder rail was that it could be perfectly fished and the joints made almost, if not quite, as strong as the rail itself, which was not possible in many forms of permanent way. With a rail 7in. deep, Bessemer steel fish plates 1ft. 6in. in length, 4¾in. in depth, and ½in. thickness were used, properly punched to avoid the difficulty of bolting. The most convenient length of rail was found to be 27ft. 11¾in. When fishing, a space of from a ¼in. to ½in. is left to allow for the expansion of the metal in warm weather, the holes in the fish plates being punched to permit of the movement. The joint of a rail was the weakest part of the permanent way, generally consisting of 13 to 16 parts, the fish bolt and nut being the members of those parts upon which to a very great extent depended the condition of the whole.

There was not, in his opinion, an absolutely best tram road. In certain cases efficiency was more important than a low first cost, in others efficiency had to be sacrificed to economy in expenditure, and in a third both economy and efficiency had to be studied. It was quite apparent that it would be an absurdity to lay down a light provincial or suburban tramway on the necessarily somewhat costly system required for Birmingham, whilst it most certainly would be nothing less than false economy to construct cheap inefficient tram roads in that city.

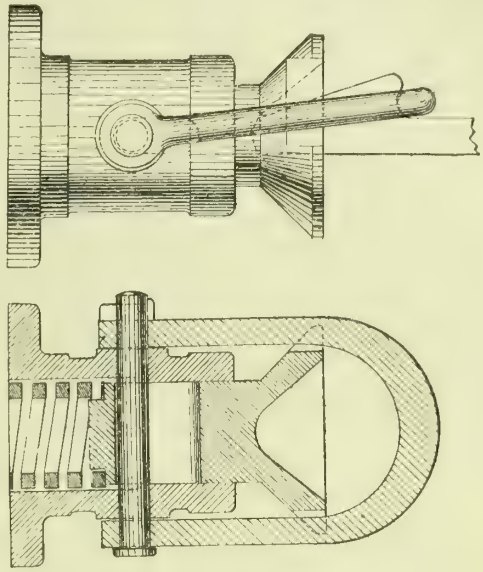

Fig. 8.

Too great care could not be taken in laying the permanent way accurately to gauge, for if there was the slightest inaccuracy there would be a great amount of friction upon the sides of the flanges of the rolling stock wheels.

Attention should be given to cleaning the grooves of the rails, for if they were filled with road detritus the wheels often ran upon the edge of the flanges and rubbed against the sides of the grooves instead of running upon the tread only.

Judging from the inconvenience which had been experienced in Birmingham from the gauge of the tramways not being of the same width throughout, he thought it would be an advantage if the Board of Trade made it a condition that all tramways in the future should of a uniform gauge, and that all engines and cars should be of the same width.

He knew an instance in which a continuous tramway, only about two miles and a half long, passed through two districts, and in the one a car of a certain width could be used, but in the other district, contiguous to the first, the width of the car must be three inches less, although in both instances the passing places were of the same width. He need hardly say that in the instance he referred to two provisional orders exist, but still his argument held good, for if the gauge and width of cars were uniform such an anomaly would disappear. On the tramways with a 3ft. 6in. gauge, with which he had been connected, the widths of the cars have been 5ft. 6in., 5ft. 9in., 6ft., and 6ft. 3in. respectively.

The gauges of tramways in England were 2ft. 6in., 3ft., 4ft., and 4ft. 8½in.

In Wales there was a street tramway for which a provisional order was obtained in 1885, the gauge of which was to be "not less than 2ft. nor more than 2ft. 6in."

For a steam tramway there should be tie-rods provided when laying the permanent way. They should be placed about 9ft. apart, the full length of the tramway; and for a 3ft. 6in. gauge they were generally of flat bar-iron or steel, 3ft. 8½in. long by 1½in. by ½in., with screwed ends (generally ¾in. diameter) to each tie.

In certain cases washers were used. He thought the gauge could be better maintained if the rods had two screwed ends instead of one end being milled out.

He would always advocate tramways to be laid as a double line throughout their entire length, especially if the service was to be a quick one; but of course, owing to the requirements of the Board of Trade and the narrowness of many streets, this was impossible, with a result that the line was constructed as single, with passing places. Now, these passing places should not be placed at less distance than 400 or 450 yards apart, and should always be so laid that a driver upon his engine can see the driver upon the approaching engine, thus averting many accidents.

An engine-driver was placed at a greater disadvantage than a driver of a horse tramcar, inasmuch as he could not guide his engine in the same manner that the driver of the horse tramcar could.

Passing places laid for a steam tramway in the same way as originally laid for a horse tramway were decidedly wrong, as the engine had a tendency in such cases to take the points in perhaps the right direction, whilst the car has been found to take the other. This was found a great difficulty, and as the erratic behaviour of the engine and cars in such cases was very likely to lead to serious accidents, "drop points" were adopted to remedy this defect. They consisted in having the groove leading into the points deeper than the groove leading out of them, to turn the engine and car attached on to the right line. When coming out of the points, however, they were found to possess the defect that the engine and car met with a severe drop each time, damaging to the springs and other working parts.

By a very simple modification in the method of laying out the points and crossings at passing places this defect has been removed. The rails were laid in the manner shown upon the diagram, fig. 7. In this way the engine, at whatever speed it was driven, was found to have a natural tendency to take the proper road.

The question of points in tramway construction was an important one, in which to obtain perfection was very necessary. That known as "Kincaid's Combination Point" was, he believed, one of the best. It was intended to fulfil all the conditions required, and to obviate the necessity of supplying different types to meet the special requirements of each particular case. It was arranged to act in such a manner that a car approaching the points could be directed automatically into the right or left-hand road, as might be desired. It could also be used as a facing point without bias in either direction, and when so used an arrangement was provided by means of which the tongues could not remain in the centre of the groove, but were pressed home on the side to which it was nearest. When so used the tongue could be easily moved from the road surface, as is the case with ordinary facing points. There were special fishing arrangements provided which rendered it applicable to any section of tramway rail, thus preventing the necessity of having special patterns made for each order.

After some remarks on the methods of paving, and several other points of greater interest to civil than mechanical engineers, the reader treated of the construction and details of tramway cars with great particularity. Of the large cars used on steam tramways we may say the bogies are of wrought iron, the sides cut out of solid plate to form guides for the axle boxes; the centres are of cast iron, and friction rollers are fitted to each side to prevent the car tilting too far over; the wheels are 21in. diameter, of chilled cast iron, and carefully bored to 2⅜in.; the axles are of mild steel, turned, and the wheels forced on by hydraulic pressure.

The brake blocks are of chilled cast iron, one to each wheel, four to each bogie, or eight blocks for one car, all operated from a hand-wheel upon the platform. The Board of Trade are very strict on the subject of brake power, both on engines and cars.

The principal details of cars for a 3ft. 6in. gauge are as follows:

	ft.	in.
Length of body inside..........................	20	0½
Length over all, including end platforms...	29	1½
Extreme width..................................	6	3
Extreme height from rail level	13	6
Centres of bogie trucks	19	8½
Centres of axles under bogies	4	3
Height of passage in saloon	6	3
Height of passage, upper compartment ...	5	6
Height from rail to upper side of channel iron at platform entrance	2	6

Approximate weight ....78 cwt.
Approximate cost £250

We now conclude our notice of an interesting paper, full of good practical detail, by describing the form of coupling used upon the Birmingham steam cars, known as Nicholson's. It is shown in fig. 8, and consists of a cylindrical casting, attached to which is a strong drag link. Within the casting is a buffer, pressed outwards by a strong spring; it finishes in a concave cup, which receives the rounded end of the drawbar. The opening is large enough to allow of considerable lateral and vertical movement, the bar still holding to the drag link. A range of 4½in. is allowed to compensate for inequalities and oscillations of engine and car. The illustration (fig. 8) fully explains the action and detail. This coupling is very satisfactory in action, and has many advantages, not the least being its certainty and self-coupling action; while it acts as a buffer and prevents any unpleasant jolting. Many other interesting details were given, which our space does not permit us to give.

AN IMPROVED FORM OF SHAFT GOVERNOR.*

In the development of steam-engine governors, from the earliest forms employed by the first designers down to the latest production of modern engineers, it is noticeable that almost without an exception centrifugal force has been employed in every successful design.

The only apparent success without centrifugal force has been in the direction of fluid governors, but even with these it has been found that the variations in the condition of the fluid used produce a corresponding departure from the desired speed, and the comparatively greater power required to drive the fluid governors is also a factor in the unfavourable verdict which practical use has established.

Although the mechanical construction of centrifugal governors present an infinite variety of designs, yet certain fundamental elements appear in every case. In every governor will be found a weight or weights made to revolve around an axis, and having a latitude of motion to and from the axis, which motion is made to control the steam supply. It will always be found, also, that the centrifugal force developed by these weights is opposed by gravity, or springs, acting as a centripetal force. The action of the governor is therefore the result of a balancing of these forces.

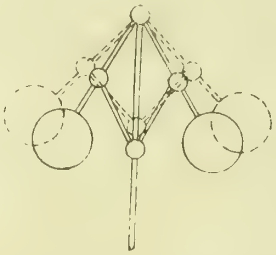

Fig. 1.

Fig. 1 illustrates a very large class of governors in which the gravity of centrifugal weights is made to oppose their centrifugal force. Springs are sometimes used in this construction to produce additional centripetal force.

Fig. 2 shows another type of governor, such as is commonly used on the main shaft of engines. In this form the gravity of one weight neutralises the other, and springs are depended on entirely for centripetal force. In all these illustrations the weights are shown in their initial position, or the position nearest the axis, and the outer position is indicated by dotted lines.

In the operation of a centrifugal governor any intermediate position taken by the weights must be one where the opposing forces are exactly in equilibrium. As the weights move outward from their axis the centrifugal force increases directly as the distance from the axis is increased. The opposing or centripetal force may also be made to increase in exactly the same ratio or scale. If so arranged, then, when the speed is such that the forces are in equilibrium in one position of the weights, they will also be exactly balanced in every position from one extreme to the other, and an engine having a governor so adjusted might be expected to show the same rate of speed under every condition of load.

Unfortunately, however, a difficulty arises in the nature of instability; for if adjusted as described, then whenever in any position of the weights the equilibrium between the opposing forces is disturbed by a change of speed, and the weights are thereby caused to move in the direction of the greater force, the same lack of equilibrium will exist when the weights have reached the extreme limit of motion in that direction ; and when the weaker force shall have become the stronger, by reason of the rapid change of speed that must follow, then the weights will move immediately to their extreme limit in the opposite direction, repeating this process constantly, and producing an effect that is called "racing" or "hunting." To prevent this, and to enable the governor to take all the intermediate positions with stability, it is necessary to arrange the centripetal force so that it will increase or decrease more rapidly than the centrifugal force when the weights move from one position to another. If so arranged, then a slight movement of the weights in the direction of the greater force will bring them to a position of equilibrium, and a still further change of speed will be required to move them to the next position. This condition of stability is therefore obtained at a sacrifice of uniformity of speed, and the greater the variation of speed between the extreme positions of the governor, the greater the stability which will be obtained.

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* A paper by F. H. Ball, read before the American Society of Mechanica Engineers.

Every designer of centrifugal governors has had to face this problem and decide just how near an approach to perfect harmony between the opposing forces would be safe, knowing that if he approach too near he must pay the penalty of instability, which is a fatal error. The question as to how near this theoretically perfect condition it is safe to adjust a governor depends somewhat on certain conditions. Light balance wheels, extreme changes of load, and friction in governing mechanism are all elements which prevent a near approach to the condition of adjustment that should produce uniform speed.

The inertia of the centrifugal weights is also an obstacle to fine adjustments, as it first prevents quick response and then overreaches the mark. For this reason high rotative speeds are desirable, as the necessary centrifugal force may be obtained from small weights having little inertia. A perfect governor should be free from unnecessary friction, and have as little weight to the moving parts as possible.

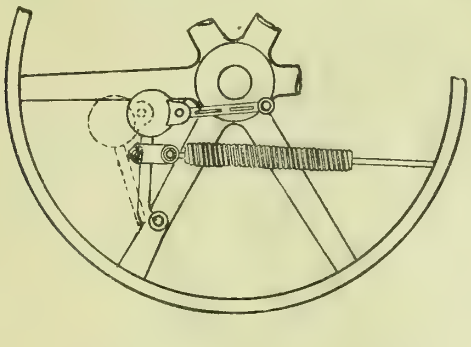


Fig. 2.

Its function is essentially to weigh quickly and accurately two opposing forces, just as a steam-engine indicator weighs the force of steam opposed to the spring, and yet there are those who load a governor down with weights, other than centrifugal weights, merely to produce centripetal force, when a suitable spring would produce the desired force without the incumbrance of weight and consequent inertia. Recognising the necessity of sacrificing theoretically correct regulation, or isochronism as it is technically called, for the sake of stability with centrifugal governors, numerous attempts have been made to obtain a better result by other means.

The fluid governors were found to come under the same general law as centrifugal governors, so far as the necessity of sacrificing isochronism for stability is concerned, and in addition to this, other defects appeared which have already been mentioned. Several attempts have been made in this country and Europe, running back through a period of over thirty years, to construct a governor without centrifugal weights which should produce uniform speed by a weighing of the load. It is safe to say that not one of these was ever a success, for the obvious reason, if for no other, that they contained no provision whatever for governing against changing boiler pressure.

In 1878 the writer conceived the idea of constructing a centrifugal governor on the shaft of an engine having all the functions of the best forms of centrifugal governors for governing against changing boiler pressure, and also so arranged that the driving pulley, instead of being keyed to the shaft, is driven by the governor in such a manner that the load is made to act as centripetal force.

With this arrangement the governor may be adjusted for ample stability, and the effort of the load adjusted exactly to correct the change of speed that otherwise would take place.

Fig. 3 illustrates the arrangement for weighing the load.

The curved arm A is keyed to the shaft, and the belt wheel is driven from the connection at the end of this arm.

The effort of the engine is thus made to act as centripetal force, and by a suitable adjustment of this force the governor weights are brought into the required position at every stage of load to compel the engine to maintain a constant speed.

This combination proved to be successful for giving exact regulation against changes of load.

With changes of boiler pressure, however, this governor acts only as a centrifugal governor, and as such it is incapable of preventing slight changes of speed under change of boiler pressure.

Where intermittent disturbances occur, a great improvement is often derived from the use of a dash-pot or oil cylinder having a piston with a small aperture for the fluid to pass from one side to the other, and attached to the moving part of the governor in a manner to prevent sudden motion.

Rankine describes the use of a dash-pot in his book entitled "Machinery and Mill Work," published in 1859, in Section 364.

Most of the builders of Corliss engines have found it desirable to make use of a dash-pot in their governors, owing to the inertia of the large slowly revolving weights, and also to the intermittent disturbances of the releasing valve gear.

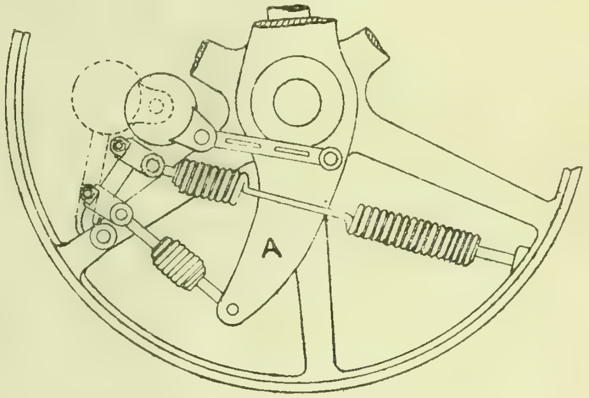


Fig. 3.

Among the shaft governors, or shifting eccentric governors according to the classification in the Patent Office, the Buckeye Engine Company, of Salem, O., seem to have been the first to apply dash-pots.

They found that with large engines, where, owing to the slow rotative speed, the forces of the governors were weak in comparison with the intermittent disturbing elements to be overcome, that a dash-pot would materially improve the action of the governor.

In 1878 they made use of dash-pots in one of their governor on an engine at the Syracuse Ironworks, Syracuse, N.Y.

A more uniform action of the eccentric was thereby obtained and from this experience the same difficulty in other engines was remedied in a similar manner.

In 1879 they put similar dash-pots on an engine at the works of the White, Potter, and Paige Manufacturing Company, of Brooklyn, N.Y., for the same purpose, and in 1880 applied the same remedy to a pair of engines at "Dows' Stores," Brooklyn, N.Y., following it up in 1881 on engines at the Hartford Carpet Company, and the Pacific Mills, Lawrence, Mass., and many others which have not come under the writer's notice.

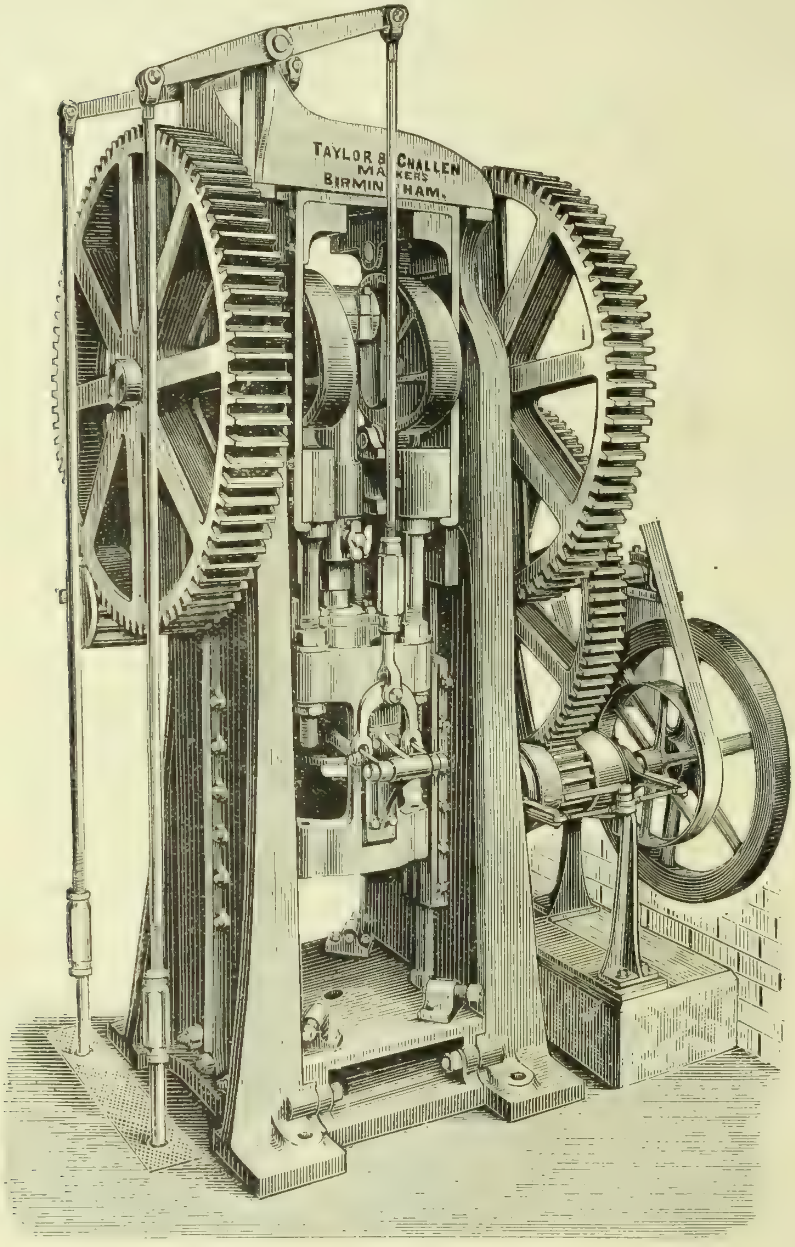
(To be continued.)

Electricity and Atlantic Liners.—The two new monster Atlantic liners for the White Star Line—the longest vessels afloat, each being 582ft. in length—will be lavishly fitted throughout with electric light, electric bells, electrical gear in connection with steering and signalling, electric search lights, and other electrical appliances of the most approved description.

New Premises for Elwell-Parker.—The Elwell-Parker Company has determined to erect new and extensive works on land adjoining the Bushbury Station of the London and North-Western Railway Company at Wolverhampton. The existing works are inadequate to the rapid growth of the company's business, and it has, therefore, been decided to provide more commodious works, for which designs, &c., are to be prepared by Mr. G. H. Stanger, C.E.

GEARED DRAWING AND STAMPING PRESS.

CONSTRUCTED BY MESSRS. TAYLOR AND CHALLEN, BIRMINGHAM.



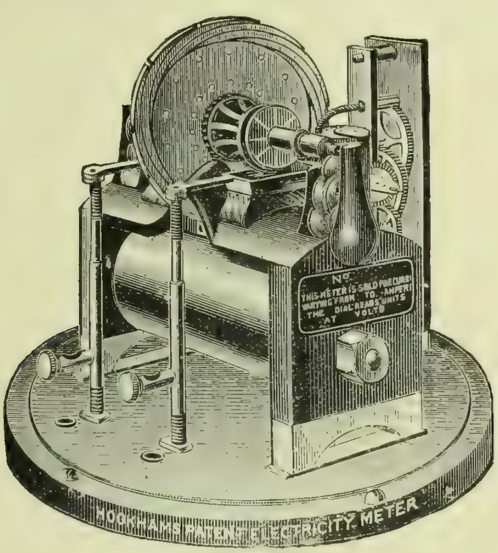
PRESSES intended for stamping or drawing metal require very great strength and rigidity, as even a very slight giving in the framework or working parts will seriously interfere with the life of the dies, and besides cause them to perform but indifferent work. It is difficult to get castings in one piece, at the same time heavy and rigid, which are sufficiently portable. In the geared press we illustrate above, designed and constructed by Messrs. Taylor and Challen, of Birmingham, this difficulty has been fully met by making the main frame of four castings, strongly bolted together, but arranged in such manner that the machine may be readily taken to pieces for convenience of transport and delivery. The bolting and interlocking are so designed that all the rigidity of a solid casting is obtained with but slight additional weight.

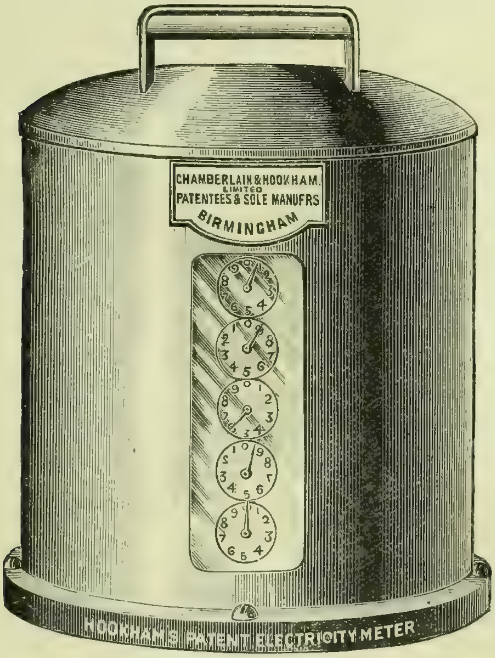
The crank shaft carries two spur wheels gearing into two pinions upon an intermediate shaft, which is driven from the pulley or flywheel shaft. The crank discs by this arrangement are each driven direct, without allowing the strain to come upon one end alone. The stroke is extra long, and the connecting rod and guides are very massive. The cams are of cast steel fitted to the webs of the forged steel crank shaft, and the starting gear consists of a friction clutch of improved design, and under thorough control. The arrangements are the result of a long-continued and extensive experience in this branch of engineering, and may be depended upon to perform efficiently the work for which they are intended.

AN ELECTRIC RAILWAY IN DUBLIN.—For some time past workmen have been busily engaged in laying down a two-feet gauge line of railway from the stores of the Dublin Whisky Distillery Company, Richmond Road, to their bonded warehouses on Distillery Road. The line is being constructed by Mr. Berry, of Manchester, and will be ready for work in a short time.

A NEW ELECTRICITY METER.

In another part of this issue we give an extended account of an interesting paper upon "Electric Meters for Central Stations," and as the subject is now assuming an ever-increasing importance, we are pleased to be able to supplement Professor Forbes' description by an account of an excellent and recent form of instrument referred to by Mr. R. E. Crompton in the discussion which followed, and omitted by the reader of the paper. The meter in question is the invention of Mr. Hookham, of the firm of Messrs. Chamberlain and Hookham, the well-known electrical engineers, Birmingham, and is exceedingly simple in principle and constructive detail. On this page we give two illustrations, one showing the interior of the instrument with the outer case removed, and the other showing it with the case in position as in actual use. We propose, at an early date, to publish a detailed description of its action and principle, with illustrative diagrams; but meantime we may state that it consists essentially of an electro-motor doing work against Foucault currents under conditions in which all other retarding influences are negligible.





When this is the case, and the armature carries the current to be measured, the field remaining constant, the speed of the armature will vary directly as the current: for the work done is proportional to the square of the speed; the brake force varies as the speed; hence the speed will be proportional to the driving force, which again, in a constant field, is proportional to the current to be measured.

The engraving illustrates a meter for a thirty-light installation. The armature sections (not shown) are built up on a copper disc, the connections passing spirally round the edge of the disc. The disc and armature rotate together between the poles of the magnet, which are of cast iron, and the magnet bars of tungsten steel, contained in a brass tube beneath. The reduced ends of the armature spindle roll on the uppermost wheels of anti-friction trains, and a commutator in which mercury contacts replace spring brushes—practically frictionless—directs the necessary distribution of current. Iron is not used in the armature, so that magnetic drag does not enter as a disturbing cause. The motions of a worm wheel, driven by a screw thread on the armature spindle, are transmitted to the counter. At present the magnets are fitted with a short circuiting bar, whose distance from the cast-iron arms of the magnet can be adjusted. The object of this arrangement is to reinforce the field if found to fall off, by removing the bar to a greater distance. In practice this has proved to be a superfluous precaution, as, after many months' testing of a considerable number of meters, in no case is there the slightest indication of the field falling off. The cause of this constancy of field is that the air-space resistance is extremely small, and the magetic circuit consequently almost closed. A further advantage of this closed circuit is that it is impossible to tamper with the field by means of external magnetism, especially as the whole apparatus is enclosed in a stout iron case. This case is glazed at the part opposite the dials, and need not be removed even at the quarterly visit of the meter inspector.

The instrument has been in practical work for central station lighting since January, 1888, and is believed to solve the problem of supplying electric energy by meter, and to have all the requisites for accurate and lasting work. It has no complications, containing, in fact, but one important moving part, which revolves at a very low speed. It requires no lubrication, and will run, if necessary, for as much as twelve months without attention. It is made in two sizes, the first being intended to measure currents varying from ·4 to 20 ampères; and the second, currents varying from ·6 to 40 ampères. For station meters, or special purposes where a small waste of energy is not objectionable, a range of as much as from one to two hundred and fifty can be obtained. Its indications are recorded on dials similar to those in use with gas-meters. As ordinarily supplied, it is standardised to read Board of Trade units, with a difference of potential in the house of one hundred and ten volts, but it can be rated for any other potential difference. No current is consumed in the meter, and the fall of potential with full load is only about one-tenth per cent.

From what we know of this ingenious instrument, we think it very closely approximates to satisfying all the rigid conditions laid down by Professor Forbes in his paper, and it seems to us that a large field of work is before it.

THE LAP AND TRAVEL OF A SLIDE VALVE.

In many of the treatises on slide valves, and the various works of reference which treat in a greater or less degree on valve gearing, great stress is laid upon the importance of arranging the proportions of a slide valve, viz., the lap and the travel, so that the opening of port to steam may be of sufficient amount to prevent the velocity of the entering steam from reaching a given maximum limit; but in no single instance has the writer seen in such books a method given for calculating, from the maximum opening of the port to steam and the required cut-off, the necessary amount of lap and travel required for a single slide valve.

It is true that in most of the better kind of pocket books of engineering formulæ certain rules are given for the purpose of calculating the lap required upon a valve under the various required conditions of working, but these are based upon the travel of the valve (which is supposed to have been predetermined), and not found directly from the required maximum opening of port.

Perhaps the most general practice in engineering establishments, when about to determine the proportions of a valve driven by "direct" valve gear, is first to determine the amount of port opening necessary, and then, having assumed a travel, to find, by some such rule as the one appended (1), the proportionate lap for that travel under the required conditions—as to the cut-off and lead—and then, having subtracted the lap thus found from half the (assumed) travel, if the remainder is found to be less or greater than the required opening of port, another travel is assumed, greater or less, as the case may be, and another calculation made, to be again repeated until a sufficiently satisfactory result has been obtained.

TABLE I.—GIVING THE AMOUNT OF LAP AND TRAVEL OF SLIDE VALVE FOR GIVEN PORT OPENINGS.

Mean Cut-off, in terms of the Piston Stroke.

	1/4		3/10		1/3		3½/10		3/8		4/10		4½/10		1/2		5½/10		6/10		5/8		6½/10		2/3		7/10		3/4		8/10		5/6		8½/10		7/8		9/10		
Maximum Opening of Port to Steam.	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	Maximum Opening of Port to Steam.
1/4	1 5/8	3 3/4	1 9/32	3 1/16	1 3/32	2 11/16	1 1/32	2 9/16	15/16	2 3/8	27/32	2 1/4	23/32	1 15/16	19/32	1 11/16	1/2	1 1/2	7/16	1 3/8	3/8	1 5/16	11/32	1 1/4	11/32	1 3/16	5/16	1 1/8	1/4	1	3/16	29/32	5/32	27/32	5/32	13/16	1/8	25/32	3/32	23/32	1/4
5/16	2	4 11/16	1 19/32	3 13/16	1 11/32	3 13/32	1 9/32	3 1/4	1 5/32	2 31/32	1 1/16	2 3/4	7/8	2 7/16	3/4	2 1/8	5/8	1 7/8	17/32	1 11/16	15/32	1 5/8	7/16	1 17/32	13/32	1 15/32	3/8	1 3/8	5/16	1 1/4	1/4	1 1/8	7/32	1 1/32	3/16	1	5/32	31/32	1/8	29/32	5/16
3/8	2 13/32	5 5/8	1 29/32	4 9/16	1 5/8	4 3/32	1 17/32	3 7/8	1 13/32	3 9/16	1 9/32	3 5/16	1 1/16	2 7/8	29/32	2 9/16	3/4	2 1/4	5/8	2 1/32	19/32	1 15/16	17/32	1 27/32	1/2	1 25/32	15/32	1 11/16	3/8	1 1/2	5/16	1 3/8	1/4	1 1/4	1/4	1 7/32	3/16	1 5/32	5/32	1 3/32	3/8
7/16	2 13/16	6 9/16	2 7/32	5 3/8	1 29/32	4 3/4	1 13/16	4 1/2	1 5/8	4 5/32	1 1/2	3 7/8	1 1/4	3 3/8	1 1/32	2 15/16	7/8	2 5/8	3/4	2 3/8	11/16	2 1/4	5/8	2 5/32	19/32	2 1/16	17/32	1 15/16	7/16	1 3/4	11/32	1 19/32	5/16	1 1/2	9/32	1 7/16	7/32	1 11/32	3/16	1 9/32	7/16
1/2	3 7/32	7 7/16	2 9/16	6 1/8	2 3/16	5 7/16	2 1/16	5 3/16	1 7/8	4 3/4	1 23/32	4 7/16	1 7/16	3 7/8	1 3/16	3 3/8	1	3 1/16	27/32	2 23/32	25/32	2 9/16	23/32	2 7/16	11/16	2 3/8	19/32	2 7/32	1/2	2	13/32	1 13/16	11/32	1 11/16	5/16	1 5/8	1/4	1 17/32	7/32	1 15/32	1/2
9/16	3 5/8	8 7/16	2 7/8	6 7/8	2 15/32	6 1/8	2 11/32	5 13/16	2 3/32	5 11/32	1 15/16	5	1 19/32	4 3/8	1 11/32	3 13/16	1 1/8	3 7/16	31/32	3 1/16	7/8	2 29/32	13/16	2 3/4	25/32	2 21/32	11/16	2 1/2	9/16	2 1/4	15/32	2 1/32	3/8	1 29/32	11/32	1 27/32	9/32	1 3/4	1/4	1 21/32	9/16
5/8	4 1/32	9 3/8	3 3/16	7 5/8	2 3/4	6 3/4	2 19/32	6 7/16	2 11/32	5 15/16	2 5/32	5 9/16	1 25/32	4 7/8	1 1/2	4 1/4	1 9/32	3 13/16	1 1/16	3 7/16	31/32	3 7/32	29/32	3 1/16	27/32	2 31/32	3/4	2 25/32	5/8	2 1/2	1/2	2 1/4	7/16	2 1/8	13/32	2 1/32	11/32	1 15/16	9/32	1 27/32	5/8
11/16	4 7/16	10 5/16	3 1/2	8 7/16	3	7 7/16	2 27/32	7 1/16	2 9/16	6 1/2	2 11/32	6 1/8	1 31/32	5 5/16	1 21/32	4 11/16	1 13/32	4 3/16	1 3/16	3 3/4	1 1/16	3 9/16	1	3 3/8	15/16	3 1/4	27/32	3 1/16	11/16	2 3/4	9/16	2 1/2	15/32	2 5/16	7/16	2 1/4	3/8	2 1/8	5/16	2	11/16
3/4	4 13/16	11 3/16	3 13/16	9 3/16	3 9/32	8 3/16	3 1/8	7 11/16	2 13/16	7 1/8	2 9/16	6 5/8	2 5/32	5 13/16	1 13/16	5 1/8	1 17/32	4 9/16	1 9/32	4 1/16	1 3/16	3 7/8	1 3/32	3 11/16	1 1/32	3 17/32	29/32	3 5/16	3/4	3	19/32	2 11/16	1/2	2 17/32	15/32	2 7/16	13/32	2 5/16	11/32	2 3/16	3/4
13/16	5 1/4	12 1/8	4 1/8	9 15/16	3 9/16	8 13/16	3 3/8	8 3/8	3 1/16	7 3/4	2 25/32	7 3/16	2 5/16	6 5/16	1 15/16	5 1/2	1 21/32	4 15/16	1 13/32	4 7/16	1 9/32	4 3/16	1 5/32	4	1 3/32	3 27/32	31/32	3 19/32	13/16	3 1/4	21/32	2 15/16	9/16	2 3/4	1/2	2 21/32	7/16	2 1/2	3/8	2 3/8	13/16
7/8	5 21/32	13 1/16	4 15/32	10 11/16	3 27/32	9 1/2	3 5/8	9	3 9/32	8 5/16	3	7 3/4	2 1/2	6 13/16	2 1/8	6	1 25/32	5 5/16	1 1/2	4 3/4	1 3/8	4 1/2	1 9/32	4 5/16	1 3/16	4 1/8	1 1/16	3 7/8	7/8	3 1/2	23/32	3 3/16	19/32	2 15/16	9/16	2 7/8	15/32	2 11/16	13/32	2 9/16	7/8
15/16			4 25/32	11 1/2	4 1/8	10 3/16	3 29/32	9 11/16	3 17/32	8 7/8	3 7/32	8 5/16	2 11/16	7 1/4	2 1/4	6 3/8	1 29/32	5 11/16	1 5/8	5 1/8	1 15/32	4 27/32	1 11/32	4 5/8	1 9/32	4 7/16	1 1/8	4 5/32	15/16	3 3/4	3/4	3 3/8	5/8	3 3/16	19/32	3 1/16	1/2	2 29/32	7/16	2 3/4	15/16
1			5 1/8	12 1/4	4 3/8	10 7/8	4 5/32	10 5/16	3 3/4	9 1/2	3 7/16	8 7/8	2 7/8	7 3/4	2 13/32	6 13/16	2 1/32	6 1/16	1 23/32	5 7/16	1 9/16	5 5/32	1 7/16	4 7/8	1 3/8	4 3/4	1 7/32	4 7/16	1	4	13/16	3 5/8	11/16	3 3/8	5/8	3 1/4	17/32	3 3/32	15/32	2 15/16	1
1 1/16					4 21/32	11 9/16	4 13/32	11	4	10 1/16	3 21/32	9 7/16	3 1/16	8 3/16	2 9/16	7 1/4	2 5/32	6 1/2	1 27/32	5 13/16	1 11/16	5 1/2	1 17/32	5 3/16	1 15/32	5 1/32	1 9/32	4 11/16	1 1/16	4 1/4	7/8	3 7/8	23/32	3 19/32	21/32	3 13/32	9/16	3 9/32	1/2	3 1/8	1 1/16
1 1/8					4 15/16	12 1/4	4 11/16	11 5/8	4 7/32	10 11/16	3 7/8	10	3 7/32	8 11/16	2 23/32	7 11/16	2 9/32	6 7/8	1 15/16	6 1/8	1 25/32	5 13/16	1 5/8	5 1/2	1 17/32	5 5/16	1 3/8	5	1 1/8	4 1/2	29/32	4 1/16	25/32	3 13/16	23/32	3 11/16	19/32	3 15/32	17/32	3 5/16	1 1/8
1 3/16					5 7/32	12 7/8	4 15/16	12 1/4	4 15/32	11 1/4	4 3/32	10 9/16	3 13/32	9 3/16	2 7/8	8 1/8	2 7/16	7 3/16	2 1/32	6 7/16	1 7/8	6 1/8	1 23/32	5 13/16	1 5/8	5 5/8	1 7/16	5 1/4	1 3/16	4 3/4	31/32	4 5/16	13/16	4	3/4	3 7/8	21/32	3 21/32	9/16	3 1/2	1 3/16
1 1/4					5 15/32	13 9/16	5 3/16	12 7/8	4 11/16	11 7/8	4 9/32	11 1/8	3 19/32	9 11/16	3	8 1/2	2 9/16	7 9/16	2 5/32	6 13/16	1 31/32	6 7/16	1 13/16	6 1/4	1 23/32	5 29/32	1 1/2	5 1/2	1 1/4	5	1	4 1/2	27/32	4 7/32	25/32	4 1/16	11/16	3 7/8	[illegible]	3 21/32	1 1/4
1 5/16					5 3/4	14 1/4	5 7/16	13 1/2	4 15/16	12 1/2	4 1/2	11 5/8	3 3/4	10 1/8	3 5/32	8 15/16	2 11/16	8	2 1/4	7 1/8	2 1/16	6 3/4	1 29/32	6 7/16	1 25/32	6 3/16	1 19/32	5 13/16	1 5/16	5 1/4	1 1/16	4 3/4	29/32	4 7/16	27/32	4 9/32	23/32	4 1/16	19/32	3 27/32	1 5/16
1 3/8									5 3/16	13	4 23/32	12 3/16	3 15/16	10 5/8	3 5/16	9 5/16	2 13/16	8 3/8	2 3/8	7 1/2	2 3/16	7 1/8	2	6 3/4	1 7/8	6 1/2	1 21/32	6 1/16	1 3/8	5 1/2	1 1/8	5	15/16	4 5/8	7/8	4 1/2	3/4	4 1/4	5/8	4 1/32	1 3/8
1 7/16									5 13/32	13 5/8	4 15/16	12 3/4	4 1/8	11 1/16	3 15/32	9 3/4	2 15/16	8 3/4	2 15/32	7 13/16	2 9/32	7 7/16	2 3/32	7 1/16	1 31/32	6 13/16	1 3/4	6 3/8	1 7/16	5 3/4	1 5/32	5 3/16	31/32	4 27/32	29/32	4 11/16	25/32	4 7/16	21/32	4 7/32	1 7/16
1 1/2									5 5/8	14 3/16	5 5/32	13 1/4	4 5/16	11 9/16	3 5/8	10 3/16	3 1/16	9 1/8	2 19/32	8 1/8	2 3/8	7 3/4	2 5/32	7 5/16	2 1/16	7 1/8	1 13/16	6 5/8	1 1/2	6	1 7/32	5 7/16	1 1/32	5 1/16	15/16	4 7/8	13/16	4 5/8	11/16	4 13/32	1 1/2
1 9/16													4 15/32	12 1/16	3 25/32	10 5/8	3 3/16	9 1/2	2 11/16	8 1/2	2 15/32	8 1/16	2 1/4	7 5/8	2 5/32	7 3/8	1 29/32	6 7/8	1 9/16	6 1/4	1 9/32	5 5/8	1 1/16	5 1/4	31/32	5 3/32	27/32	4 13/16	23/32	4 9/16	1 9/16
1 5/8													4 21/32	12 9/16	3 15/16	11 1/16	3 5/16	9 7/8	2 25/32	8 13/16	2 9/16	8 3/8	2 11/32	7 15/16	2 7/32	7 11/16	1 31/32	7 3/16	1 5/8	6 1/2	1 5/16	5 7/8	1 3/32	5 1/2	1 1/32	5 5/16	7/8	5	3/4	4 3/4	1 5/8
1 11/16													4 27/32	13 1/16	4 1/16	11 1/2	3 7/16	10 1/4	2 29/32	9 3/16	2 21/32	8 3/4	2 7/16	8 1/4	2 5/16	7 31/32	2 1/32	7 7/16	1 11/16	6 3/4	1 3/8	6 1/8	1 5/32	5 11/16	1 1/16	5 1/2	29/32	5 3/16	25/32	4 15/16	1 11/16
1 3/4													5 1/32	13 9/16	4 7/32	11 15/16	3 9/16	10 5/8	3	9 1/2	2 25/32	9 1/16	2 17/32	8 5/8	2 13/32	8 1/4	2 1/8	7 3/4	1 3/4	7	1 13/32	6 5/16	1 3/16	5 7/8	1 3/32	5 11/16	15/16	5 13/32	13/16	5 1/8	1 3/4
1 13/16															4 3/8	12 3/8	3 11/16	11	3 1/8	9 7/8	2 7/8	9 3/8	2 5/8	8 7/8	2 1/2	8 9/16	2 3/16	8	1 13/16	7 1/4	1 15/32	6 9/16	1 7/32	6 1/8	1 1/8	5 29/32	31/32	5 19/32	27/32	5 5/16	1 13/16
1 7/8															4 1/2	12 13/16	3 13/16	11 3/8	3 7/32	10 3/16	2 31/32	9 11/16	2 23/32	9 3/16	2 9/16	8 7/8	2 9/32	8 5/16	1 7/8	7 1/2	1 1/2	6 3/4	1 9/32	6 5/16	1 3/16	6 1/8	1	5 25/32	7/8	5 1/2	1 7/8
1 15/16															4 21/32	13 1/4	3 31/32	11 3/4	3 11/32	10 9/16	3 1/16	10	2 13/16	9 1/2	2 21/32	9 3/16	2 11/32	8 9/16	1 15/16	7 3/4	1 9/16	7	1 5/16	6 1/2	1 7/32	6 5/16	1 1/32	6	29/32	5 11/16	1 15/16
2															4 13/16	13 5/8	4 3/32	12 3/16	3 7/16	10 7/8	3 5/32	10 5/16	2 29/32	9 13/16	2 3/4	9 1/2	2 7/16	8 13/16	2	8	1 5/8	7 3/16	1 3/8	6 3/4	1 1/4	6 1/2	1 3/32	6 5/32	15/16	5 27/32	2
2 1/8															5 1/8	14 1/2	4 11/32	12 15/16	3 21/32	11 9/16	3 11/32	11	3 1/16	10 7/16	2 29/32	10 1/16	2 9/16	9 7/16	2 1/8	8 1/2	1 23/32	7 11/16	1 7/16	7 1/8	1 11/32	6 15/16	1 5/32	6 9/16	31/32	6 7/32	2 1/8
2 1/4																	4 19/32	13 11/16	3 7/8	12 1/4	3 9/16	11 5/8	3 1/4	11	3 3/32	10 5/8	2 23/32	9 15/16	2 1/4	9	1 13/16	8 1/8	1 17/32	7 9/16	1 13/32	7 5/16	1 7/32	6 15/16	1 1/32	6 9/16	2 1/4
2 3/8																	4 27/32	14 7/16	4 3/32	12 7/8	3 3/4	12 1/4	3 7/16	11 5/8	3 1/4	11 1/4	2 7/8	10 1/2	2 3/8	9 1/2	1 29/32	8 9/16	1 5/8	8	1 1/2	7 3/4	1 9/32	7 5/16	1 3/32	6 15/16	2 3/8
2 1/2																	5 3/32	15 3/16	4 9/32	13 9/16	3 15/16	12 7/8	3 5/8	12 1/4	3 7/16	11 13/16	3 1/32	11	2 1/2	10	2 1/32	9	1 11/16	8 7/16	1 9/16	8 1/8	1 11/32	7 11/16	[illegible]	7 5/16	2 1/2
2 5/8																	5 3/8	15 15/16	4 1/2	14 1/4	4 5/32	13 1/2	3 13/16	12 7/8	3 19/32	12 3/8	3 3/16	11 9/16	2 5/8	10 1/2	2 1/8	9 1/2	1 25/32	8 7/8	1 21/32	8 9/16	1 7/16	8 1/8	1 7/32	7 11/16	2 5/8
2 3/4																	5 5/8	16 3/4	4 25/32	14 15/16	4 11/32	14 3/16	3 31/32	13 7/16	3 25/32	13	3 11/32	12 1/8	2 3/4	11	2 7/32	9 15/16	1 7/8	9 1/4	1 23/32	9	1 1/2	8 1/2	1 9/32	8 1/16	2 3/4
2 7/8																	5 7/8	17 1/2	4 15/16	15 5/8	4 17/32	14 13/16	4 5/32	14 1/16	3 15/16	13 9/16	3 15/32	12 11/16	2 7/8	11 1/2	2 5/16	10 3/8	1 31/32	9 11/16	1 13/16	9 3/8	1 9/16	8 7/8	1 11/32	8 7/16	2 7/8
3																	6 1/8	18 1/4	5 3/32	16 5/16	4 23/32	15 7/16	4 11/32	14 5/8	4 1/8	14 3/16	3 5/8	13 1/4	3	12	2 7/16	10 7/8	2 1/32	10 1/8	1 7/8	9 3/4	1 5/8	9 1/4	[illegible]	8 13/16	3

Again, in many offices where Zeuner's diagrammatic method of treating slide-valve problems has become more or less firmly established, it is a common practice to fix upon the necessary "travel" and "lap" by a system of "trial and error," somewhat similar in principle, but certainly simpler in application, than the previous method. The main reason for this is no doubt owing to the difficulty of solving the problem by the Zeuner method in a sufficiently easy manner, as it is perhaps the most difficult, but at the same time the most useful, problem in valve designing.

Now, it will be admitted that both the foregoing methods are very tedious, and, at their best, most unscientific in character, so that the annexed Table I. will probably be useful for the purpose of determining for a given maximum opening of port the necessary amount of lap required upon a simple slide valve at various points of cut-off, and also the length of travel which the valve will require under similar conditions of working; and further, as the amount of lap L and the required travel T are placed side by side under the various points of cut-off, the table may serve a double purpose, as we may, by assuming a given travel and cut-off, find in the adjoining column (under the same heading) the necessary lap for those conditions.

It may be as well to observe that the various values of the lap given in Table I. are to the nearest thirty-second of an inch division, and also to note that the amount of travel there given has been computed from the opening of port, and separately from that of the lap, so that if there should be a slight difference between the values given for the travel and those which may be found by doubling the sum of the lap and the port opening, it is owing to the slight error introduced by the adoption of the thirty-second of an inch as the least unit of measurement. Also, that the lap and opening of port under consideration is the mean of the top and bottom values; that the slight influence produced by the angularity of the eccentric rod is of course neglected, this being generally inappreciable in amount; and finally it is unnecessary to state that no allowance has been made in the table for any "lead" which may have been arranged for, as the necessary allowance for such lead may be readily made when applying Table I. to any given case—as will be explained in the following rule:—

Rule: From the mean (greatest) opening of port required, subtract half the mean[*] lead, if any, and opposite the value (thus obtained) in the port opening column read off under the desired cut-off the values for the lap L and the travel T there given. Then from the lap thus found subtract half the mean lead, and the result will be the true mean lap.

For example: Required the mean lap necessary for a valve, the mean cut-off to be at seven-tenths (·7) of the stroke, the mean (greatest) opening of port to be $1\frac{1}{2}$in., and the mean lead $\frac{1}{8}$in.

Subtracting half the mean lead from $1\frac{1}{2}$in., we obtain $1\frac{7}{16}$, and on referring to the table we find, under a cut-off of 7-10ths of the stroke, and on the same line as $1\frac{7}{16}$in. in the port opening column, the lap L is $1\frac{3}{4}$in., and the travel T $6\frac{3}{8}$in., so that the true mean lap will be $1\frac{3}{4}$in., less half the lead, or $\frac{1}{16}$in., that is to say $1\frac{11}{16}$in., and as the travel should be equal to twice the sum of the lap and port opening, we may prove the truth of the above value for the travel thus: $(1\frac{11}{16}\text{in.} + 1\frac{1}{2}\text{in.}) \times 2 = 6\frac{3}{8}$in., as already found.

By the usual formula—as given in Molesworth and other pocket books—for finding the lap in terms of the travel—

$$\text{Lap} = \left(\tfrac{1}{2}\text{ travel}\sqrt{\frac{\text{whole stroke} - \text{cut-off}}{\text{whole stroke}}}\right) - \tfrac{1}{2}\text{ lead} \qquad (1)$$

$$= \left(3\tfrac{3}{16}\sqrt{·3}\quad\right) - \tfrac{1}{16}$$

$$= (3·1875 \times ·5477) - ·0625$$

Lap = 1·6833 or $1\frac{11}{16}$in. very nearly.

If the lead at the top (in the above instance) was arranged to be $\frac{1}{16}$in., and that at the bottom $\frac{3}{16}$in., we should have to reduce the mean lap from $1\frac{11}{16}$in. to $1\frac{5}{8}$in. for the lap at the bottom, and increase the same value to $1\frac{3}{4}$in. for the value of the lap at the top; that is to say, we decrease or increase the mean lap by an amount equal to half the difference between the top and bottom leads, always remembering that the sum of the laps and leads at each end must be equal to one another.

In order to increase the usefulness of these notes, we append a formula, which may be found of service where other values are assigned for the cut-off than those given in the Table I.

It is as follows:—

$$L = \frac{\sqrt{x}}{1 - \sqrt{x}} \times O \qquad (2)$$

Where L = the mean lap of a valve.
O = the required opening of port.
x = the portion of the stroke to be performed after the point of cut-off.

The lead may be neglected and accounted for as shown in a preceding rule.

If we substitute the symbol k for the fractional coefficient $\frac{\sqrt{x}}{1 - \sqrt{x}}$ in the above, we may write

$$L = k \times O \qquad (3)$$

And in Table II. will be found a number of values of this multiplier k for a number of different points of cut-off, and, on working out an example, these will be found to agree pretty closely with the results in the Table I.

TABLE II.—THE LAP OF A VALVE IN TERMS OF THE OPENING OF PORT.

From formula $L = k \times$ opening of port. (3)

Cut off.	k	Cut off.	k	Cut off.	k
·25	6·462	·5	2·41	·75	1·
·3	5·122	·55	2·04	·8	·81
·33̇	4·4	·6	1·72	·83̇	·68
·35	4·16	·625	1·58	·85	·632
·375	3·76	·65	1·45	·875	·54
·4	3·436	·66̇	1·37	·9	·4625
·45	2·87	·7	1·21		

Also it may be easily proved that the travel

$$T = 2\,(k + 1) \times O \qquad (4)$$

and therefore, if M be put to represent the factor $2\,(k + 1)$, we may write

$$T = M \times O \qquad (5)$$

and in Table III. we give a number of values for the multiplier M for various points of cut-off, and the results obtained by the use of these will also agree very closely with those given in the Table I.

TABLE III.—THE TRAVEL OF A VALVE IN TERMS OF THE OPENING OF PORT.

From Formula $T = M \times O$ (5)

Cut off.	M.	Cut off.	M.	Cut off.	M.
·25	14·924	·5	6·82	·75	4·
·3	12·244	·55	6·08	·8	3·62
·33̇	10·8	·6	5·44	·83̇	3·36
·35	10·32	·625	5·16	·85	3·264
·375	9·52	·65	4·90	·875	3·08
·4	8·875	·666	4·74	·9	2·925
·45	7·74	·7	4·42		

ELECTRICAL TRANSMISSION OF POWER.[*]

THE following data have reference to the transmission of power from hydraulic works at Thorenberg to a flourmill in Lucerne. Dynamos of Brown's design are employed, the generator and motor being of the same type but differently wound. The plant has to transmit 120 H.P., with 1,000 volts, at a speed of 450 revolutions, and 80 ampères. The principal dimensions of the machines are as under:—

	Generator.	Motor.
Diameter of armature in centimetres	80	72
Length ,, ,,	80	80
Number of turns on armature	396	360
,, segments on commutator	132	120
,, turns on field-magnets	315	279
Diameter (in millimetres) of wire on field-magnets	10	10
Resistance (in ohms) of armature between the brushes	0·220	0·200
Resistance of field-magnets	0·245	0·207
Total resistance of the circuit in ohms	2·85	

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[*] By mean lead, mean opening of port, mean lap, is meant the mean of the leads, opening of ports, or laps at the two ends of the valve.

[*] Foreign Abstracts, Proc. Inst.C.E.

The line, which is partly above and partly underground, has a total resistance of about 2 ohms. The above-ground portion is 3,040 metres long, and 63 square millimetres in section, and is suspended on porcelain double-bell insulators. In order to prevent the two machines from being injured by short-circuiting caused by any accidental contact of the two line wires, a special electro-magnetic accessory is joined up in the general circuit, so that immediately the current strength becomes abnormal the field-magnets of the dynamos are automatically shunted. The strength of the magnetic field consequently falls to zero and no current is generated. This automatic circuit-closer consists of a straight electro-magnet, having each end of its core fixed in a mass of iron. Beneath these prolongations of the core is an armature which works on a hinge, and, in its position of rest, holds up the weighted extremity of an upright lever, the lower end of which turns on an axle held in a frame. At the lowest part of the base-board are two metal springs; as soon as the current attains a strength of about 20 per cent more than the maximum, the armature of the circuit-closer is drawn upwards and releases the lever, which falls between the contact springs and thereby short-circuits the field-magnets of the dynamo.

A hand cut-out of special form is also used in this installation, so that, in case of necessity, the circuit of a machine in action can be opened without endangering the insulation. This cut-out is composed of a base on which is mounted a carbon rod, held at its lower end between two flat metallic springs that are fixed on an insulating handle, the latter being attached to a bar which can be slid up and down. In order to avoid an abrupt severance of the circuit, the handle is moved slowly downwards; directly the springs and carbon are separated the space between them is bridged by an arc, which, with careful manipulation, can be made to attain a length of 50 centimetres before the circuit is finally broken.

ELECTRIC METERS FOR CENTRAL STATIONS.

At the seventh ordinary meeting of the Society of Arts, held on Wednesday, 23rd January, a paper upon Electrical Meters was read by Professor George Forbes, F.R.S., the well-known electrician. In his opening remarks the reader said that he had devoted much time and thought to the consideration of the distribution of electricity from central stations in Europe and America, to thoroughly understand the methods of operation in extensive use. Meters must fulfil many stringent conditions; the principal were accuracy, sufficient range, a minimum consumption of current, simplicity of construction, durability, and need of little attention. They should register clearly and intelligibly, should be easily tested, should be beyond the possibility of tampering, and should be without liquid capable of freezing. No one meter, he said, fulfilled all these requirements, but in the important ones many were complied with. He then proceeded to describe the various meters, beginning with the Edison. We shall now give his description in his own words.

Edison Meter.

In describing the different meters, I will begin with the Edison meter, not only because it was the first to be used, but also because it has done a larger amount of useful work in central stations than any other meter. In its original form, as shown in the Paris Electrical Exhibition in 1881, it consisted of two copper plates suspended from the two ends of a balanced beam in a solution of sulphate of copper. A continuous current passing through from one plate to the other decomposed one plate and deposited copper on the other. This one eventually got heavy enough to tip over the balanced beam. This mechanical action had two effects—(1) it registered a unit on the counting mechanism, and (2) it reversed the direction of the current; and now the lighter plate received the copper deposit, and so the process went on continuously. It was not possible to pass the whole current in this way through the solution, because the resistance would be too great. Hence the depositing cell was put as a shunt on the main current.

Several objections to this type soon became apparent in practice. (1) When the temperature of the air was high the resistance of the solution diminished, while the resistance of the alternative metal path increased. Hence with high temperatures a greater proportion of the total current went through the meter. (2) It was soon found that a make and break, as necessitated by the reversals in the direction of the current, led to endless trouble, and the ingenious method of counting had to be abandoned. In the improved meter zinc is the metal employed, and sulphate of zinc the solution. The current always goes in one direction. Fresh plates are inserted as they wear away. To determine the consumption of electricity the meter is carried away and the loss of zinc in the positive plate is weighed, and the consumer charged for a proportionate number of units of electric current; $\frac{1}{1000}$th of the total current passes through the zinc solution. In series with this solution is placed a copper resistance, so arranged that with a rise of temperature the fall in resistance of the solution equals the rise in resistance of the copper, the alternative path being of German silver. Thus between 4 deg. and 34 deg. C. the same fraction of the current passes through the solution. To prevent freezing, an incandescent lamp is always kept burning in the case containing the meter during the months that freezing is possible.

The range within which the meter is said to be accurate within 3 per cent is from 5-fold to 10-fold; *i.e.*, if one ampère is the lowest current for which it is accurate, then from 5 or 10 ampères is the maximum current for which it is accurate.

Now, you may say that this is not exactly the kind of meter we require, because customers cannot check the weighings, and are absolutely dependent on the good faith of the company supplying the electricity. It has also been argued that the shunt arrangement cannot be perfect with varying temperatures. Well, I can only say that the meter in practice is found to do good work. I agree entirely with what Mr. Edison said to me about it. He said: "It is not an ideal meter, but it is simple and effective, and gives general satisfaction wherever it is used." I endorse this opinion. But the managers of central stations where it is used have given me higher estimates still of its value. They say that customers are all quite content with the manner of reading it. As to accuracy, many customers have kept accurate tally of the lamp hours which they have consumed, and compared it with the charges by meter, and have often come within 2 or 3 per cent. At the splendid central station at Milan, which I lately visited, this meter is in constant use, and is much appreciated by the company. They say that the expenses of maintaining the meter department are not large when the whole thing is well organised. The total number of ampère hours sent out from the station, as measured by the ampère meters, agrees with the meter accounts within 3 per cent. This station, which I have carefully inspected, is an admirably conducted one, and embraces three systems, the Edison low tension, the alternating high tension, and the Thomson-Houston arc lamp systems.

Ferranti Meter.

The next meter which I wish to describe is that of Mr. Ferranti. It is one so beautifully simple in its principle as to please at first sight. It is founded on the principle that when an electric current passes through a fluid which is placed in a magnetised space, the fluid tends to move in a direction perpendicular to the current and to the magnetic action. Two magnetic poles of circular form are placed one above the other, one being a north pole, the other a south pole. Between these two is a circular insulated trough containing mercury. The current enters the mercury at the centre of the trough, and the outer rim of the trough forms the other electric terminal where the current goes out.

The original instruments were intended for currents continuous in direction, and the magnets were excited by the electric current to a moderate amount, so that the magnetism was proportional to the current. Thus the moving force was proportional to the square of the current, and the friction of the mercury being approximately as the square of the velocity, the indications of the instrument would be accurate. Of course the law I have spoken of is only true as a sort of approximation. The friction of the indicating mechanism follows a different law, and affects the result. The number of rotations made by the mercury is indicated by the rotation of a float of special construction, resting on the mercury, connected by a spindle, with a train of wheelwork which indicates the total number of revolutions. The meter has also been adapted for alternating currents, and is rendered more delicate by having an additional shunt winding of very high resistance. This circuit is put in multiple arc with the lamps on the two mains of the house supply. The friction of the wheel train is reduced to a minimum by employing the finest and lightest mechanism which can possibly be constructed. I am sorry to say that Mr. Ferranti has not been able to furnish me with any tests or specimens of his alternating current meter, as he is even now introducing some improvements. I am told the range is about 50-fold, and that it is very accurate. I may mention, in praise of Mr. Ferranti's ingenuity, that both Mr. Edison and Mr. Weston, in America, two of the most prolific inventors, tried to work out a similar instrument and found it ineffective. The chief difficulty was one which, until Mr.

Ferranti attacked the problem, has been taken as a universal fact, viz., that mercury is unsuited for a permanent contact. They found that the mercury got covered with a film or powder which interfered with its free movement.

ARON'S METER.

I now come to a very interesting type of meter, the principle of which was first suggested in this country by Professors Ayrton and Perry, and which has been made a practical instrument by Mr. Aron, in Germany. I have lately visited the central stations of Berlin, the largest existing on the Continent. These stations are the best equipped in the way of boilers, engines, dynamos, and accessories of any low-tension system I have ever seen. There is this defect, however, that they have hitherto used a distributing system with two instead of three wires. This fault will be remedied in the future. They supply at present current sufficient for a maximum supply of 26,000 incandescent lamps of 16-candle power. And here let me protest against the practice, beginning in this country, of taking an 8-candle power lamp as the normal one. Everyone is dissatisfied with the low candle-power prevalent in London, and, as a general rule, 16-candle power lamps have been found in actual experience in hundreds of central stations to be the most suitable. The stations also light the Unter den Linden with 108 arc lamps of 15 ampères, and the Leipziger Strasse with 36 arc lamps. The former is the finest piece of street lighting ever accomplished.

All the incandescent lamps are charged for by meter, and the Aron meter is always used. Originally it consisted of an ordinary clock, with a permanent magnet for the bob of the pendulum; below this a coil of wire is fixed with its axis vertical. The current to be measured passes through this and repels the magnetic pole, thus diminishing the influence of gravity on the pendulum, and causing the clock to lose time. The loss of time in any period, as compared with a good, uninfluenced clock, shows the number of units of electricity which have passed through the instrument. It takes a long time to test such an instrument over its whole range, and I have not been able to obtain any tests. The chief inconvenience of the instrument in its old form was that a clock could not be depended upon for accuracy more than about half a minute a week. One minute a week would be the smallest registerable quantity. Suppose this means one lamp hour, then the maximum loss of the clock in the week being 12 hours, the instrument could not register more than $12 \times 60 = 720$ lamp hours per week. Another inconvenience was having to wind up so many clocks every week. The former defect has been got over by mounting two clocks on the same framework, one in its normal condition, the other governed by the current. The two trains of wheels are connected by a differential gear with a third train of wheels with dials and pointers like a gasmeter. This increases the range of the instrument, so as to be practical. Of course, this improvement diminishes the accuracy of the instrument (1) by introducing more work for the clocks to do, and (2) by having to deal with the ordinary errors of two clocks, and every clockmaker knows that two pendulum clocks, mounted on the same frame, affect each other's going, and introduce errors. The principle of this meter is very beautiful, and in the Berlin central stations the authorities speak in very high terms of its value. Complaints from customers do come in, but in these cases the meters are tested, and found to work quite well. Its range is greater than for any other meter, being about 100-fold, I believe.

This meter has been altered to adapt it for registering alternating currents, by replacing the permanent magnets by coils, or electro-magnets. In the central station at Rome, which is in many points the finest and best designed station for alternating currents which I have yet seen, it is intended to test these meters, but I can say nothing about their accuracy. I will only point out that in this case the retarding influence varies as the square of the current, whereas, with the permanent magnet, it varies as the current. This does not lead us to hope for the same satisfaction as is afforded by the type for continuous currents.

LOWRIE-HALL METER.

I will now say a few words about a meter specially designed for alternating currents, which resembles the Edison meter more than any other. This is the Lowrie-Hall meter. A battery—preferably a secondary battery—is placed on the secondary circuit of a transformer. An electrolytic cell is also placed in the circuit. Now, there is no complete circuit through the battery and electrolytic cell except when lamps are in circuit, and it is only then that electro-chemical action can take place. The alternating current does not transfer metal from one plate to another. The whole effect in this way is produced by the battery, which acts as if the alternating battery did not exist. The continuous current thus flowing is proportional to the conductivity of the circuit—*i.e.*, to the number of lamps at work. Thus the total number of lamp hours, or Board of Trade units, is measured by the quantity of metal lost by one plate or gained by the other. This is an extremely novel and ingenious idea. One is inclined to ask how long the battery will stand the alternating current, and whether there is much trouble in charging and replacing the secondary batteries. I am informed that these meters have been successfully at work at Eastbourne for more than a year.

SCHALLENBERGER METER.

A very practical form of meter has lately been brought out by Mr. Schallenberger, electrician to the Westinghouse Company at Pittsburg, an extremely ingenious and accomplished electrician. It also is intended for use only with alternating currents. This is not the place to go into a scientific examination of the theory of its action. I will try to explain it in popular language. A circular iron disc is placed on a vertical arbor connected with the indicating mechanism, and also carrying a fan to introduce resistance to the movement by air friction. The iron disc rotates very freely. Two diameters of this disc are chosen, inclined to each other at 45 deg. A coil of wire or copper ribbon fixed to the casing is coiled round each of these diameters. One of these coils is connected with one of the wires going to the lamps, and consequently has an alternating current flowing through it. The other coil is closed on itself, and has induced currents attaining their maxima a quarter of a period later than the main current—*i.e.*, when the main current is zero. Now, consider the instant when the main current is a maximum. It magnetises the iron disc, and a quarter of a period later the induced current, acting at an angle of 45 deg., tends to turn the disc in a certain direction. When the main current is reversed the magnetism is reversed, and the secondary current is also reversed, and hence rotation in the same direction ensues. Thus we have continuous rotation of the iron disc when an alternating current is flowing through the main coil. It is found that for a 15-fold range the number of revolutions of the disc indicate the total number of lamp hours, or Board of Trade units, which have passed. This is a very convenient type of meter. It does not require great delicacy of construction, and is not liable to get out of order. The objection to it is that its indications vary with the speed of reversals of the alternating current, and our best governors are not perfect, and our most reliable suppliers of electricity would be tempted to alter its indications by increasing the speed of the engines a little. But the meter remains a beautiful practical instrument, which is doing splendid work in the United States. Mr. Schallenberger promised to send me one of these meters, but I am sorry to say it has not yet arrived.

FORBES' WINDMILL METER.

Some years ago, when I first realised the value of the invention of Messrs. Gaulard and Gibbs for distributing high-tension currents in the mains, and delivering it as low tension in the houses, I felt that one difficulty in the way of adopting it was the want of a meter for alternating currents. Such a thing did not exist, and I felt certain that the public would never be satisfied with a meter whose indications depended on the speed of reversals. It therefore seemed to me that the heating quality of the currents was the only one which would succeed, and would be equally applicable to continuous and alternating currents. I was fortunate enough to have the kind assistance of Mr. A. Stroh for perfecting the details, and eventually the windmill meter was completed, in which the heat generated in a resistance sets up convection currents in the air, which work a kind of windmill. Here the force is proportional to the square of the current, and the opposing resistance is air friction, which varies as the square of the velocity, so that it was natural to expect that the indications would be accurate, and this was found to be the case.

The windmill which I use is made of a horizontal mica disc, with mica vanes round the edge, inclined at 45 deg., attached to it by small pieces of pith. It has a hole in the centre, in which is fitted a thin paper cone, which has at its apex an aluminium cone, supporting a steel pinion with a ruby cup in its centre. This cup rests on a needle point, and the pinion works into the train of wheels which does the counting.

When this meter was perfected, it seemed that the English demand was not great, and it was best to modify it to suit the American market. I went to America to find out exactly what was wanted, and altered the instrument accordingly. The chief objection raised to it was the difficulty of mailing it, and a fear that it was too delicate. Consequently I strengthened some of the parts, reduced the sharpness of the needle point, and provided a metallic case in place of a glass shade. A considerable number have been sent across the Atlantic in both directions by the ordinary channels without any injury. On arrival, all that has to be done is to release a spring, so as to free the windmill and let it play upon the needle point. The electric resistance of the conductor had also been objected to. This I was able to correct by altering the form of the conductor in which the heat is produced. Its resistance is now $\frac{1}{100}$th of an ohm, and Mr. Schallenberger, after testing, at Pittsburg, a batch which were sent direct from the workshop, without any adjustment, wrote to me, saying that they are quite accurate, and that the fall of voltage, due to resistance, is quite low enough, and that they were put to work on the regular commercial circuits. Mr. Westinghouse has acquired the rights for America, and is now manufacturing them at Pittsburg. It is the only meter which he supplies for motors and continuous currents, and it also works equally well with alternating currents, of any speed of alternation. For alternating currents he has hitherto used the Schallenberger meter. The range of my meter in the American pattern is about 12 to 15-fold, about the same as the Schallenberger meter. When I use more delicate wheel work the range is greater.

I need hardly say that the perfecting of such a meter has led to innumerable experiments. Trials have also been made of a variety of other means of utilising the heat. I would not be doing my audience justice if I did not show them one other type which I have constructed, which is very simple and effective, but which has one slight defect, viz., that it is not easy to manufacture in numbers all exactly alike. It consists of a wire conductor covered with cotton, which absorbs alcohol from a reservoir. The electric current being passed through the wire heats it and evaporates the liquid, which is condensed in a tube, where it is measured. This quantity is an exact measure of the quantity of electricity which is passed through. This instrument has not been used on commercial circuits.

Since the beginning of September, 1887, when I first exhibited the mill-wheel meter, an enormous number of patents for meters have been taken out, but I think I have described all that have as yet proved themselves to be of practical value. Each of the meters I have described has its merits, and all are doing good work in central station distribution.

An interesting discussion followed the paper, in which Mr. R. E. Crompton remarked that considerable difficulty had been experienced with the Aron meter, which, however, had been overcome by slight alterations in detail; he also mentioned a meter by Messrs. Chamberlain and Hookham, at work in Liverpool, on a different principle, which gave exceedingly satisfactory results. Prof. Ayrton, F.R.S., followed, and criticised Prof. Forbes' conclusions on the omission of measuring variations of potential in electric currents, as well as the Ferranti meter. Mr. Shoolbred and Mr. Smart also spoke. After a reply by the reader of the paper, the Chairman—Mr. W. H. Preece, F.R.S.—summed up, and spoke most hopefully of the immediate future of electric lighting enterprises.

THE CHANNEL TUNNEL.

(Concluded from page 61.)

THE reader, continuing his paper, discussed the statistics of the interchange of products between this and other countries, as well as the fears of the shipowners, on the possibility of a diminution of trade, which fears, he stated, were groundless. He then mentioned how impossible a channel bridge would be, and insisted upon considering the tunnel question as a purely commercial and not a military one, and pictured the enormous difficulties in the way of any possible invader from France. In conclusion, he said: If the French could land and seize Dover, an invasion is possible without a tunnel at all; but the idea of Dover being captured by a French army collected without our knowledge, and transported across the ocean without our knowledge, while our navy is still unimpaired, is perfectly chimerical. The truth about invasion is, that so long as the British navy can sweep the seas an invasion of this country is impossible, and it does not in the least matter whether the Channel Tunnel exists or otherwise. If our navy is not strong enough to hold the seas, it would require no invasion to reduce us to any terms the enemy might choose to impose. There is often, in this country, not more than six weeks' consumption of food for our teeming population. If our navy could not hold the seas, our supplies of food would be cut off, and we should be obliged to surrender as surely and certainly as any blockaded city is when provisions are exhausted, and hunger forces it to capitulate. The key to the security of England lies in the maintenance of an efficient and overpowering navy. If we have such, we can laugh at the panic of those who see any cause for fear in the construction of a tunnel.

It has been argued that if the tunnel existed, and we were defeated or invaded by another route, one of the conditions of peace wrung from us would be that we should hand over the tunnel to our enemy, to use as they liked. If there were no tunnel, and we were so heavily defeated or invaded by another route, might not, even at the present moment, the demand be equally made that we should give up our navy, and if we were compelled to do so, then our shores would be opened freely to the invader, without the question of whether there was a tunnel or not.

It has been stated that, in the course of time, if the tunnel existed, our sentries would be negligent, and precautions would be allowed to fall away, and we should be, through more security, liable to be surprised. It is difficult to realise, even if that were the case, how the tunnel could be seized, as the troops to march through and seize it would require twelve hours, and the stoppage of all traffic, and consequent alarm. The troops coming across the sea would require transports to assemble, and considerable time would be required for disembarkation. But there appears to be no reason to believe that our sentries are liable to be negligent. Malta and Gibraltar are not supposed to be negligently guarded, and have not for many years been open to attack. The sentries there have not gone to sleep, nor have the officers been found wanting. If soldiers are not to be trusted to guard the fortresses committed to their charge, there is little use in going to the expense of fortifying coaling stations, or building defensive works anywhere. Certainly, if the troops who are to hold them are so unworthy of confidence that they cannot be expected to preserve our national interests and our national honour, the least we should do as men of business is to save our national pocket.

If we were at war with another country than France, the tunnel might afford us means of communication which would be very valuable. It is to be sincerely hoped that we may never be at war with the United States, but if such an unhappy catastrophe occurred, the United States would certainly cover the seas with cruisers and men-of-war, and we should probably be more hardly pressed to hold our maritime supremacy than in the case of war with any other nation. If American frigates, even for a temporary period, prevented our food ships running across the seas, we should be exposed to severe distress and danger of famine. In this case, however, if a tunnel existed which could not be assailed by hostile cruisers, we might draw our supplies through France, and thus feed the country, which would otherwise be compelled to capitulate through hunger.

In conclusion, I would wish briefly to summarise my arguments, which I have endeavoured to express, as follow :—

1. That our position and prospects as a nation depend in the main upon our commercial prosperity.
2. That that commercial prosperity is being jeopardised by the want of railway communication between this country and our customers and markets on the Continent.
3. That this railway communication can only be obtained economically and certainly by a Channel tunnel.
4. That the national dangers to be apprehended from the construction of this tunnel are so infinitesimally small that they cannot be weighed against the commercial advantages likely to arise from that construction.

I have not touched upon the position in which we now stand with regard to foreigners, but it is not pleasant for Englishmen travelling abroad to find how friends of our country lament, and enemies of England scoff at, the position taken up by our Government with regard to this matter. It is galling to be assured that the military valour of England has departed, and the army which carried the British colours early in this century from Madrid to Toulouse, from Brussels to Paris, is now incompetent and afraid to defend the narrow issue from which hardly twenty men could advance abreast. We can only trust that if those who believe in the advantage of this scheme temperately and quietly place their views before their fellow-countrymen, reason may before long again in England assert her sway, panic and prejudice may be put aside, and that both our allies and our enemies abroad may again recognise that the glorious heritage bequeathed to our country by Nelson and by Wellington has not fallen into unworthy hands.

Finally, I must add that if I have not been able to communicate to you a conviction that a Channel tunnel will be not hurtful but beneficial to us as a nation, my failure is due to no want of strength in the case, but to want of skill in the advocate.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STEAM-ENGINE EFFICIENCY.

To the Editor of " The Practical Engineer."

SIR,—I have been greatly interested in the discussion which is now going on in your columns on the above subject. I only wish we had more of a similar nature, as questions of this kind are always deeply interesting to men such as myself, who have engines and boilers under their care.

But with regard to this particular case of " L. C. D.'s," possibly some slight saving may be effected by adopting a lower boiler pressure and later cut-off in the high-pressure cylinder, and at the same time lapping the valves so as to cut off earlier in the low-pressure cylinder, as recommended by your correspondent "Draughtsman." But what is most wanted here is, I think, an efficient economiser for heating the feed-water with the waste gases from the furnaces. And if such were only put down and properly attended to, there is not the slightest doubt but that, instead of the feed-water entering the boiler at the low temperature of 100 deg. F., it would most probably be raised as high as 240 deg. F., the result being a saving of at least five tons of coal per week.

I was rather surprised by the statement of " Draughtsman " in regard to the Corliss gear, viz., that it would not trip later than half-stroke, as I have always been given to understand that this could be effected from nil to three-quarters and seven-eighths of stroke by means of this gear. Would he kindly explain why it will not do this?—Yours, &c.,

W. H.

To the Editor of " The Practical Engineer."

SIR,—This subject is certainly one of some interest and importance. I for one fully appreciate "Draughtsman's" answer, and hope that he will kindly favour me with his valuable experience when any similar opportunity may present itself. I should advise " L. C. D." to try the following very simple experiment, and give the result for our benefit, viz., move the low-pressure eccentric forward on the shaft say 1¼in., which can be done in a few minutes. If secured by pinching screws and dies, which it no doubt will be, he need have no misgivings as to the result, and should that be the case, the fact that it can so easily be put back into its original position should give him courage to try it.—Yours, &c.,

H. B.

To the Editor of " The Practical Engineer."

SIR,—Seeing that " L. C. D.'s " compound engine is of the tandem type—that is, both pistons are on the same piston rod—it is a matter of small consequence in the first place, so far as engine strains or wear and tear of machinery are concerned, what the ratio of work done by each piston is, inasmuch as their sum (132 H.P.) is what has to be transmitted through the piston rod to do the required work on the crank. And in the second place, any effort to equalise the respective amounts of work done by each piston can only be done by lessening the steam pressure, and also lessening the total grade of steam expansion in the two cylinders in combination; which really means lessened efficiency of the steam in the engine. I consider, firstly, that nothing is to be gained by equalisation of the work on each piston, and, secondly, that there must be a direct loss by it. Such a step is therefore not advisable, and the less so, seeing that the boiler is already hard pushed to supply the engine, together with the other heating work it has to do.—Yours, &c.,

W. A.

INCREASE OF PRESSURE IN COMPOUND ENGINES.

To the Editor of " The Practical Engineer."

SIR,—As one in charge of engines and boilers in a large works, I thank you for having allowed in your paper practical questions, similar to that by " L. C. D." They are, to my mind, what you call your paper, "practical." The answers " L. C. D." has had are of interest and profit to others than himself; and I am encouraged to ask, with your permission, a similar question. One of the engines under my charge is under its work with our present steam pressure, and we propose to raise that pressure from 75lb. to 100lb. The engine is compound; non-condensing cylinder, 23in. diameter; condensing cylinder, 36in. diameter; both 4ft. 6in. stroke, running 45 revolutions per minute, driving about 320 I.H.P. Are our cylinders of suitable proportion? Will they work economically? They are in very fair condition at present. I would also ask if any of your readers have had any experience in ejector condensers, applied to engines of about similar size to above; if so, will they please say what it has been, and about the cost to apply them?—Thanking you again for allowing these practical questions, yours, &c.,

J. B. B.

QUERIES AND REPLIES.

9. **Grinding Optical Glasses.**—Will some kind reader inform me how to grind optical glasses? Is there a book published on the subject, and, if so what is the price, and who is the publisher?

Answer.—This operation is one requiring a somewhat lengthy description, which you will find fully treated on in the later editions of " Ure's Dictionary of the Arts and Manufactures." Many works on optical instruments also give details. One entitled " Optical Instruments," by J. F. Heather, M.A., in Weale's series, may suit your purpose.

11. **Compounding Engine.**—Could any reader kindly inform me of the best rule to apply for compounding a vertical engine, 12in. cylinder by 24in. stroke? The steam pressure is 60lb., and the high-pressure cylinder to cut of at $\frac{5}{8}$ths of the stroke. Is there any rule stating at what part of the stroke the low-pressure cylinder should be cut off, and how much should the area of the casing of the low-pressure cylinder be in order to act as a receiver?—C. E.

Answer.—The absolute pressure of his steam I presume to be 75lb., and I also presume he intends condensing the steam after it leaves the low-pressure cylinder. The high-pressure cylinder being 12in. diameter, the low-pressure one should be say 26½in. diameter, the cylinders to be placed side by side, their respective cranks being in line and opposite each other, the steam being cut off at $\frac{5}{8}$ the stroke in high-pressure cylinder is required after its expansion throughout the remainder of the stroke to be passed as directly as possible by a short, free, and roomy passage into the corresponding end of the low-pressure cylinder, there to follow, without cut-off, that piston throughout its stroke; after which to make its escape to the condenser as unobstructedly as possible. I am aware that a legion of different arrangements and proportions may be made, but I offer this as perhaps one of the simplest and least complicated, and certainly as the most economical and effective for the development of power from a given weight of steam at a given pressure.—W. A.

2. **Varnish for Papier-mache Goods.**—Would some reader kindly inform me how to make the black varnish that papier-mache goods are coated with? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished?—J. T. L.

3. **Slide Valve of Hydraulic Engine.**—Will some reader kindly inform me which is the best form of slide valve to adopt? The engine makes 20 strokes per minute, and the pressure is 1,000lb. per square inch. I should be glad also to learn what kind of stop valve is generally used for hydraulic cranes.

7. **Blacklead Pencil Making Machinery.**—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery?—B. B.

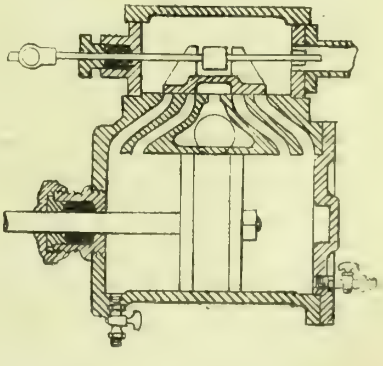
TO CORRESPONDENTS.

Common Logarithm.—You will find a chapter upon logarithms, dealing as fully as you require, in Todhunter's well-known Larger Algebra, to be obtained from any bookseller. Your query is hardly of enough practical engineering interest to be dealt with by us.

R. W. Birkenhead.—There is no work specially on the petroleum or paraffin oil engine. For information on gas and explosive engines generally, you will find " The Gas Engine," by Clerk, published by Longmans, Green, and Co., contains much detail. There is another book upon the gas engine by Macgregor (the publishers are Messrs. Whittaker and Co.), but the details are not given so completely.

Designer.—Apply at the drawing office of some well-known Glasgow shipbuilder. You will require to serve your time to ship designing just like any other business. If you draw well, you may get into some office without premium. Books will do you no good without practical daily experience.

X. Y., Leeds.—Worthington pumps always contain at least two steam cylinders and two water cylinders; that is, each consists of two separate steam pumps placed alongside each other. Two slide valves are used, one to each steam cylinder, and each valve receives its motion from a lever actuated by the piston rod of the other cylinder. The slide valve of cylinder A is not actuated from its own piston rod, but from the piston rod of the cylinder B. In consequence of this arrangement a Worthington pump is always ready to start, in whatever position it may stop, just like an engine with two steam cylinders and cranks at right angles. The double steam port (shown in illustration) is required to cushion the piston and to prevent it striking the covers. When the piston passes the first port towards the cover it compresses the steam contained, and stops. If the second port does not go to the end, then, when the steam port opened, the piston would not be started. If the first port came to the end, then there would be no cushion.



MISCELLANEA.

Non-conducting Coating for Steam Pipes.—A non-conducting coating for steam pipes, &c., is described in a recent issue of the *Revue Industrielle* as being conveniently applied and cheap; while it can be prepared by any steam user. It consists of a mixture of wood sawdust with common starch, used in a state of thick paste. If the surfaces to be covered are well cleaned from all trace of grease, the adherence of the paste is perfect for either cast or wrought iron, and a thickness of 1in. will produce the same effect as that of the most costly non-conductors. For copper pipes there should be used a priming coat or two of potter's clay, mixed thin with water and laid on with a brush. The sawdust is sifted to remove too large pieces, and mixed with very thin starch. A mixture of two-thirds of wheat starch with one-third of rye starch is the best for this purpose. It is the common practice to wind string spirally around the pipes to be treated, keeping the spirals about ⅝in. apart, to secure adhesion for the first coat, which is about ¼in. thick. When this is set, a second and third coat are successively applied; and so on until the required thickness is attained. When it is all dry, two or three coats of coal-tar, applied with a brush, protect it from the weather. It is stated that 20 shillings worth of starch will go as far in this way as £40 spent in any known commercial non-conductors of heat.

The New Cruiser Narcissus.—Another fast cruiser has been added to the active list of the Royal Navy by the completion for sea of the Narcissus, which was recently built for the Government by Earle's Shipbuilding Company, of Hull. The Narcissus is sister ship to the Orlando and Australia, and was built of steel from the designs of Sir N. Barnaby, K.C.B., late Director of Naval Construction. She is 300ft. in length, 56ft. in breadth, and has a mean load draft of 22ft. 8in. Her engines are of the triple-expansion type, and at her trials off Sheerness developed 8,574 horse power, with a speed of between 18 and 19 knots. The armament of the Narcissus consists of two 9·2in. 22-ton breechloading guns, mounted on Vavasseur central pivot fittings; ten 6in. 5-ton breechloading guns, and 16 3-pounder and 6-pounder quick-firing guns. She is also supplied with machine guns, and fitted with a torpedo armament both above and below the water line. She has a coal-carrying capacity of 900 tons, and with full bunkers is capable of steaming 8,400 knots at a reduced speed of ten knots. The Narcissus is fitted with the electric light and all the latest improvements in shipbuilding science. She will be placed in the first division of the Medway Steam Reserve, and will probably be commissioned in the spring to take part in the forthcoming naval manœuvres.

Improvements in Ships' Propellers.—Mr. Chas. Spinks, Balerno, has recently exhibited in Leith harbour a small working model (6ft. long) of a vessel with improvements in the construction of the propeller, which he has invented and patented. The vessel is constructed in the ordinary manner until towards the stern, where, instead of ending in a single keel, a double keel is formed, which completely encases the propeller, and on either side the keels are fitted with sluices, to be used as required. It is claimed that from the position of the propeller between the two keels it can never be thrown clear of the water, consequently rendering it safer, and greatly reducing the strain on engines and machinery, and also, from the protection so afforded, is not nearly so liable to accident as is the case with propellers as at present situated. It is further held that a higher rate of speed will be reached by the improvements. From the tests, the vessel appeared to go as fast astern as ahead. In the case of going ahead, by raising the starboard sluice, an additional motive power was gained by the rush of water through the aperture acting on the propeller as on a horizontal turbine; and on reversing the engine, by closing that sluice, and opening the one on the port side, a corresponding acceleration of speed was the result in the backward movement. A large number of local shipbuilders, engineers, and shipowners watched the experiments.

Proposed Ship Canal between the Bristol and English Channels.—We are informed that a scheme for connecting the Bristol and English Channels will be brought prominently before the public in the course of a few months. The route fixed upon by the engineers who have recently surveyed the district is from Stolford, in Bridgwater Bay, passing through the towns of Bridgwater, Langport, Ilminster, and Chard, to Seaton, on the English Channel. The total length of the canal will be about 45 miles, and, with the exception of the Chard range of hills, the work of excavating, &c., for the whole distance will be comparatively easy, no engineering difficulties presenting themselves. The Chard district is formed of lias, so that in excavating through the high ground an ample supply of lime will be obtained, which will be useful for the other portions of the work. The canal is intended to be in every way capable of admitting the largest mercantile steamers afloat, as well as the ships of war. From a national point of view, therefore, this new canal will be of immense importance, as our ironclads would be able to steam across from channel to channel in a couple of hours, instead of having, as at present, to go round the Land's End. The greatest benefit would also accrue to the trade of South Wales, for, when shipping to London and the Continent, by using this canal a distance of 300 miles would be saved, to say nothing of avoiding the great risks to which vessels are liable while sailing around this part of our coast.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

January 11th.

546 Air Compressors, T. W. Barber, London.
550 Spiral Brake, G. Azzeroni, Cardiff.
560 Copper Precipitates, G. Gatheral, London.
562 Gas Governors, S. Elster, Sheffield.*
566 Reducing Valves, S. McLoud, London.*
571 Locomotive Engines, W. M. Smith and J. W. Smith, London.
573 Locking Safety Lamps, L. Plom, London.
574 Steam Engines, A. G. Hay, Glasgow.

January 12th.

577 Gas Tongs, A. G. Boutcher, Buckinghamshire.
579 Steam Pipes, J. A. G. Ross, Newcastle-on-Tyne.
587 Rings for Pistons, A. Gibb, Greenwich.
599 Manufacture of Gas, J. T. Key, London.
601 Ring Spinning, A. Smith and F. Maccrimmon, Manchester.
607 Composition for Steam Boilers, W. D. Pratt, Middlesex.
612 Rotary Fans, S. C. Davidson. London.*
617 Street Locomotives, A. J. Boult, Middlesex. (T. Roberts, United States.)*
620 Cocks and Valves, A. H. Smith, London.
628 Projectiles, F. H. Snyder, London.
629 Lubricator, J. Coey, London. (A. C. Buzby, United States.)
636 Fans, R. H. Heenan, London.*

January 14th.

654 Driving Belts, T. Hughes and G. Chapman, London.
658 Steam Engines, M. C. Bowie, Glasgow.
661 Motor Engines, W. P. Theermann, Manchester.
663 Millstone Machinery, W. F. Goreham and M. Watson, Newcastle-on-Tyne.
666 Stone-breaking Machines, A. Hill, Leicester.
668 Iron and Steel Forgings, J. Willis, Sheffield.
674 Piston Rings, J. Robinson and W. Summers, Sheffield.
687 Ball Bearings, C. Inwood, Kent.*
698 Slide Valves, J. Marshall, London. (H. Hanna, United States.)
701 Locomotives, F. W. Webb, London.

January 15th.

708 Gas Engine, J. Taylor, Nottingham.
723 Setting Steam Boilers, J. Y. Johnson, Middlesex. (The Edge Moor Iron Co., United States.)*
725 Driving Spindles in Mules, J. Hargreaves and J. Houlden, London.
730 Motive Power by Magnesium, A. Wilson and T. H. Baker, London.
731 Conduits for Electric Railways, W. J. Brewer, New York, U.S.A.
733 Controlling the Speed of Engines, R. Wilby, Halifax.
736 Steam Cock, H. Brecknell, London.
751 Boilers, G. Clark and Sarah Todd, London.
759 Switches for Electric Railways, C. H. Wells, London.*
769 Casting of Metals, R. S. Casson, Middlesex.
773 Lubricators, — Amundsen, — Bruff, and —Sahlie, London.*
775 Exhaust Steam, J. D. Carmichael, London, (Ruggiero Petrini, Italy.)
776 Mounting Cranks and Pulleys, I. W. Boothroyd and P. L. Renouf, London.

January 16th.

789 Taps and Valves, F. Hayward, Sheffield.
794 Drawing Compasses, H. Gohrt, Liverpool.
812 Cast-steel Shells, R. A. Hadfield and A. G. M. Jack, London.
817 Carding-engine Cylinders, J. McQueen, Manchester.
830 Percussive Rock Drills, A. W. Daw and Z. W. Daw, London.
832 Hydraulic Brakes, H. Schneider, London.
836 Coal-breaking Machines, N. Freer and C. Schoeller. London.
839 Steam Generators, P. A. Thomas, London.
841 Extracting Precious Metals from Ores, J. B. Hannay, London.
852 Steam Engines, O. E. Pohl, Liverpool.

January 17th.

868 Heating Steel Plates, J. Hart, Yorkshire.
869 Looms, J. Vickerman, Leeds.
870 Lock-nut, E. J. Ainsworth, Blackburn.
872 Cutting Milling Tools, T. Gare, Stockport.
875 Gas Engines, E. Repland, London. (P. Niel, France.)
886 Drilling Tools, J. Brierley, London.
894 Air Motor Engines, J. F. H. V. Hoop, London.
901 Motor Engines, O. Imray, London. (J. Gräbner and H. Ruportl, Germany.)
914 Journals, E. Hüller, London.*

January 18th.

921 Starting Gear, R. Lindner, Berlin.*
930 Steam Boiler, J. Brown, Fulham.
937 Trip Gear, E. Wigzell and J. Pollitt, London.*
944 Metallic Packing, R. J. Paris, Liverpool.
949 Machine Tools, W. T. Rowden, Glasgow.
952 Tube Expanders, A. B. Jardine, J. Jardine, P. Jardine, and J. Jardine, London.*
955 Pulleys, W. H. P. Ard, London.
970 Lifting Jacks, J. P. Cito and P. Funck, London.*

January 19th.

985 Looms, T. Catlow, London.
1000 Pump Buckets, J. E. Rogers, Tipton.
1008 Looms, A. Sowden, Halifax.
1036 Pump Buckets, N. S. Hawks, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10, can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from either of our offices on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER.

FEBRUARY 8TH, 1889.

THE USES OF GASEOUS FUEL.

DURING recent years the production and application of fuel in the gaseous form have occupied many eminent engineers, and considerable though by no means complete success has attended their efforts. The late Sir C. W. Siemens distinguished himself greatly in this branch of engineering, and we think it is generally admitted that he thereby revolutionised several industries. His name stands out most prominently among those engaged in the work, and he was the first to introduce, although not to propose, the extensive use of gaseous fuel. He very clearly understood the conditions of success in its application, and also the conditions when its adoption would be unsatisfactory and disappointing to the user. More recent inventors, however, do not seem to share his clearness of vision, and, we fear, imagine an extension of application which facts do not warrant.

When the heat from burning fuel is wanted for industrial purposes the requirements may be divided into two great classes—first, where the aim is to obtain quantity; and second, intensity, or high temperature. In the first case the object of the apparatus is to absorb as much of the heat as possible from the burning fuel, but at a comparatively low temperature; while in the second case the quantity of heat required may not be great, but the temperature required is high. In steam boilers, even with modern high pressures, the temperature of the steam is low compared with that of flame, but the quantity of heat absorbed is very great, and the object of the constructor is to get as much as possible of the heat in the form of steam, and to lose as little as possible by radiation, conduction, or discharge of hot gases, the products of combustion.

In furnacing operations, on the other hand, the actual amount of heat required, as measured by a calorimeter, may be little, but it is absolutely essential that the temperature or intensity should be high. Now, the relative merits of gaseous or solid fuel depend entirely upon the purposes for which the heat is required. If for steam-raising, gas, unless under exceptional circumstances, offers no advantage, while for furnace work it is invaluable. A little consideration will make this clear. A good Lancashire steam boiler, with an economiser, often gives in steam an efficiency of 80 per cent; that is, of 100 heat units put upon the fire-bars in the form of coal, 80 of those units go to the work for which they were intended (the production of steam), and only 20 per cent, or one-fifth of the whole, is lost from various causes. Evidently only a small margin for possible improvement exists here; and unless a better result can be obtained by converting the coal into gas previous to burning, no advantage will accompany its use. When gas is produced from coal by destructive distillation in closed retorts, the heat evolved by its combustion is only about 22 per cent of that of the original coal. When the whole of the coal is converted into gas in a gas producer, besides the volatile matters, the carbon acts on steam and air, producing carbonic oxide and hydrogen, and the resulting gas when burned will evolve in a favourable case about 70 per cent of the heat of the coal. All existing methods of gasifying fuel involve a necessary loss, causing the gas when burned to evolve less heat than the original coal when burned direct. It is true arrangements are conceivable which, theoretically, would give a perfect gas producer—that is, a producer in which the gas contains all the original chemical activity of the coal, but no inventor has as yet succeeded in getting over 70 per cent of it.

It is clearly evident that, as there is a greater loss of heat in the preliminary process of gasifying fuel than the loss of a good boiler burning solid fuel, however perfect the combustion of gas in the boiler, it cannot be as economical as the coal. Gas from any producer must, therefore, give a greater fuel consumption in steam-raising than coal burned directly in the best manner. Sometimes a very cheap supply of waste fuel may be obtained, which can be utilised in a producer, and could not be burned direct. In this case there may be a monetary advantage, depending, of course, on the price of the waste fuel. In most cases, however, it is a mistake to fire steam boilers with producer gas, and we have known cases of great disappointment, where the users, after being put to great expense and trouble in erecting gas producers, were promised great saving of fuel, and found instead a greatly increased coal bill.

With furnacing work the case is quite different. The ease with which the chemical nature and intensity of the flame can be regulated, and the facility with which regenerative appliances can be adopted with gas, make its use well worth the preliminary loss of heat in gasifying, and allows of a great saving in the end. In furnace operations the quantities of heat actually used are small, and the gases leaving the furnace require to be at the full temperature; so that the regenerator can be applied to pick up this heat, and restore it to the entering gas and air, and thus increase their temperature before combustion commences. The very general use of gas furnaces for metallurgical purposes sufficiently proves the appreciation of this fact.

In some metal-working operations it even pays to use the expensive illuminating coal gas to produce a very high and purely local temperature. As an example, we may mention the operation of welding boiler flues, for which purpose ordinary coal gas is now extensively used by Messrs. Piggot and Co., in Birmingham, and till recently was largely used by Mr. Samson Fox, in Leeds. The temperature produced by the flame from a properly proportioned mixture of coal gas and air is very high, approaching nearly to 3,700 deg. F., and that without regenerator or preliminary heating of any kind. Not only can high temperatures be easily attained, but by varying the admixture of air a chemically reducing or an oxidising flame may be applied at will. When there is an excess of air the flame is oxidising, and tends to burn metal heated by it; but if there be excess of gas it becomes reducing, or the tendency is to reduce oxide to the metallic state. Ordinary producer gas is not adapted for the production of high temperatures by direct combustion without preliminary heating, and accordingly is not well suited for welding when a locally high temperature is wanted.

In America water gas is extensively used, and the process is an interesting one, which we have already described in our pages. It possesses the advantage over producer gas of being almost free from the diluent nitrogen. Although in its manufacture a large supply of ordinary producer gas is necessarily formed, it is well suited for giving an intense local temperature, and therefore for welding. We give an account of its application in a paper by Mr. Samson Fox, which we publish this week, from which it will be noted that the diluted gas is used to raise steam—a very proper proceeding in this case—where otherwise it would be wasted.

In the great mass of cases, however, it is a misuse of fuel to subject it to a preliminary gasifying before using it for steam-raising, and we consider it our duty to point out this fact to steam users, many of whom might otherwise be induced by enthusiasts to go to great and useless expense.

THE MERCHANDISE MARKS ACT.

This Act, which received the Royal assent in August, 1887, and came into operation on the 1st January of last year, was framed with a view to check the unfair and untruthful marking of goods, and is directed particularly against the importation and sale of foreign-made goods as of British manufacture. Large quantities of cutlery and watches had been imported from abroad bearing British trade marks, or colourable imitations of them, and sold at low prices, to the great damage of British trade and to the injury of the unwary purchasers. People, by the way, who knew no better, pointed to the cheapness of these goods as a proof of the dangerous competition of the educated and clever foreigner and the decadence of British skill. However, in order to protect the public, and to compel the vendors of foreign-manufactured goods to offer them in their own actual and honest garb, the new Merchandise Marks Act was passed, and the older one of 1862 repealed. The provisions of the Act were made very stringent. Persons convicted under it render themselves liable to imprisonment, with or without a fine, and with or without hard labour, and to the forfeiture of every article by which the offence has been committed. In order to remove as far as possible the liability to such pains and penalties, goods brought to the Customs, which bear the name or trade mark of any manufacturer, dealer, or trader in the United Kingdom, unless such name or trade mark are accompanied by a definite indication of the country in which the goods are made or produced, are prohibited to be imported. This provision seems simple enough on the face of it. But after the Act had been only three months in operation, the Commissioners of Her Majesty's Customs became aware of great difficulties in carrying out its provisions to their extreme limit, partly by reason of the expense, partly because of the difficulties of practical working. Thus an exhaustive examination of all imported goods would entail the cost of a large additional staff, and would demand a most varied technical knowledge, far greater in amount than the officials could be expected to possess. Moreover, constant risk of delay would prove vexatious to trade interests, by checking rapid delivery of goods. That they have not been idle in the matter is apparent from the official statement that in three months only after the Act came into operation there were detained at London and Liverpool alone 2,152 consignments, and at the outports 1,739, representing more than 110,000 separate cases and packages. After London and Liverpool, the bulk of the detentions arose at Harwich, Hull, Grimsby, Newhaven, Dover, Newcastle, and Southampton. At the latter port large quantities of food produce—eggs, fruit, and butter—came in with English trade descriptions. Most of these were admitted on the illegal marks being destroyed, or properly qualified. The Commissioners, however, say that in some instances "the importers have abandoned their goods in preference to meeting our requirements as to marking."

There is thus no doubt that during the very short period which the Act has been in operation it has been productive of much good in checking the importation of falsely-labelled goods. But here comes the difficulty. In order to render it as fully operative as its promoters desired it to be, it is necessary that the hearty co-operation of manufacturers and traders be secured. It is clear that the Customs officials can only act on their own initiative when the provisions of the Act are glaringly falsified. It is for this reason that the Commissioners of Her Majesty's Customs have issued instructions to their officers that in those cases where special knowledge is required the officers will not as a rule be expected to move, except on information afforded by persons who would be aggrieved by the importation of the supposed illegal goods. Every facility is given for the lodging of such information; but in order to check malicious or frivolous motives, detention will then take place at the risk of the informant, who will be required to give security commensurate in amount with the value of the goods detained for inquiry.

At first sight this may appear to some rather a hardship. But it is not so in reality. No responsible and sensible person would move in such a matter without taking care to inform himself beforehand as to whether the Act were really being infringed. Having done so, and placed the matter in the hands of the Customs officials, there would practically be no risk of pains and penalties. The idea in lodging information is to set the Customs officers in motion in cases where, through lack of technical knowledge, they cannot be expected to know of their own experience anything about the methods of production, or the qualities of materials of goods, or the precise signification of different trade marks, or the exact routes through which goods may, under certain conditions, arrive in this country.

It is evidently not to the advantage of the public that the Act should be administered too rigorously, particularly at the first; and the Commissioners are actuated by the laudable desire to carry out the spirit of the Act without insisting too strongly upon the letter. Goods marked with descriptions or statements which are misleading, or indirectly false, as to the place or country in which they are made, are detained. But, on the other hand, there is no objection to placing English inscriptions on foreign goods, or descriptions in English of foreign-made goods, provided the words "made abroad" are added. When, however, the trade description in itself necessarily carries with it and involves the name of a particular country or district, the genuine article being made in no other country or district, then it is absolutely essential that the name of the country shall be specified. Moreover, where such qualifying inscriptions are used, the rule is stringent that they shall form a portion of the principal description, forming part of the same label, in type that will readily catch the eyes, and not on separate labels or in small type, or in positions where they would be likely to be overlooked.

While endeavouring to avoid all measures which would have a tendency to hamper trade, the Commissioners are compelled to stringency in such minutiæ, since some traders appear to be "prompted by a desire to find out how nearly the law might be skirted." On the whole we believe the Act is a good Act, judiciously framed and administered judiciously, and if the efforts of the officials are seconded by the public, much benefit must accrue therefrom to British trade. The tares and the wheat will be readily distinguishable, and people who want cheap and nasty goods will buy them with their eyes wide open, and the sins of foreign imitators and forgers will not be visited upon the unoffending heads of honest British manufacturers and workmen.

THE PANAMA CANAL.

In a letter to the *Glasgow Herald*, lately published, a correspondent gives a description of the progress of the work of the Panama Canal up to the beginning of December, 1888, which may prove of some interest to our readers at this time, when the scheme is to all appearance on the verge of failure. Though the writer was struck at first with the amount of wasted and abandoned engineering machinery accumulated along the course of the works, yet after he had been conducted over all those portions of the works which he thought it necessary to see, and had realised the magnitude of the enterprise and the enormous difficulties which were in the way, he came to the conclusion that this loss was one of the inevitable accompaniments of such a great engineering enterprise which had to be carried out under many novel difficulties, and which could only be successfully overcome by repeated trials and failures. The experience gained at the construction of the Suez Canal was of no use for the one at Panama. The machinery most effective for the light soil there soon broke down here, all the sooner because of the inexperience of the workers, and when it was superseded by fresh inventions more suitable for the work at Panama, there was nothing else to be done but to leave the useless or damaged machinery lying by the way, as its removal was far too costly.

Another source of loss was the pernicious system in use at first of paying the contractors 10 per cent on their actual outlay. This acted as a direct incentive to spend as much money as possible; but, according to the writer, this has all been changed, and a spirit of integrity is abroad among the officials.

The climate was a difficult and expensive obstacle which had to be constantly contended with. Colon, the landing place on the Atlantic side, was nothing but a black pestilential morass, and firm ground had to be made even before landing machinery. The labourers first imported (Chinese and Coolies) were useless. The Chinese left and set up as shopkeepers all over the district, and the Coolies could not stand the climate. These were followed by negroes, who are seemingly the only people who can stand the climate, but they have to be taught like children from the first, and it is only now, when they have really learnt their work, that the work is progressing rapidly.

Of course, with all these initial difficulties to contend against, work done in the past six years cannot be any criterion of the rate of progress that will be made with what is yet to do. It is thought that at the present time the canal can be finished and open for traffic within four years; some of the contractors think even two and a half years will be sufficient. The estimates of time and cost must be, of course, more reliable now, when the work is going on in a steady manner, and nearly every obstacle capable of being met with has been encountered. The writer says it is estimated that three-fifths of the canal proper is completed. Seventeen miles on the Atlantic side are completely finished, the works and houses are vacated, and only a few dredgers are left deepening the channel. On the Pacific side about seven miles are completed and being dredged, and the great cutting at Culebra, through a range of hills 250ft. high, is nearly finished.

The writer's conclusion was that the work has advanced so far that no disaster to the present company will prevent its ultimate completion. If the present company fail, another will be found ready to finish it. It should, he says, be clearly understood that even its being open for traffic will not imply its completion or financial success.

The writer notices with regret that very little of the machinery came from Britain, the bulk of it being from Belgium, and many of the dredgers from Holland. He mentions that Lobnitz, of Glasgow, supplied all the buckets for the dredgers and excavators, and some of the steam tugs. The dredging machinery at work he thinks the finest in the world. The American firm who finished the Colon section of the canal had dredgers with iron discharge pipes about 40in. in diameter, in 16ft. sections, which discharged *débris* to a distance of 150ft. They lost one such dredger, costing £26,000, by fire. The contractors and constructors are mostly French.

The Canal Company have erected hospitals both at Colon and Panama, and have shown a spirit of humanity towards their workers which is very praiseworthy. They have also made good roads, which seem to be the only roads worthy of the name in the country.

We must hope that the financial difficulties of the company will yet be got over, and that M. de Lesseps will live to see the completion of this his latest and most difficult project.

LAUNCHES AND TRIAL TRIPS.

There has just been launched from the yard of Messrs. W. Simons and Co., Renfrew, a patent stern well-hopper dredger named Otter, which has been constructed to the order of Mr. Walter Peace, agent for the Natal Harbour Board. The vessel was launched complete, with machinery on board. The naming ceremony was gracefully performed by Mrs. William Brown, of Renfrew. The Otter is of the following dimensions: Length, 170ft.; breadth, 32ft.; depth, 14ft. In the forward part of the dredger are fitted two pairs of independent compound surface condensing engines of 500 I.H.P., each pair driving its own line of propeller shafting, while the dredging operations can be carried on by either pair of engines, and each of which will be capable of raising 400 tons of ordinary material per hour. Steam is supplied by two steam boilers at 100lb. pressure. When the boilers are cold, and when raising steam in them, separate donkey boilers and engines are provided for circulating the water; this is a very necessary provision against their unequal expansion and contraction, so ruinous to boilers. The engine-room, which is very spacious, is provided with Blackman's patent ventilating fans, and has also telegraphic communication between the bridge and the dredging gear. Patent steering gear is provided. An important improvement has been developed by this firm in connection with the dredging gear—Brown's patent traversing gear—by which the bucket ladder can be moved forward or backward independent of the vessel, and thus be made to project through the stern of the vessel and cut its way into and through sandbanks where there would not ordinarily be sufficient water to float in. The point of difference between this and other dredgers is not in the application of the traversing gear, but in the stern being divided instead of the bow for the projection of the bucket ladder, and in this manner having a solid instead of a divided bow, which is better able to withstand heavy seas. In the suspension of the bucket ladder another improvement has been effected by hanging the bucket ladder on a separate shaft from that which holds the top tumbler, so that the latter may be taken out without having to disconnect the lower tumbler. Spring buffers are fitted at the top bearings of the bucket ladder, so that when rising and falling in a swell when dredging the risk of breakage to the ladder shaft bearings is reduced to a minimum. The buckets have a capacity of about half a ton each, and are of somewhat different form, and a decided improvement upon those now in general use. Ripping claws are provided for the disintegration of hard material.

The fine new steel screw steamer Dresden, built and engined by the Fairfield Shipbuilding and Engineering Company, Glasgow, for the North German Lloyd Company, went on her trial trip a few days ago, in splendid weather. She is a vessel of 5,000 tons, and her principal dimensions are: Length over all, 405ft.; breadth, 46ft. 6in.; depth, 33ft. The Dresden is built throughout of the best ductile Martin steel, and has two water-tight steel decks all fore and aft, poop bridge-house, and topgallant forecastle. The vessel has accommodation for about 40 first-class, 16 second-class, and about 2,000 third-class passengers, besides ample accommodation for the officers and crew. The Dresden is lighted throughout with electricity, for which purpose she has two distinct engines and duplicate dynamos, each furnishing power of about 300 incandescent lights. Provision has been made to guard against fire by suitable sub-division of the ship, and by steam injectors and independent water service by powerful hand and steam pumps. The vessel is fitted with surface-condensing engines of the triple-expansion type, having three inverted cylinders; the diameters respectively are—high-pressure, 30in.; medium pressure, 50in.; and the low-pressure, 80in., each adapted for a piston stroke of 4ft. 6in. The steam required for working the engines will be generated by two double-ended boilers and one single-ended auxiliary boiler, made of steel plates throughout. The furnaces, 15 in number, are also of steel, and are corrugated. The boilers have been constructed in accordance with the British Board of Trade and Germanischer Lloyd rules for a working pressure of 150lb. per square inch. The steamer started from the Tail of the Bank, and after a few preliminary turns in the Firth she proceeded under full steam as far as Ailsa Craig, the return journey being also at full speed. The trial was satisfactory in every respect, the engines working with remarkable smoothness, while the vibration throughout the vessel was exceedingly slight. An average speed of fourteen knots was attained, which is about a knot faster than guaranteed.

The screw steamer Hessle, built by Messrs. Craig, Taylor, and Co., of Stockton-upon-Tees, for the Hudson Shipping Co. Limited, West Hartlepool, and engined by Messrs. Westgarth, English, and Co., had a very successful loaded trial, when a speed of over nine knots was easily attained. The vessel is of the following dimensions: 270ft. by 37ft. by 19ft. 8in. moulded, and carries over 2,700 tons. The representatives of the owners expressed themselves highly satisfied with the vessel and the machinery. After the trial trip, she proceeded on her voyage to Calcutta.

Two weeks ago, Messrs. Wigham Richardson and Co. launched from their Neptune Works, Newcastle-on-Tyne, a large steel cargo and passenger steamer, intended for the China and Japan trade, which they have built for the Mogul Steamship Company, Limited, of London, the managing agents for which company are Messrs. Gellatly, Hankey, Sewell, and Co., of Leadenhall Street. The dimensions of the hull are 345ft. long, 40ft. beam, and 25ft. 9in. depth of hold, and she will be classed 100 A1 steel three-decked at Lloyd's. She is to be fitted with steam windlass, steam steering gear, steam winches, and every other modern appliance for the rapid loading and discharging of cargo, and will be supplied with the builders' own type (Tweedy's patent) triple-expansion engines. The construction of the ship and her machinery has been under the superintendence of Mr. Frederick Edwards, Bishopgate Street, London.

An electrical locomotive is building at the New York Locomotive Works, in Rome, N.Y. The engine is to be operated solely by electricity. It will weigh fifteen tons, and when turned out of the shop will, in appearance, be an exact counterpart of an ordinary locomotive.

COMPOSITION OF THE FLUE-DUST OF AMERICAN FURNACES.*

Many Virginia furnaces are troubled with a small percentage of zinc in their stock, this element being present, although the chemist may have failed to report it, either in the ore or in the limestone. When many hundreds of tons are passed through the furnace, the zinc appears in the flues to a marked degree. Sometimes the quantity is such that the metal appears through the walls of the furnace; but this is a rare occurrence.

At Low Moor, Va., when furnace A was blown out, at the completion of blast No. 3, a mass of high-grade zinc oxide, weighing nearly six tons, was found suspended to the lining almost directly below the tunnel head. The presence of this mass and its effect on the charging would readily explain the bad working of the furnace on one side.

The tunnel head itself had been a source of constant care during the blast. The zinc would accumulate there in such quantities as to affect very materially the passage of gas into the down-take, and thus cause a strong back-pressure on the blowing engine. There seemed to be no remedy for this but to take the blast off the furnace and knock out the deposit. This enlarging of the tunnel head became necessary once a month. Probably the only way to reduce this deposit would be to construct the down-take so as to enter the furnace at as small an angle as possible, and thereby avoid any bench room for a deposit at that place.

The introduction of a dust catcher with a small bell has greatly reduced the amount of dust in the flues. Every day this bell is lowered at least twice, and the dust is allowed to fall out from above. The amount of dust thus obtained is usually about 600lb. to 1,000lb. per day. The analysis, by J. C. Smith, in the laboratory of the Massachusetts Institute of Technology, of a sample from the dust collected at this point shows it to have the following composition:—

	Per cent.		
Zinc oxide	87·660		
Protoxide of iron	1·270		
Binoxide of manganese (MnO_2)	3·600		
Alumina	0·228		
Lime	1·850	Metallic zinc	70 356
Silica	2·410	Metallic iron	0·988
Phosphoric acid (P_2O_5)	0·701		
Sulphuric acid (SO)	0·493		
Loss on ignition	0 640		
	98·852		

The deficiency in the total of the above analysis was ascribed by Mr. Smith to the omission to determine magnesia and alkalies. Possibly there may have been a loss of some zinc. At all events there was obtained by a volumetric method a trifle over 71 per cent of zinc from the same material.

The analysis of a sample taken from the flue in front of the boilers, one hundred and fifty feet from the furnace, shows about 30 per cent of metallic zinc in the form of oxide. The mass found inside of the furnace is almost pure zinc oxide.

Furnace B, at present in blast for the first time, being 5ft. higher than furnace A, will probably, when blown out, be found to contain a larger mass beneath the tunnel head than did furnace A.

WATER GAS.

On Monday evening, the 28th ult., a paper on Water Gas, by Mr. Sampson Fox, C.E., was read before the members of the Hull and District Institution of Engineers and Naval Architects. The writer, having fully described the many attempts which had been made to render the manufacture satisfactory considered commercially, proceeded to explain the various methods of producing gas from coal, viz.:

1. By destructive distillation of coal without access of air in closed retorts, yielding about 10,000 cubic feet of gas per ton of fuel, 97 per cent combustible.
2. By distillation, and oxidation of the residual carbon in a vessel, with access of air, as in the Siemens generator, yielding about 140,000 cubic feet of gas to the ton of fuel, 28 per cent combustible.
3. By distillation, and oxidation of residual carbon in the same vessel, with access of air and steam combined, yielding about 160,000 cubic feet of gas to the ton of fuel, 37 per cent combustible.

C. Means, Am. Inst. Mining Engineers

4. By the alternating process, with a periodical injection of steam, and with a high column of fuel without access of air, yielding about 35,000 cubic feet of water gas, 95 per cent combustible, and 140,000 cubic feet of producer gas, 31 per cent combustible.

The temperatures of the flames produced by the gases from these processes were: First, coal gas burnt in a Bunsen burner, 2,430 deg. F.; second, producer gas, without steam, 3060 deg. F.; third, producer gas, with steam, 3,600 deg. F.; fourth, producer gas, without steam, high column, 3,300 deg. F., and water gas, 5,112 deg. F.

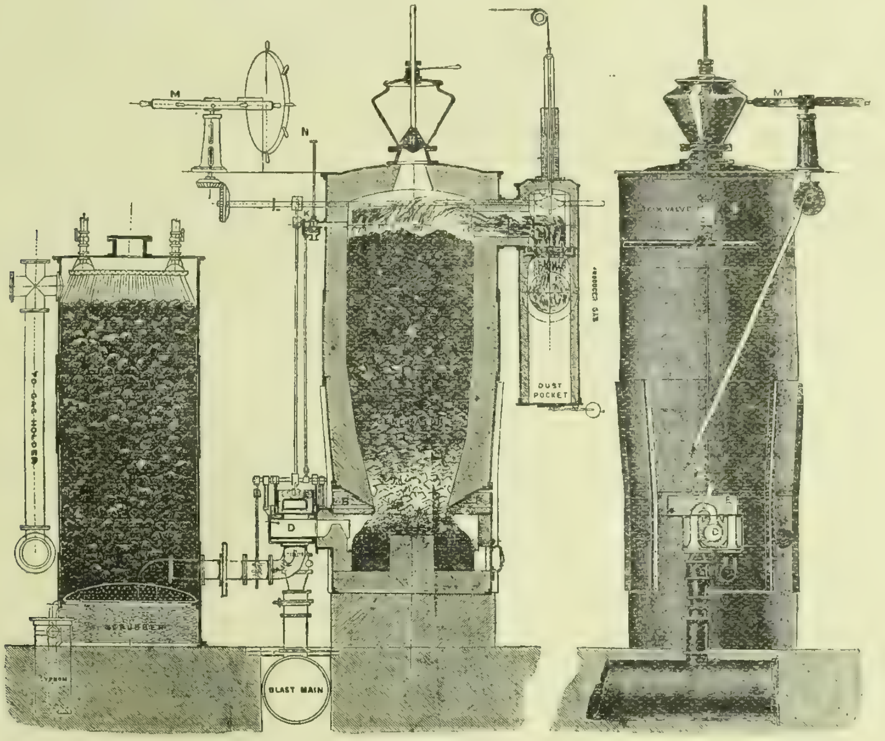
Analyses of the different gases were given, and a comparison of the heating value of coal, producer, and water gas were made, as in the following table:—

HEAT EVOLVED BY DIFFERENT GASES.

	Heat Units Per 1,000 cubic feet of gas.	Heat Units Per ton of fuel.	Percentage of heat units in gas to heat units in fuel.
1. Coal gas	672,000	6,720,000	21 7 per cent.
2. Water gas ..	336,000	{ Water gas 11,760,000 } { Producer 15,680,000 } 27,440,000	88·5 per cent.
3. Producer gas.	112,000	17,920,000	57·8 per cent.

The cycle of operations is as follows: By means of the handwheel M, the valves E and G are opened as shown, and allowed to remain so for a period of ten minutes, during which time the contents of the generator are brought to a state of incandescence by the upward passage of the blast through it.

During this period a large quantity of "producer" gas is generated, which readily passes out through a valve into brick-lined flues or passages, conveying it to the boiler furnaces, where it meets with a supply of atmospheric air, and is completely consumed for the purpose of steam raising. At the end of this period the two valves governing the air blast and outlet are simultaneously closed, and the small steam valve K, together with the communication between the port D of the valve E and the gas scrubber shown. This having been done, the steam passes downwards through the column of incandescent carbon, and becomes decomposed, with the ultimate result: Carbon + water ($C + H_2O$) = carbon-monoxide + hydrogen ($CO + 2H$). The chemical action supposed is this: The steam, on first coming in contact with the top layers of incandescent fuel, is decomposed into hydrogen and carbonic acid gas (carbon dioxide)—that is, $C + 2H_2O = 4H + CO_2$. This decomposition takes place at a temperature of about 900 deg. Fah. The carbonic acid gas (carbon dioxide) is driven still further through the mass of fuel, and then meets with more heated carbon in its passage, and is converted into carbon-monoxide, or CO. This conversion requires a temperature of from 1,800 deg. Fah. to 2,200 deg. Fah. The conversion having been accomplished, the products of decomposition pass through the valve E into the scrubber, where, in ascending, the gas is rapidly cooled down, and passes down the pipe shown into the gas-holder, which is not shown in the illustration.



Water gas, it will be observed, evolves, for equal volume, about half the heat of coal gas, and about three times that of producer gas.

Analyses had been made on Saturday, 26th ult., of water gas, as follow: Hydrogen (H), 52·5; carbon-monoxide (CO), 45·7; oxygen (O), 1·0; carbonic acid gas (CO_2), a trace only; and nitrogen (N), 0 8. The presence of the $\frac{8}{10}$ of a per cent of nitrogen is caused by the residual air remaining in the passages after the "blowing-up" process.

On this page we illustrate a water-gas plant capable of producing 20,000 cubic feet per hour. The centre cylinder A is the generator, in which the fuel, generally consisting of the cheapest kind of coke mixed with small coal, is fed through the feeding hopper, shown at the top, through the valve H. Round the throat, or lower part, is arranged a water jacket to prevent the rapid destruction of the furnace at that point where the most intense heat is produced. The blast main, shown beneath the level of the ground, communicates with the generator through the D-shaped valve E. Its construction may be seen most clearly in the right-hand figure, where it will be observed that the blast pipe is at present in communication with the generator. It will be seen in the figure that the whole of the valve is surrounded by water, to prevent its destruction by the heated gases which in the next stage of operations pass through it.

It is claimed that, by the use of water gas as a substitute for coal gas in metallurgical operations, but more particularly in the case of welding steel plates, a saving of more than fifty per cent may be effected, and it is an acknowledged fact that the absence of the great fluctuation in pressure, which occurs in the case of ordinary coal gas, in most large manufacturing towns, is a source of great satisfaction, as the pressure may be regulated and maintained at that found most suitable for the work for which the gas is required.

THERE was recently launched from the shipbuilding yard of Messrs. John Scott and Co., Kinghorn, a fine iron screw trawler named the Scottish Maid, built to the order of Messrs. Robert Brown and Co., Aberdeen. The following are the dimensions: Length, 100ft.; breadth, 20ft.; depth, 10¼ft. She is fitted up with vertical direct-acting compound engines of such a kind as to render her one of the most powerful trawlers afloat, and is expected to attain a speed of 15 knots an hour, thus giving her a decided advantage in getting her fish early into the market. She was launched with steam up, and sailed to Burntisland without the aid of a tug.

HYDRAULIC MACHINERY EMPLOYED IN THE TRANSMISSION AND CONCENTRATION OF POWER.—1.

THE object of the series of articles we propose to publish, relating to the above subject, will be in the first place to describe and illustrate *in extenso* the various types of elementary parts which compose, when suitably connected and combined, the complete, efficient machine, giving full practical instruction as to the proper dimensions, construction, and most appropriate material for each detail. We shall then proceed to the description of complete machines, their most economical design, cost of working and maintenance of machines, and complete plants of machinery, and the conditions which determine whether the hydraulic or some other system of power transmission is preferable.

In the description and illustration of what we may term the elements—that is, the component parts or details of machines—we shall be led to introduce much information which to the experienced hydraulic engineer or draughtsman will no doubt appear superfluous. The more experienced reader should, however, bear in mind that to many practical engineers the conditions and mode of working, the details of construction, the soundness or unsoundness of various arrangements, and even the general principles of action of hydraulic machinery, are a true *terra incognita*, while to the younger engineers and draughtsmen the more fundamental portion of our article may not be the least valuable.

We shall, then, first take up the consideration of the elements, the details of construction, of hydraulic machinery, commencing with the simplest parts, such as the pump valves and seatings, various types of packings (their friction and best method of construction), pipes, joints, glands, safety valves, stop valves—passing from the simplest screw-down valve to the more complicated types which command the whole action of a complex machine by the movement of a single lever, and may almost be considered machines in themselves—the chains, hooks, rings, and slings employed in lifting, and the various other details, the correct design and construction of which are of importance as affecting the permanence, economy, or safety of the machine.

Before proceeding to the discussion of the different forms of the details, which taken together constitute a complete machine, it will be first convenient and judicious to preface a few observations on the materials employed in their construction, with especial reference to their employment in the manufacture of hydraulic machinery, as regards their comparative fitness for the various duties they are called on to perform, and the test and working stresses to which they may be safely subjected under the actual conditions of every-day work.

We must commence by stating that, for the proper consideration of the subject, it is absolutely necessary to divide hydraulic machinery into at least three classes, defined according to the intensity of the pressure by which they are operated. This is due to the extended range of pressure adopted in the working of different types of hydraulic machines. Thus, the writer has designed hoists which work successfully and with fair economy with a water pressure of only 5lb. per square inch, and on the other hand plants for testing the internal steel tubes of modern ordnance to the intense pressure of 1,000 kilogrammes per square centimeter, or about 6½ tons per square inch, a pressure equivalent to that of a column of water nearly 6½ miles high.

The contrast between steam and hydraulic machinery is in this respect very striking. Whereas in the case of hydraulic work we have a range of pressure of from say 5lb. to 22,400lb. per square inch, necessitating considerable modification in the details of construction and choice of material for the various parts, we have in the case of steam machinery a maximum practical range of pressure of from 7lb. per square inch to 250lb. per square inch only, and the small modification of construction and material of detail at the higher pressures is due more to the difference of temperature of the steam than to difference in its pressure; a difference of temperature which, on the other hand, does not occur in the case of hydraulic machinery.

We shall, then, divide hydraulic machines into three classes:—

1. *Low Pressure.*—Comprising all machines intended to work with a pressure of less than 200lb. per square inch.

2. *Medium Pressure.*—Comprising machines intended to work at pressures of from 400lb. per square inch to 1,500lb. per square inch.

3. *High Pressure.*—Comprising machines intended to work at pressures of from 1 ton to 10 tons per square inch.

The low-pressure class is largely used in the operation of hydraulic lifts for hotels, &c., steam or gas engines being fixed in the basement to supply the requisite pressure, either direct or by pumping into a tank on the roof of the building, at a sufficient height to furnish an adequate head for working the lift. Hoists supplied with pressure from the water supply mains of the town also fall into this class, and are largely used. It is an excellent practice, in the case of large works and manufactories in which fire-mains are laid down and steam pumps fixed to supply them, to keep the pumps running as required throughout the day instead of standing idle, and utilise the pressure in the operation of hoists of this first class throughout the establishment.

The medium-pressure class includes the Armstrong type – the pressure originally employed by Mr. Armstrong (now Baron), who may be considered the foster parent of the system of working an entire plant of lifting and hauling machinery by hydraulic pressure generated at some convenient centre and distributed by mains, being 700lb. per square inch—a very suitable pressure for dock and station work and many descriptions of hydraulic machines, and adopted as a mean pressure by the hydraulic-power companies of London and Hull for their extensive plants for the distribution of power to consumers by mains laid beneath the public streets. 700lb. per square inch is, however, objectionably low, and even absolutely inadmissible for direct use in powerful hydraulic presses—generally inviting the additional complication of an intensifier—and too high for simple application to direct-acting lifts when the height of lift is considerable. Medium pressures of from 700lb. to 1,500lb. per square inch are usually employed in connection with hydraulic riveting plants of the Tweddell and other types.

With reference to the third class, working at pressures of from 1 ton to 10 tons per square inch, a higher pressure than 2 tons to 3 tons per square inch is not to be recommended for permanent machinery and plants. For small apparatus, such as punching bears for boiler and ship work, where portability is one of the most sought-for qualities of the machine, a pressure of 4 tons per square inch may be adopted with fair success, but pressures exceeding 3 tons per square inch should never be employed unless the conditions of the case are in great measure compulsory.

The reasons why pressures of say from 3 tons per square inch to 7 tons per square inch cannot be used with such practical success as lower ones do not arise so much from any difficulty in making joints, valves, or rams initially free from leakage, or in obtaining sufficient strength in the cylinders to resist the intense pressure; but lie in the rapid wear of the ram packings, from causes which will become apparent when we consider the action of the various packings available, as we propose to do in a subsequent article; and also in the rapid deterioration of the valves and valve seats. At these high pressures, when once a current (however infinitesimal) is established past the valve beat, either through the lodging of a minute particle of some hard substance on the beat, or other cause, the water cuts rapidly into the metal of the valve or valve seat, sometimes forming a straight groove, sometimes a curious crooked one. In a very short time a large plant may be rendered useless for a time from this cause. To comprehend the nature of this erosion of the hardest metals by a current of water, it is necessary to consider the enormous velocity at which water will pass through an aperture at these high pressures. The table below gives the velocity in feet per second, at pressures of from 700lb. to 10 tons per square inch, which the molecules of water will acquire if discharged into the atmosphere through an approximately frictionless aperture. Velocities for intermediate pressures may be calculated from the formulæ—

$$\text{Velocity in feet per second} = 12{\cdot}19\sqrt{\text{pressure in lbs. per sq. in.}},$$

$$\text{and velocity in feet ,, } = 577\sqrt{\text{pressure in tons per sq. in.}}$$

Velocity in feet per second	326	472	577	707	816	912	999	1290	1527	1824
	Lbs.		Tons.							
Pressure per sq. in.	700	1500	1	1½	2	2½	3	5	7	10

Thus the velocity of the molecules of water and any small particles of solid matter they may carry with them is as high at a pressure of 10 tons per square inch as the muzzle velocity of a modern cannon shot, and the effect of this bombardment of the valves and seats may be compared to the action of the well-known Zilghmann's sand blast. Even at a pressure of only 2 tons per square inch the velocity will be seen to be 816ft. per second, and will rapidly cause erosion or cutting if once a current is established. It is on this account advisable with all high-pressure hydraulic work to pass the water through a rough filter before reaching the pumps, in order that it may be as free from all solid particles as possible.

A pressure as high as 2 tons per square inch, however, may be successfully employed throughout a large establishment, and is indeed a very suitable pressure to adopt where capstan or other rotary engines are not needed, and the work required is mainly press work. We remember a well-known engineer asserting that it was impossible to work a large plant of hydraulic machinery with success at a pressure of 4,000lb. per square inch. This is, however, quite a mistake. The writer had under his personal observation for many years a large plant working at this pressure, and comprising forging presses, hoists, punching and shearing machines, boiler and girder riveters, and, in addition, the crane and hoist of a steelworks, and with perfect success. It must, however, be admitted that to prevent failure careful attention is needed. Accumulator packings must be replaced at regular intervals, whether worn out or not, and all valves and seatings similarly examined at stated periods, and trued up or replaced if showing the least tendency to deterioration. If in addition ample pumping power and accumulators in duplicate be provided, a pressure of 2 tons per square inch can be adopted as confidently as a pressure of 700lb. per square inch, and has the advantage noted above of being much more suitable for heavy press work.

Three tons per square inch may be considered as the standard pressure adopted in the Manchester packing houses; many oil presses, and a considerable number of the large cotton-baling presses used in India, are also worked up to this pressure. In the case of such presses, however, an accumulator is rarely used for the maximum pressure, and pumps, valves, pipes, &c., are subjected to the extreme pressure only at the termination of the stroke of a press.

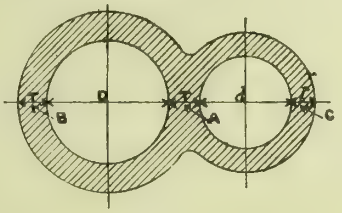


FIG. 1.

In treating of the materials used in the construction of hydraulic work, we shall make our remarks very brief, limiting them to such features as are of special importance in connection with hydraulic machinery. The general properties of such materials will be found so fully detailed in many works already in the hands of engineers, that it would be superfluous to recapitulate them here.

Cast iron is the metal most largely employed by the hydraulic engineer. It has, however, a reputation for want of reliability, especially in the construction of cylinders for high pressures. This reputation has been too often earned, however, by failure from improper disposition of the material, inadequate dimensions, or improper treatment in the foundry. As instances of the former fault, we illustrate above two typical cases, examples of which may frequently be met with in practice, even in the work of reputable engineers, and such as we have known to result in failure in more than one instance.

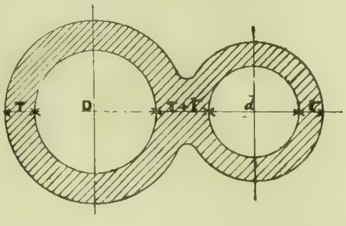


FIG. 2.

Figs. 1 and 2 represent a cross-section through a cylinder (diameter = D), having a passage (diameter = *d*) cast on at the side. Fig. 1 shows the faulty construction, and fig. 2 the correct construction. In fig. 1 it will be seen the designer has determined the thickness T of the cylinder D in the ordinary way, and then clapped on the passage *d*, without considering the effect of the addition on the stress on the metal between the cylinder—that is, at A. Thus, if P be the water pressure, the stress on the metal at A is $\frac{D + d}{2\,T} \times P$, while at B it is only $\frac{D}{2\,T} \times P$. Hence if the metal at B be properly proportioned to withstand the pressure P, the metal at A is decidedly too weak, and its thickness should have been T + *t*, as indicated in fig. 2.

Fig. 3 similarly illustrates a faulty and a correct method of making the inlet-pipe connection to the side of a high-pressure cylinder. A is of course the correct construction, and B the faulty one. At B a large hole for the reception of the inlet nipple has been drilled and tapped, and only reinforced by a shallow boss, and, in some cases which have come under our notice, by no boss at all. At A only the comparatively small and necessary inlet hole penetrates the barrel of the cylinder, and the strength of the metal thus taken away is amply supplied by the substantial boss into which the inlet nipple is screwed. Such faulty constructions as those illustrated by figs. 1 and 3 may stand the test pressure and work without failure for a considerable time, or, indeed, if there be ample material, may outlive the machine. On the other hand, if the thickness of the metal be originally somewhat inadequate, or the machine overstressed through some accidental cause, weak points have been provided by the designer at which fracture may commence, causing, possibly, great loss and annoyance, and resulting simply from the want of a few pounds of metal *in the right place.* The construction illustrated at B is especially faulty owing to the intense stresses liable to occur at the edges of the nipple hole, owing to the break of continuity of the metal and consequent localisation of strain.

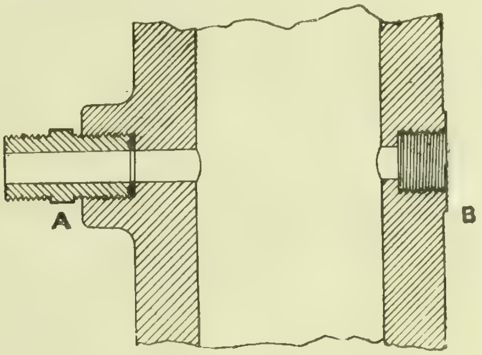


FIG. 3.

If, however, cast-iron cylinders be well and properly designed, cast from a suitable blending of metal and with proper care on the part of the founder, they may be used with confidence for pressures up to 2 tons per square inch, and for thoroughly steady loads, such as those obtaining in the case of ordinary presses used in the compression of yielding and elastic substances, a pressure of 3 tons per square inch is not inadmissible.

AN IMPROVED FORM OF SHAFT GOVERNOR.

(*Concluded from page 75.*)

FIG. 4, taken from a working drawing of a Buckeye governor with a dash-pot, shows the method of its application. It is here attached to the arm which carries the centrifugal weight, and through its connection with the eccentric is made to steady the action of the eccentric. Profiting by the experience of the Buckeye Company and others, A. L. Ide, of Springfield, Ill., designed a shaft governor in 1882, having a dash-pot for preventing irregular motion of the eccentric.

Fig. 5 shows the construction of the Ide governor, and the manner of attaching the dash-pot, which is so identical with the Buckeye arrangement as to need no special description.

The only novelty in this governor is the peculiar arrangement at B, where the end of the spring is attached to a sliding block, operated by a screw, the direction of motion being such that by this single operation a double effect is produced—that of shortening the arm or lever by which the weight is controlled, and at the same time increasing the initial tension of the spring.

In centrifugal governors, where the forces are weak and easily disturbed, this dash-pot permits a finer adjustment, and therefore makes the governor more nearly isochronous; but it also makes the action sluggish, and it is questionable whether without the dash-pot the governor cannot be made fully as near isochronous by increasing the forces of the governor. If so, the dash-pot is the less desirable remedy, and amounts to a positive damage.

A dash-pot governor of any of the kinds described, adjusted to be strictly isochronous, must depend entirely on the resistance of the fluid for stability, and this resistance must become an important factor in the governor. Consequently the sluggish action must be exaggerated or increased, thereby producing disastrous results. When a governor is thus arranged and adjusted, if in the operation of the engine it becomes necessary for the governor to move from one position to another, it cannot do so quickly, but must drag along tardily, during which time the engine is getting badly off its speed. Therefore the former instability in the nature of rapid and extreme fluctuations of speed is changed by the dash-pot to more moderate fluctuations, each of which covers a longer interval of time.

Dash-pot governors, such as have been described, do not appear to be capable of giving satisfactory results under a finer adjustment than is employed with strong centrifugal governors without dash-pots. At least such would be a fair inference from the fact that the great mass of governors are still made without dash-pots, after more than a quarter of a century of experience with their use.

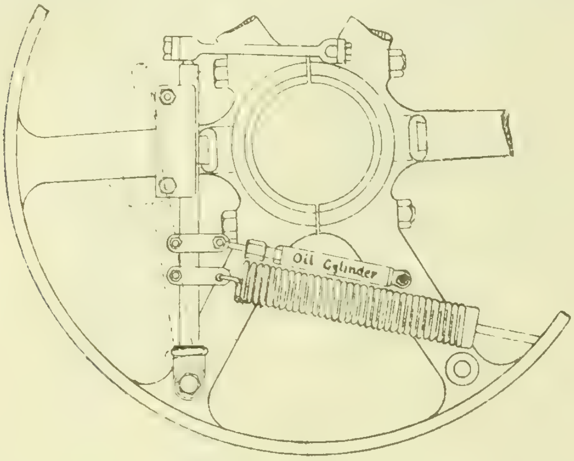


Fig. 4.

During the past year the writer has discovered a new application of a dash-pot to centrifugal governors, which seems to be entirely free from the difficulty formerly encountered.

The principles involved may be understood by reference to fig. 6. The governor here shown is one of the ordinary forms of shifting eccentric governors.

The introduction of the spring S between the dash-pot and the movable part of the governor is the new feature. Its operation and effect are as follow:—

Suppose the long spring D be drawn up until its initial tension, in distance of stretch, shall correspond exactly with the distance between the centre of gravity of the weight and the axis of revolution. This is what is called "full theoretic tension."

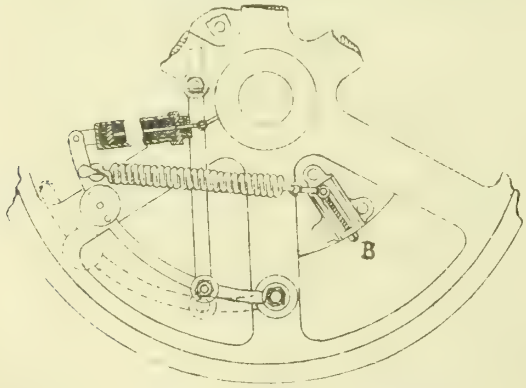


Fig. 5.

The condition is the same as would be obtained if the weights were first placed at the centre of the shaft, and after attaching the spring without any tension the weight was then moved out to the position shown.

With this relation between the position of the weight and the tension of the spring, the increase and decrease of centrifugal force caused by moving the weight to or from the axis of revolution would exactly harmonise with the changes of resistance of the spring due to said motion; and if the two forces were in equilibrium in one position, they would be so in every position at the same speed. This condition, as has already been said, should be expected to give uniform speed of the engine at every position of the governor, but has been found impracticable on account of its instability.

The object of the dash-pot and spring here shown is to allow the theoretically perfect adjustment of the long spring, and to furnish ample stability without making the governor sluggish, or in the least preventing a quick and delicate balancing of the forces.

This spring S is arranged for both compression and extension, and has a range of deflection sufficient to allow the full motion of the governor, from one extreme to the other, without regard to the motion of the piston of the dash-pot to which it is attached.

The resistance of this spring S, having no initial tension, is entirely out of harmony with the other spring, and combined with them produces exactly the effect when motion takes place that is obtained ordinarily in centrifugal governors, by using springs with less than the full theoretic tension, and if the dash-pot piston should remain stationary, the same change of speed would be found between the extreme positions of the governor, but by reason of the movement of this piston the tension on spring S is released, and it then ceases to be a factor in the speed, which is only the result of the long spring, and, as has been previously shown, it must be the same at every position of the weight.

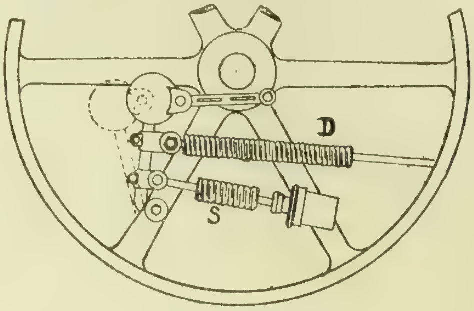


Fig. 6.

This theory, though somewhat obscure, seems to be correct, and its practical operation under careful tests proves it to be so.

Governors are now made of various types, embodying this principle, and have been found to compel the same number of revolutions per minute of the engine under any condition of load or boiler pressure within the full capacity of the engine.

SILICON IN CAST IRON.*

During the past two or three years consumers of pig iron have been seeking more knowledge regarding the chemical questions involved in foundry practice. This desire has been increased by the papers of Professor Thomas Turner, of Mason College, Birmingham, reporting a series of tests made to show that silicon is a useful rather than a damaging element when present in proper quantities in cast iron, and that by its use pig irons and scrap, which when used alone are totally unfit for foundry purposes, may be made to give satisfactory results. Professor Turner has shown that the strength of a cast iron depends on—

1. The amount of weakening impurities present;
2. The proportion existing between the combined and the graphitic carbon in the cast iron.

He says that the tendency of combined carbon is to increase hardness and brittleness, while graphitic carbon makes iron soft, malleable, and tough; too much of either form is a disadvantage; the strength depends on the proportion.

Strength being the thing most desired, irons having an excess of weakening impurities will not find a market, and therefore the only thing to provide for is the proper proportion between combined and graphitic carbon. Professor Turner shows that by a judicious use of silicon this proportioning can be accomplished exactly according to the wish of the founder, an increase of silicon changing combined carbon to graphitic, and *vice versa*. When the founder understands its use he may soften and toughen, or harden and strengthen his iron to suit his requirements; but Professor Turner warns him against the use of silicon without first understanding when it is needed; for in an iron where the carbon is already graphitic, more silicon may weaken it and make it brittle.

From the effects produced by the extensive use of high silicon irons for many years, and from the discussion of the subject during the past few years, silicon has come to be considered as a softening agent.

In the United States for a number of years past many foundrymen have depended upon the irons made from the lean ores of Ohio and Kentucky as softeners to counteract the hardness of irons made from the refractory ores of Lake Superior and northern New York and the irons of the South; but it has only lately been generally understood that this softening quality is due to silicon.

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* W. J. Keep and E. Orton, Am. Inst. Mining Engineers.

Upon examining the analyses of Ohio softeners made from native ores, it will be found that the percentage of silicon runs from 3 per cent to 7 per cent, and that none regularly made previous to 1887 contained more than 7 per cent.

As the process by which silicon accomplishes these desirable results has become better understood, the demand for high silicon iron has increased. In 1887 foreign irons containing as high as 10 per cent of silicon were imported into the United States. These high silicon irons go under the name of ferro-silicon. As the call for this imported product increased ferro-silicon containing from 7 per cent to 14 per cent of silicon, and of a very high grade in other respects, has been produced in America to supply this demand.

The question has naturally arisen, whether the use of irons containing such a high percentage of silicon is as economical as when the percentage is lower. This has led us to the experiments and conclusions set forth in the present paper. We shall treat the subject under the following general divisions: First, a comparison of the composition of foreign and American ferro-silicons; secondly, the inquiry whether the silicon in the pig is retained in the iron when re-melted; and thirdly, the inquiry whether the silicon in the pig is imparted to other irons during re-melting without loss of silicon.

(To be continued.)

BELT AND ROPE GEARING.—IV.

CENTRIFUGAL FORCE.

It is usually considered that under similar conditions and with a given maximum stress the *power* of a belt increases in direct proportion to the increase in its speed, and the inference to be drawn from an inspection of formula (12) would tend to support such a theory; but, nevertheless, the assumption thus made is not strictly true, owing to the presence of certain stresses induced by the *disturbing effect* of centrifugal force on the power which may be transmitted by a belt (or rope) under given conditions of working, more especially at high velocities. The primary and chief effect of centrifugal force is its tendency to lift the belt from off the surface of the pulley, and thus to lessen the pressure, and therefore the friction of the belt, upon the same; but this is not the only influence which this force has upon the working of the belt, as the *stress* produced by centrifugal force in the material of the belt itself becomes at high rates of speed a serious quantity.

THE EFFECT OF CENTRIFUGAL FORCE ON THE TENSIONS IN AN ENDLESS BAND.

The formula for the *centrifugal force* of a body of weight w_0 in pounds, describing a circle of r_0 radius in feet, with a uniform velocity v in feet per second, is as follows:—

$$\text{Centrifugal force F} = \frac{w_0 v^2}{g r_0} \qquad (28)$$

where $g = 32{\cdot}2$, the acceleration of gravity, and F = centrifugal force in pounds.

And it may be readily proved (see footnote) that the stress per square inch induced in each side of the belt is equal to

$$\text{Stress} = \frac{w v^2}{g} \qquad (29)^*$$

where w = the weight of a running foot of belt (or rope) *one square inch* in section.

The weight of a running foot of leather belting $w = \frac{62}{144} =$ 0·43lb.; so that for belts made of leather

$$\text{Stress} = \frac{v^2}{75} \qquad (30)$$

The amount of tension produced by this force in a belt made of leather, whose sectional area is A square inches, will therefore be

$$\text{Centrifugal tension } T_c = \frac{A \times v^2}{75} \qquad (31)$$

If A = one square inch, then T becomes the stress, as in (30).

The *aggregate tension* existing in the belt will be equal to the sum of the two tensions T and T_c, that is

$$T_2 = T + \frac{A \times v^2}{75} \qquad (32)$$

and it is for this amount of tension that the belt should be designed, and not, as is usually the case, for the tension T only.

This formula may for *general* purposes be written

$$T_2 = T + \frac{A \times w \times v^2}{g} \qquad (33)$$

A, w, and g having values as before.

It may be readily seen from an inspection of formula (30) that at some particular speed the stress induced by the centrifugal force alone would amount to the maximum allowable working stress. For instance, if we take the working stress as before, viz., 300lb. per square inch, then, on substituting this value, we obtain from (30)

$$300 = \frac{v^2}{75}$$

$$\text{therefore } v^2 = 75 \times 300 = 22500$$

$$\text{so that } \quad v = \sqrt{22500} = 150\text{ft. per second,}$$

at which speed the belt would only be able to drag itself round the pulley provided that the initial tension was so arranged that the maximum limit of stress could not be exceeded.

This limit of speed would certainly not be safe, apart from the question of available power, as the severe strains set up in the rim of the pulley would in such an event become, in the case of cast-iron pulleys, a dangerous element to deal with, as may be easily shown as follows:

As w for cast iron = $(12 \times 0{\cdot}26)$,

$$\text{stress in rim of pulley} = \frac{(12 \times 0{\cdot}26) \times v^2}{g} = \frac{3{\cdot}12\, v^2}{32{\cdot}2}$$

$$\text{stress} = {\cdot}097\, v^2, = \tfrac{1}{10}\, v^2 \text{ (very nearly)} \qquad (34)$$

and at the above velocity (150ft. per second) the stress in the rim would become $\frac{1}{10}$ of 22500 = 2250lb. per square inch, a sufficiently large working stress for cast iron in tension considering the serious nature of the initial stresses due to the contraction of the metal when cooling.

As a matter of fact, instances have occurred where large fly-wheels and pulleys have flown to pieces, a subsequent investigation into the matter fully proving that the centrifugal tension was the most active, if not the only, cause of the disaster.

The importance of these facts cannot have been sufficiently realised, or we should not be constantly hearing of instances where these excessively high speeds have been adopted, and I am certainly of opinion that when about to determine the size of a belt or rope necessary for the purpose of driving a machine requiring a high speed of rotation, it is most desirable, in order to obtain satisfactory results, that the influence of this somewhat hidden force should be considered, and its effect taken into account.

Moreover, I believe it is not generally known that for a given maximum working stress there is a certain limiting velocity beyond which it would not be advantageous to go, from the fact that an increase of speed above that limit could only be accompanied by an increase in the amount of power transmitted at the expense of the stress per square inch to which the material was subjected, as the initial tension would require to be proportionately greater if extra power were required. The following reasoning will, I trust, make this point sufficiently clear:—

The amount of power transmitted by a belt or rope varies in direct proportion to its linear velocity, *i.e.*, if the amount of available driving tension $(T - t)$ be considered as constant. But the tension produced by the action of the centrifugal force is in direct proportion to the square of the velocity; therefore it is only fair to suppose that the effect of these two elements will—particularly in the case of high speeds—become most conflicting in their nature, as any apparent increase of power which might be due from an increase of speed (above that limit) will be more than balanced by the diminution in the amount of available working tension, resulting from centrifugal force, which, as stated above, increases at a much greater rate than that of the former element for any given increase of velocity.

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[*] $$\text{Centrifugal force F} = \frac{w_0 v^2}{g r_0} \qquad (28)$$

Considering the effect upon a ring of material one inch wide by one inch thick—*i.e.*, one square inch of section—the force acting on *each cubic inch* will be expressed by the formula (28) if we take w_0 as being the weight in pounds of a cubic inch of the material. As the above force acts in a similar manner to that of the steam in a boiler—that is, in a radial direction—we may use the formula that applies thereto, viz.:—

$$\left.\begin{array}{l}\text{Stress per square inch on dia-}\\ \quad\text{metrically opposite sections}\end{array}\right\} = \frac{\text{Pressure of steam per sq. inch} \times \text{dia. in inches}}{2 \times \text{thickness in inches.}}$$

In this case the thickness is *unity*, so that

$$\text{Stress per square inch} = \text{Pressure} \times \frac{\text{diameter in inches}}{2}$$

Substituting the centrifugal force F for the pressure, and adopting the *foot* as a unit of measure, we obtain

$$\text{Stress per square inch} = 12 \times \text{F} \times \text{radius in feet,}$$

which may be written

$$\text{Stress} = \frac{(12 \times w_0)\, v^2}{g}$$

As $(12 \times w_0)$ represents the weight of a running foot of material = w, we may write

$$\text{Stress} = \frac{w \times v^2}{g} \qquad (29)$$

In the case of leather belting, $w = \frac{62}{144} = {\cdot}43$; so that

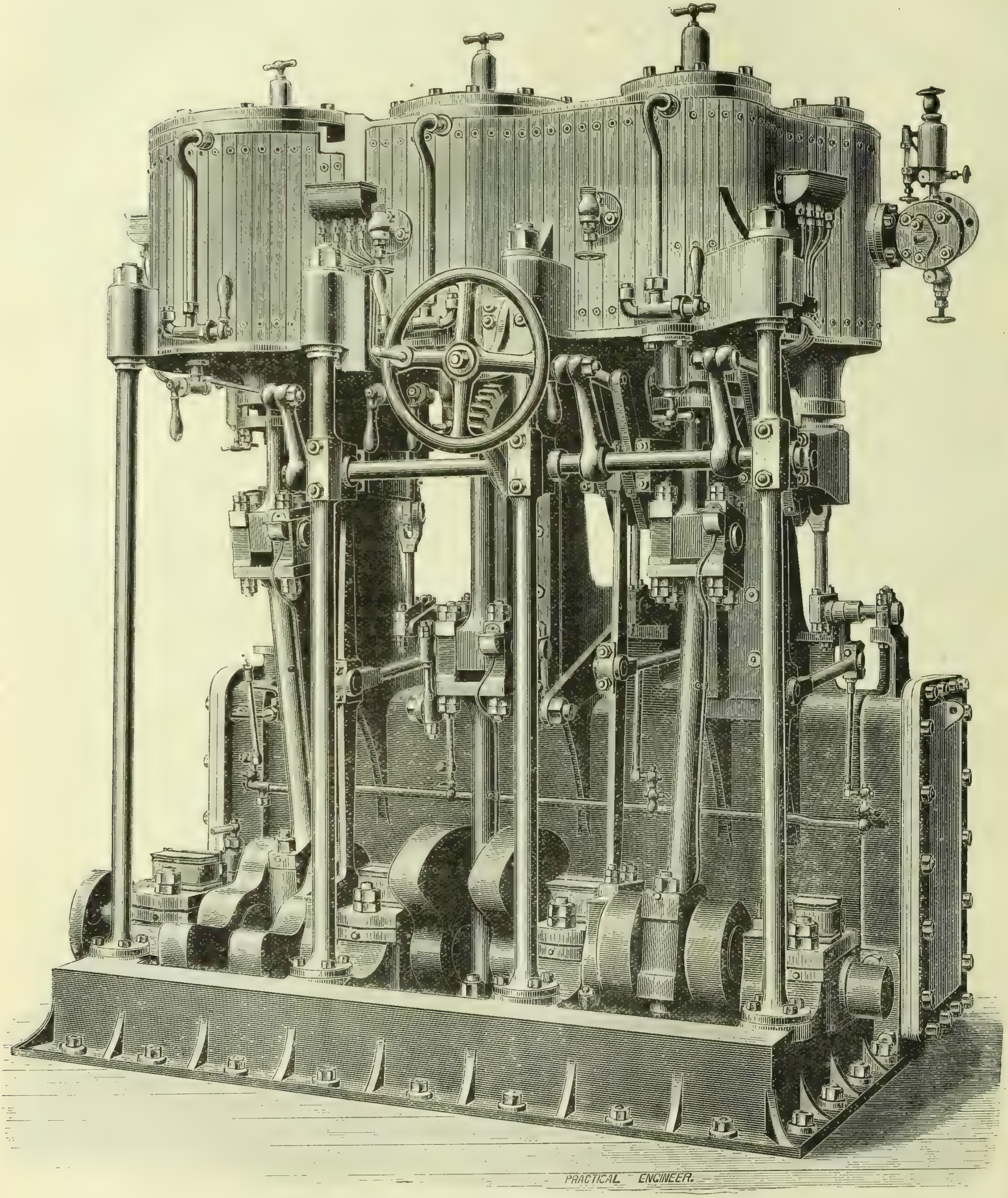
$$\text{Stress} = \frac{v^2}{75}$$

It is interesting to note that the centrifugal stress is not affected by any change in the diameter of the pulley if the velocity v is not altered; but in the case of centrifugal force the radius of the pulley is an important element.

TRIPLE-EXPANSION ENGINES OF THE STEAM YACHT MALOOM.

CONSTRUCTED BY MESSRS. MUIR AND HOUSTON, ENGINEERS, GLASGOW.

(For description see page 96.)

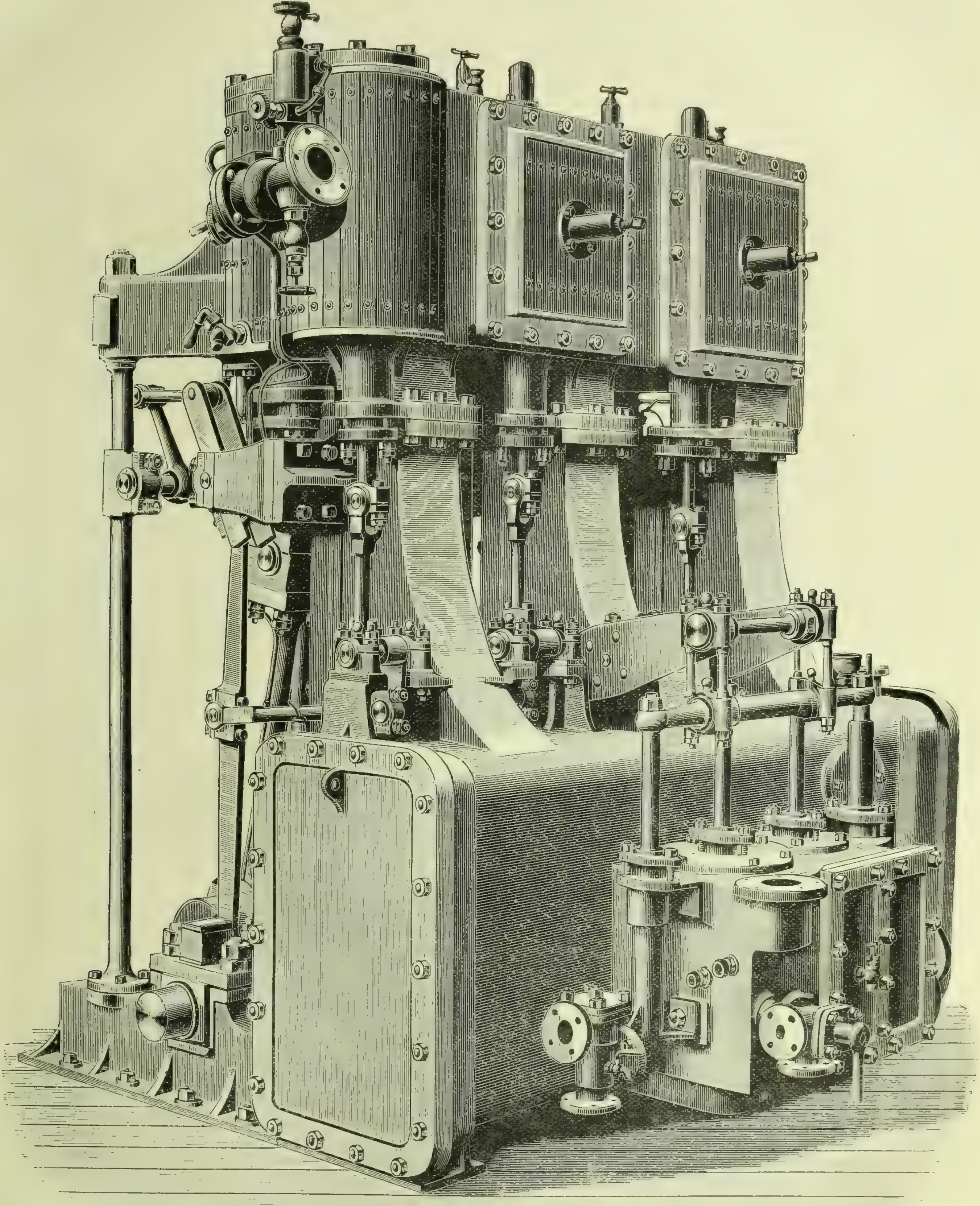


FRONT ELEVATION.

TRIPLE-EXPANSION ENGINES OF THE STEAM YACHT MALOOM.

CONSTRUCTED BY MESSRS. MUIR AND HOUSTON, ENGINEERS, GLASGOW.

(For description see page 96.)



BACK ELEVATION.

TRIPLE-EXPANSION ENGINES OF THE STEAM YACHT MALOOM.

This week we give illustrations on pages 94 and 95 of the engines built by Messrs. Muir and Houston, of Glasgow, for the screw yacht Maloom, the property of John Baird, Esq., of Knoydart. The yacht was built from the designs and under the supervision of Mr. G. L. Watson, the well-known naval architect of Glasgow, and designer of many famous racing yachts, including the Thistle, by the Ailsa Shipbuilding Co., of Troon. The vessel, which is classed 100 A 1 at Lloyd's, is 80ft. long by 14ft. 2in. beam by 10ft. deep, 66 tons yacht measurement, is built entirely of steel, and is handsomely fitted up.

The engines, as will be seen from our illustrations (pp. 94-95), are of the triple-expansion type, having three cranks at equal angles of 120 deg., and the three cylinders are respectively 8in., 13in., and 21in. diameter, and 15in. stroke. The crank shaft is of the best selected scrap iron, built on the plan now usually adopted by marine engineers, and runs in four main bearings carried on the sole plate. The four wrought-iron polished columns on which the fronts of the cylinders are supported give the engine a fine open appearance, and allow of plenty of room for overhauling the principal working parts. The air, circulating, feed, and bilge pumps are all driven by levers attached to the crosshead of the intermediate engine, and from their position are easily accessible at all times.

In steam yachts fore and aft space is of the greatest importance, and to diminish to a minimum that taken up by the engines a modification of Hackworth's valve gear is adopted. The valves are placed at the back of the engines, as is readily seen. The high-pressure valve, which is one of the piston type, has a cover on the top in line with those of the cylinders, to allow it to be removed; while the other two slide valves have large doors at the back, allowing of the valves being taken out and the faces seen with very little trouble. The piston rods are of forged steel, and have adjustable brass slippers of large area.

It will be seen that the engines are arranged with every requisite for safe working and quick handling. Each cylinder is fitted with relief valves, top and bottom, and there is also one to each steam-chest—all having polished brass covers. The other fittings include indicator gear, starting valves to each receiver, drain cocks to all cylinders and casings, sight-feed lubricator on main stop valve, and four syphon lubricators on each engine supplying the quick-moving parts, viz., the crossheads, crank pins, and guides.

The water service for main bearings is connected to the discharge side of the circulating pump, and is placed in a convenient position. It is conveyed through polished copper piping, with universal joints to each bearing, and also to the back of the slipper guides.

The reversing gear consists of a worm and quadrant of quick action, and is conveniently accessible from all valves for stopping and starting.

The steam receiver and vacuum gauges are suitably arranged on the bulkhead, and here is also a reply telegraph for communicating with the deck.

The surface condenser is of the usual construction, and of large dimensions. There are 194 brass tubes, ⅝in. diameter, 5ft. 6in. long, giving a total cooling surface of 209 square feet.

The propeller is one of Mr. Houston's particular design. It has three blades of specially-cast metal, containing a large proportion of steel, which gives great strength, and is not therefore likely to become easily damaged.

In our next issue we purpose giving drawings and sections of the engines and boilers, with details of working pressures and power obtained, but meantime we may state that the boilers are constructed for an ordinary pressure of 160lb. per square inch, and that the engines, running at 180 revolutions per minute, indicate 130 horse.

The whole design and details are excellently conceived and carried into effect, and we have much pleasure in placing it before our readers as an excellent example of Clyde marine engine practice, as applied to steam yachts.

The Grosvenor Gallery.—At a meeting of the St. George's (Hanover Square) Vestry last week, a memorial was read from some ratepayers in New Bond Street, complaining of the annoyance caused by the electric lighting works of the Grosvenor Gallery Company. The memorial was referred to committee for consideration and report.

AN ENGINEER'S LIFE AT SEA.—XXIII.

BY A SEA-GOING ENGINEER.

Coal and Ashes.

In joining a steamer for the first time a chief must see that his bunkers are full, or what empty space there is on the top of the coal in each bunker. On the outward run he should watch this day by day, to see if there were any hollows left by the trimmers, and as soon as he reaches the outer port he should again measure the empty space. He will thus know how much coal he has used per day. Before the fires are laid he should also estimate how much has been used for the winches, and he should see how much he uses to get up steam. If these points are not closely attended to, his account of coal consumption will not agree with what he found on board. As soon as possible he should have the coal tallied in baskets for 24 hours, as a check on his calculation. This cannot well be done until it ceases "to run," but as soon as it gets back in the bunkers, and the trimmers have to throw or carry it, the average basket being weighed, count is kept of the number of baskets. Tallying for only a watch or two is misleading, as everything would depend on the amount on the fires at the beginning and end of each watch. If it is necessary to get the daily consumption while the coal is running, and if the usual iron measure is not aboard, then the bottom should be knocked out of an old ash bucket, and the weight which fills it ascertained. When full it is simply moved to another part of the footplates and filled again, emptying itself through its open bottom. With coal getting short, on account of bad weather or other cause, the engines should be slowed down, for the consumption decreases much faster than the speed, there being thus a saving on each mile run. If, however, the slowing down be carried too far, then the friction of the engines' radiation of heat and resistance of the water will transform the gain of the previous case into a loss. In such matters the engineer has to use his judgment, remembering that for equal reductions of speed the gain is less the slower the speed. For a similar reason it is of little use trying to force the steamer against a head wind and sea. It is better to save coal till the weather moderates, and then it can be put to its most effective use; but at the slowest enough speed has to be maintained to keep steerage way on the ship. When running with a fair wind and sea an engineer is tempted to leave his engines full open, so as to feel that he is making a rapid run, but in this case also it is best to close up a little, as the unusual speed of revolution tends to loss of fuel. The practice of dividing the number of tons of coal used by the number of days of the voyage may give a rough estimate, but when used to show that an engineer is wrong in his estimate of coal consumption per day it is absurdly inaccurate. An engineer has to take account of running at half-speed, of lying under steam, or of winch work. Also for his own safety he must see that if he err at all he must err on the side of understating the amount of coal he has to start with.

Sometimes coal turns out to be bad and wasteful, but perhaps the greatest trouble is with slack. In one steamer the coal was carried aboard in baskets, through deluges of rain. It was also nearly all slack, but as the chief was on bad terms with the captain he said nothing. The steamer got out, and at first all went well; but in a day or two nine knots steadily diminished till it settled at four and a half knots an hour, and beyond that the utmost efforts and rivalry of the firemen could not get the engines to drive the ship—with wet slack running out of the bunkers, and hissing on the fires. The captain believed at first that the chief had hit on some new annoyance, but after he had seen for himself he retired, leaving the chief grimly smiling. On another steamer, which had an excellent outward run, bad coal was taken aboard in the Mediterranean. On the home run strong head winds were met with. This, combined with fires which would not keep up steam, and which had to be frequently cleaned, produced the spectacle of a steamer advancing no faster than a man could walk, with the captain standing on the deck, watch in hand, counting the revolutions when at their worst. In such cases the engineer, who has done his best, knows that the cause is beyond control, but the captain is perhaps not at all sure of this, and also has a reputation for quick runs to make or to lose. He has a sense of injury if, after all his energy and expedition in port, and his skill and seamanship in following the shortest routes, the engines simply refuse to go, and especially if he and the chief are not on the best of terms.

At the beginning of a voyage the coal trimmers have a holiday time, but as the bunkers empty they have perhaps the hardest and most disagreeable work on board. They usually keep six-hour watches instead of the firemen's four, and, being unskilled labourers, their pay is less. In hot climates their lot is not enviable, but in African waters negroes are usually employed to take their places.

When trimmers disagree among themselves it is best for the engineer to keep out of the squabble, and tell them to refer it to the firemen. But among the firemen also disputes are frequent, though with these also an engineer should have as little to do as possible. Sometimes an alteration in the watches will be found to restore harmony. A trimmer can, if he likes, do a great deal for or against his fireman. For instance, when there is much slack, he will run a rake lightly over the top of it, and this has a marvellous effect in extracting all the lumps, leaving the slack for others; or if, having discovered a vein of better coal, he conceals it from his fellows, an intelligent trimmer can by thus taking pains enable his fireman to keep better steam than others.

The bunkers are at all times gloomy, but especially so at night, when the smoky flame of the lamp is obscured by clouds of coal dust. Into one such nearly empty cavern a certain coal trimmer went one night as usual, and in his diligent excavations had temporarily blocked himself in with a pile of coal against the door. A third, who knew the superstitious nature of the individual, had previously descended through the bunker lid on the deck, and stood in the farthest corner waiting for this. Then, to the startled ears of the trimmer came in hollow tones the intimation that he was "come for." Frantically battering on the door for help the coal was removed as fast as possible from the outside, and he was dragged out more dead than alive. In the meantime the third had departed and silently closed the lid. Nothing could ever afterwards persuade the man that he had not seen the Prince of Darkness himself. This, of course, was not flattering to the third, but having owned that he was the individual referred to, he had only the additional compliment of not being for a moment believed. The curious part of it was that the fireman instinctively took it for granted that the summons must be from the lower world, and not from any higher region.

Besides throwing out coal, the trimmers help the firemen in various ways, such as getting the tools together, and assisting in cleaning fires or sweeping tubes. They also help to get up the ashes before each watch. To a wakeful engineer the first summons that his watch is at hand is the rattling of the empty chain, the rise of the bucket, its arrival on deck, and journey to the side, with the hot ashes hissing into the water, and the empty bucket afterwards rattling down the shoot again for another load. When ashes accumulate in port they are always got over the side as soon as the pilot has left the ship, all hands being turned out for the purpose. In foreign ports boatmen will usually take them away for nothing, especially if a few broken firebars be given to them. In some cases the firemen can even manage to extract from the boatmen a bottle of the country's wine or a few cigars. Whether they succeed in this or not, there is always a lively negotiation over the matter, to the amusement of the engineer, who is not supposed to know anything about it.

THE INSTITUTION OF CIVIL ENGINEERS.

At the ordinary meeting on Tuesday, the 29th of January, the President (Sir George B. Bruce) being in the chair, the first paper read was on "The Trincheras Steep Incline on the Puerto Cabello and Valencia Railway, Venezuela," by Mr. John Carruthers, M.Inst.C.E.

In this paper a comparison was instituted between two different methods of setting out lines of railways in mountainous countries; namely, that of adopting, as nearly as possible, a uniform gradient in order to surmount a high summit; or that of keeping the line as long as possible in the valley, and overcoming the ascent by steep inclines. The interior of Venezuela was cut off from the Caribbean Sea on the north by a range of mountains, which had now been crossed by two lines of railway, one of which, the line under discussion, was 34 miles in length, with a summit level of 1,950 feet. It connected Valencia, the capital of the State of Carabobo, and the second city of the Republic, with the harbour of Puerto Cabello. The principle adopted in setting out this line by the engineer, General J. C. de Castro, was that of making the gradient uniform from the sea level at Puerto Cabello to the summit. The author was invited by the President of the Republic to report upon the line thus traced out, and, on his recommendation, further studies were undertaken, including a survey for a new line, adopting the principle of getting down from the summit as quickly as possible by a steep incline, and then following the valley bed. Of the two sets of surveys made, one was with a gradient of 1 in 20, with the view of using ordinary locomotives, and the other with a gradient of 1 in 12½, on which some special mode of traction would be necessary. The latter line was adopted on the recommendation of the author, and the railway had been constructed upon it. The rack system, as improved by Mr. Abt, was adopted for working the incline. In this the rack consisted of three parallel plates, $1\frac{9}{16}$in. apart, bolted firmly together; each plate was a complete rack, and they were laid breaking joint both as to the ends of the plates, which were all of the same length, and also as to the position of the teeth. The two pinion wheels on the engines, which worked into the rack, were formed each of three tooth rings, one for each rack-bar. They were laid together with the teeth of one ring leading those of the next by the amount of stepping or overlap in the teeth of the rack. The rings had an elastic connection with the shaft, to correct inaccuracies due to imperfect workmanship, or to the expansion and contraction of the rack rails; and in practice no jar was felt, even when the engine was running at 15 miles per hour. Plans and sections between Puerto Cabello and La Entrada, of the original line with uniform gradient, and of the line as constructed with an inclined plane, were given. For brevity, the former was called the "Guaiguaza" line, and that with the inclined plane the "Palito" line. In making the comparison regard was paid to—1, original cost; 2, maintenance of ways and works; and 3, locomotive expenses. It was shown that the Guaiguaza line would have been much more costly than the other. The country through which that line passed was extremely rough, the general slope of the hills being not flatter than 2 to 1. The cuttings and embankments would have been seldom less than 30ft. or 40ft., and often 100ft. on the centre line. Many viaducts and heavy retaining walls would have been necessary, and the cost of the railway would have been more than double that of the Palito route. It was known from experience gained on another line through a similar country, subject to the same climate, that the Guaiguaza route would have been liable to constant landslips, and might have been blocked several times every rainy season; but on the Palito route the danger of slips was almost entirely removed; for, owing to the formation level being close to the bottom of the valley, the line was kept further out from the hillsides than would be possible where, owing to the steepness of the latter, the toe of an embankment would have found no support until it reached the valley bed. There was a further advantage in this case, that the rocks were more solid in the lower levels, changing, in the section between Trincheras and Castano, into hard granite, and not, therefore, liable to slips of any moment. On the Palito route the curves, obtainable at an expense within the resources of the railway, were much better. This tended to economy in the maintenance of way and works. Taking all these matters into account, the author came to the conclusion that the Palito route was as much the better of the two lines in regard to maintenance of way and works as in first cost. The author then proceeded to show that the Palito line was somewhat superior in respect of locomotive expenses, and was capable of handling a greater traffic than the other with the same engine power, and of carrying passengers safely and economically at a higher average rate of speed, by means of a time-table for each line, showing what could be done with four engines in steam, working steadily for the whole day, without shunting work at the terminal stations. The length of the two lines was the same within 100ft. It was shown that on the Guaiguaza route a traffic of 90,000 tons a year each way, and on the Palito route one of the 108,000 tons, could be carried. The number of engine-miles daily would be, for the Guaiguaza route 408, and for the Palito 350. The time occupied between terminals for passengers would be two and a quarter hours for the Palito and two and three-quarters hours for the Guaiguaza. By adopting the Palito route, therefore, the carrying capacity was increased 20 per cent, the engine mileage reduced 14 per cent, and the speed increased 17 per cent. For working the up traffic an engine left Puerto Cabello in the morning with a full load, generally twelve wagons, for Cambur. Eight wagons were left at Cambur, and four taken up the bank to Trincheras, where they were placed in front of the rack engine, and taken by it up the incline to the summit at La Entrada. The engine, as soon as it had placed the wagons in front of the rack engine, returned to Cambur, and brought up another set of four, placing them again in front of the rack engine, which had by that time come back down the incline. This process was continued until the whole train with which the engine left the Port in the morning was taken to the summit, when the engine returned to the Port, having done its day's work by running 102 miles, and having been seven and a half hours in steam. The several return trips of the ordinary and of the rack engines were not made light, as the latter brought down from the summit to Trincheras, and the former from Trincheras to the Port, the down goods which a third engine had brought from Valencia. The remaining traffic of the day was worked in the same manner, the wagons being taken up as in the other case in several trips from Cambur to the summit, and thence into Valencia by the Valencia engine. The author then proceeded to show in what respects the engines used by Mr. Abt on the Hartz Railway, and elsewhere, differed from those adopted for the Trincheras incline, in that the latter dispensed with adhesion altogether, working only through the rack. The two pinion wheels in the Trincheras engines were each actuated by a separate pair of cylinders, and both pinions pressed fully against the teeth of the rack, notwithstanding any slight irregularities in the latter. There were two cylinders on each side of the engine, one above the other, so arranged that the same steam chest, slide valve, and valve motion served for both. The two lower cylinders actuated the leading, and the two upper the trailing, pinion wheel. There were three independent brakes on the engine. The principal details and dimensions of the engines were then given. In working, the engine always pushed the load up the incline. The gradient of the incline was 1 in 12½ for a distance of 7,700ft., and from 1 in 28 to 1 in 21 for the remaining 4,000ft., the total length of the incline being about 2¼ miles. The minimum radius of curvature, 500ft., occurred on the steepest part of the gradient. All the stock was furnished with the Heberlein brake, and the trains were completely under the drivers' control. The only structures of importance on the incline were four viaducts. The author's object in this paper was to draw the attention of engineers to the advantages, not in his opinion adequately recognised, of the system of using steep inclines instead of long gradients. On the Puerto Cabello line the incline led to no saving of distance, and the cost of locomotive working was not much reduced; but in the majority of cases, where an incline could advantageously be used at all, it would save a long development of line, with consequent economy. The Trincheras gorge, although rough and with very steep side slopes, was unusually straight, and the author was at first inclined to advocate the system of rope traction; but he found that the local authorities would not approve of the system, and he did not, therefore, prepare any plans for rope traction, but recommended the Government to specify the Fell system, which was done. When, however, the company was formed for constructing the line, the consulting engineers, Messrs. James Livesey and Son, decided to use the Abt system of rack. In the author's opinion the change was an improvement, experience of both systems having convinced him that the improved rack was better than the Fell centre-rail where the curves were moderately good, especially where engines independent of ordinary adhesion could be used, and where the complication of coupled pinions could be got rid of. On the Trincheras incline, with curves of not less than 500ft. radius, the pinions worked with practical accuracy into the rack. The mechanical drawbacks of the two systems might be thus summarised: In the Fell system there was increased journal friction, due to the pressure in keeping the gripping wheels in adhesion with the centre-rail; in the rack, friction was due to the imperfect adaptation of the pinion to the rack. The one was independent of the curvature of the road, while the other increased rapidly with it; and there was, therefore, some radius of curves at which the two systems would be equally favourable, an increase of the radius tending to give the superiority to the rack, while a decrease would tend to give it to the Fell. The Trincheras incline was open for public traffic in March, 1888, and had been working ever since without accident or difficulty.

The second paper read was on the "Cost of Working the Hartz Mountain Railway," by Mr. Robert Wilson, M.Inst.C.E., and the third was on "Further Information on the Working of the Fell System of Traction on the Rimutka Incline, New Zealand," by Mr. J. P. Maxwell, M.Inst.C.E. Both papers were interesting, and contain much detail and statistics especially treating on the financial results.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STEAM ENGINE EFFICIENCY.

To the Editor of "The Practical Engineer."

SIR,—The interesting correspondence now appearing in the columns of your valuable paper on the above subject no doubt will prove very instructive to a numerous class of readers. It is a subject which ought to be studied in all its details by practical engineers, as there are such conflicting opinions amongst them on the different methods of construction and mode of working the steam engines and boilers which are placed under their charge, but all have one common object in view, viz., how to obtain the highest efficiency. This interesting correspondence may be the means of preventing any false impression in the minds of your readers. The prevailing idea amongst engineers in some districts, and what is considered the proper thing to do in the present day, is to obtain the highest possible boiler pressure, but, I fear, regardless of the means of using it, and without considering whether the existing engines are adapted for the increased pressure, or, if new engines are designed, whether the cylinders are correctly proportioned for the ratio of expansion and the load to be driven. Eventually this has led either to costly breakdowns of the old engines or wasteful expenditure in the cost of running and maintenance. In these days of keen competition amongst manufacturers every avenue of expenditure has to be carefully looked after, and many steam users have found, to their sorrow, that an extra outlay in this direction has not always proved a good investment, and that simply an increase of boiler pressure has not always been attended with increased economy.

Turning to the question at issue, that of your correspondent, "L. C. D.," of Jan. 11th, who gives a practical illustration of the motive power applied. Now, "L. C. D." says that he has a horizontal compound tandem engine, with cylinders 16in. by 28in. diameter, with piston speed of 464ft. per minute, the cylinder ratio being 1 : 3·08, with an available steam pressure of 100lb. per square inch, and he gives the collective power of the two cylinders as 132 I.H.P., and the coal consumed as 7lb. per H.P. per hour for all purposes. The boiler supplies steam for the usual heating of mill and one sizing machine. Assuming about 12 per cent of the gross consumption for heating and sizing, would leave about 20 tons to be accounted for, and this practically consumed by the steam boiler and engine in the ordinary 56½ hours weekly run. Now, here we have a steam boiler and engine, evidently of modern construction, consuming about 6lb. of coal per I.H.P. per hour, and working with the fanciful pressure "which must be the proper thing nowadays."

From the appearance of "L. C. D.'s" diagrams, as regards the initial pressure, adjustment of valves, and the valves and pistons, if they are practically steam tight, the engine does not appear to be using 6lb. of coal per I.H.P. per hour; but it is quite evident the engine is too large for its work, and the cylinder ratio not correctly proportioned for the initial steam pressure, and in the first instance, and under present circumstances, I would advise "L. C. D." to reduce the load on the safety valves, and so adjust the point of cut-off in the high-pressure cylinder to about one-third of the piston's travel, and from the sketch of valve which accompanies the diagrams, and which appears to be a common slide valve on the low-pressure cylinder, with $2\frac{1}{16}$in. lap and 8½in. traverse, with cut-off at about three-fourths of piston's travel. Now, to the steam edges of this valve, if there is room in the valve box for extra lap with the same traverse, add 1in. positive lap, and the exhaust edges, or negative lap, to remain as at present, move the eccentric forward on shaft, so as to give five-sixteenths lead at the steam edge, and the cut-off in this cylinder will then be about five-twelfths of the piston's travel. It is not practicable to cut off any earlier with a common slide valve. My object in doing this is to fill the passages between the cylinders with a pressure, if possible, equal to the terminal pressure in the non-condensing cylinder. Adjust your injection tap so that the temperature of discharge from hot well is about, or not below, 102 deg., as probably the boiler is fed from this source.

I hope that "L. C. D.," if he decides on making any alterations, will give us the results of his experience, and if this should be unfavourable, attention should next be paid to the boiler and its connections.—Yours, &c., A. EVANS.

Farnworth.

To the Editor of "The Practical Engineer."

SIR,—I cannot agree with your previous correspondents as to their methods of reducing the coal consumption of "L. C. D.'s" engine. "W. A." is, in my opinion, wrong in stating that the work done by each of the two cylinders cannot be equalised by any arrangement of low-pressure cylinder valve; also in his second letter he states that nothing is to be gained by equalisation of the work of each piston, and by so doing a direct loss would be the result. I find from experience that the economy of the compound engine lies in having the engine proportioned to the load required, and equalising the load, and therefore the fall of temperature in each cylinder. Let the engine be compound or tandem compound condensing, it matters not. In proof of the above, I give an instance where, by the equalisation of the load in each cylinder of a compound condensing engine, the result was a saving of over 20 per cent, which reduced the coal per hour per I.H.P. in summer months to 2·0lb., without alteration of boiler pressure (95lb.) or cylinder proportions, which are three to one, the alteration being made on low-pressure valves, the high-pressure valves being regulated by automatic gear. I should not advise the lowering of boiler pressure, and under no conditions lap the exhaust edges. The engine is certainly too large for the load. I should recommend the cylinders to be bushed, the high-pressure reduced to 12¾in., and the low-pressure to 22in. diameter. There would not be much space between bush and cylinder of high-pressure for jacketing, but the low-pressure might be conveniently jacketed, the low-pressure valve to have ¾in. of lap on each steam edge, and $\frac{1}{32}$in. of lead at each exhaust edge. The above diameters of cylinders would turn over 132 I.H.P. comfortably and economically. I should also recommend an economiser to be fixed with not less than 96 pipes. If the above alteration be carried out I cannot see any reason why "L. C. D." should not reduce the coal consumption at least about fifty per cent. With fourteen tons of fair slack per week we get 190 I.H.P., driving over 400 looms, winding, warping, slashing, and supplying steaming shed, with one boiler 95lb. pressure and one economiser. This is very much better than "L. C. D.'s" 23 tons per week, giving only 132 I.H.P.—Yours, &c. BOLTON.

INCREASE OF PRESSURE IN COMPOUND ENGINES.

To the Editor of "The Practical Engineer."

SIR,—The question "J. B. B." has asked with reference to the proportion of his cylinders is one which cannot be correctly answered without more details as to present cut-off in high-pressure cylinder, type of engine (whether tandem or otherwise), capacity of condenser, and pumps, &c. It will be readily acknowledged by "J. B. B." that, if the present cut-off in the high-pressure cylinder (with 75lb. pressure of steam) is maintained, and the boiler pressure increased to 100lb., the weight of steam passed through the engines will be materially increased in amount owing to the increased density of the same, and it should be noted that unless an increase in the initial pressure is accompanied by an increase in the number of expansions given to the steam, the full benefit of the higher pressure will not be obtained, so that unless the cut-off which at present exists is altered to suit the higher pressure, the engine will certainly not be as economical as at present, and as the weight of steam which has to be condensed would be greater than before, it remains to be seen whether the present condenser and pumps would be of ample size for the purposes for which they are required.

With respect to ejector condensers, I am of opinion that in most cases where they are adopted it will be found that, unless they are of relatively large capacity, the vacuum obtained by their use is materially less than that of a condenser of the usual type.

With reference to the number of expansions required, we get—

$$\text{Total number of expansions} = \frac{100 + 15}{15} = 6{\cdot}1\dot{6}\dot{6}$$

The ratio of areas of cylinders is at present

$$\frac{36^2}{23^2} = 2{\cdot}44$$

so that the number of expansions in the high-pressure cylinder would require to be

$$\frac{6{\cdot}166}{2{\cdot}44} = 2{\cdot}52 \text{ (about)}$$

that is to say, the cut-off would require to be at about $\frac{4}{10}$ of the stroke. —Yours, &c., OMICRON.

To the Editor of "The Practical Engineer."

SIR,—In reply to "J. B. B." as to whether the cylinders of his engine are of suitable proportion, I beg to say that he does not tell us the purpose for which the suitability is required. But if it be that each cylinder may do about half the total work performed by the pair, then, besides the data he has already given us, the point of cut-off or ratio of steam expansion in the high-pressure cylinder is required, as well as the amount of receiver space between the two cylinders, together with the back pressure per square inch, or defect of vacuum opposing the advance of the low-pressure piston. As to the question of the pair of cylinders working economically, there is no reason to apprehend anything to the contrary from any information that is given. But the amount of work done per pound of steam used will mainly depend on the total amount of expansion in the combined cylinders.—Yours, &c., W. A.

COMPOUND ENGINES.

To the Editor of "The Practical Engineer."

SIR,—I have read with much interest the answers *re* compound engines, and it seems to me that the compound engine is but little understood by a large number of young engineers; and I have a suggestion to make which I think, if acted upon, would be of great interest and instruction to the readers of *The Practical Engineer*. It is that some thorough practical man would give an article, or series of articles, on the type of compound engine as used to drive the machinery in our Lancashire cotton mills, viz., the compound horizontal side-by-side receiver engine, with cranks at right angles; taking an engine of a given indicated horse power, and working out the sizes of cylinders, &c., to give such results as might be expected in actual practice, and dividing the power equally between the two cylinders.

The following are a few points which might with advantage be touched upon:—

The best ratio of cylinders for various boiler pressures.
The usual loss of pressure between boiler and high-pressure cylinder steam chest.
The best point of cut-off in the high-pressure cylinder.
The best point of cut-off in the low-pressure cylinder.
The most economical final pressure in the low-pressure cylinder.
The best capacity of the receiver in relation to the high-pressure cylinder.
How to find the pressure in the receiver—that is, the exhaust line in the high-pressure diagram—and the initial pressure in the low-pressure cylinder at the commencement of the stroke.
The most economical final pressure in the high-pressure cylinder.
The usual loss, if any, of pressure between receiver pressure and initial in low-pressure cylinder.
The most economical piston speed for different indicated horse powers.
The best speed of steam through the ports of both high-pressure and low-pressure cylinders.
The most economical number of expansions (total) for various boiler pressures.

I am sure any information on the above subject would be most welcome to many of your readers, besides yours, &c., PISTON.

NEW TORPEDO BOATS.—The construction of two fast torpedo gun vessels, to be named the Gossamer and the Gleaner, has been commenced at Sheerness Dockyard. Each vessel will be 230ft. long, with a displacement of 735 tons, and will carry two 36-pounders and four 3-pounder quick-firing guns, as well as five torpedo tubes.

QUERIES AND REPLIES.

3. SLIDE VALVE OF HYDRAULIC ENGINE.—Will some reader kindly inform me which is the best form of slide valve to adopt? The engine makes 20 strokes per minute, and the pressure is 1,000lb. per square inch. I should be glad also to learn what kind of stop valve is generally used for hydraulic cranes.

Answer.—The slide valve for a hydraulic engine is precisely similar to that for steam, only it is heavier and smaller. The illustration fig. 1 shows section and details of a valve suitable for 1,000lb. per square inch. Fig. 2 shows a common form of stop valve as used for hydraulic cranes. We commence in this issue a series of articles on hydraulic machinery, in which full details, with dimensions, will be given.

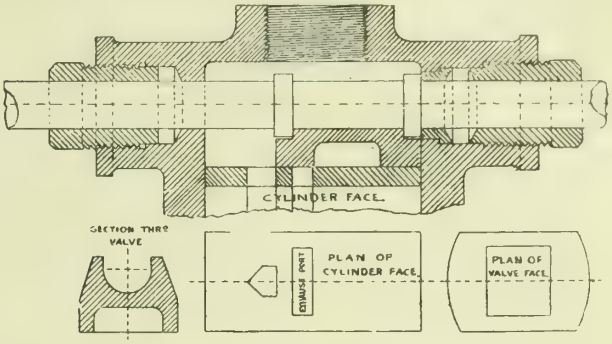


FIG. 1.

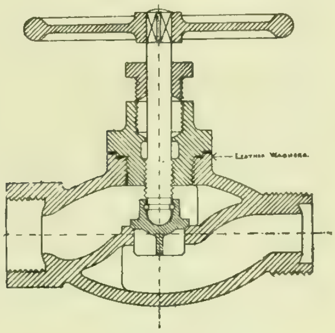


FIG. 2.

2. VARNISH FOR PAPIER-MACHE GOODS.—Would some reader kindly inform me how to make the black varnish that papier-mache goods are coated with? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished?—J. T. L.

7. BLACKLEAD PENCIL MAKING MACHINERY.—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery?—B. B.

12. MOST ECONOMICAL TYPE OF ENGINE.—Will some reader kindly inform me which type of engine is best for factory purposes, as we think of replacing our present engine by one of the most improved and economical type. What dimensions should give 250 I.H.P., and which is best beam, vertical or horizontal?—T. H. P.

TO CORRESPONDENTS.

J. W. H., Belfast.—To qualify as a boiler inspector you should make yourself thoroughly familiar with the construction and working of boilers, particularly of the land type, Lancashire and Cornish, and also be able to calculate strength of boilers and riveted joints. Messrs. Crosby, Lockwood, and Co. publish a book on boilers, by Mr. R. Wilson, which is very good. To get on the staff of a boiler insurance company you should call on the chief engineer personally, and inquire as to vacancy; this is much better than writing, as the chief can form an idea of your capacity. There are no cut and dried series of queries put to a candidate any more than for a post in a private firm.

WORKING DRAUGHTSMAN.—We thank you for your letter expressing approval, and we hope to publish after a time a series of articles on the stationary compound steam engine, dealing with the matter from a practical point of view.

STUDENT, Todmorden.—You should apply at some steamship office personally. There are examinations, which have been very fully described in our article on "An Engineer's Life at Sea." The examinations are held at large seaport towns.

FISHER, Darsley.—"The Works Manager's Handbook" is published by Messrs. Crosby, Lockwood, and Co., London, and is written by W. S. Hutton, C.E. The published price is 15s.

P. C., Leeds.—Your cast-iron flywheel shaft is too small in diameter for the load you now put upon it. The margin of safety is very much less than it ought to be. Cast-iron shafts are not now used for such purposes. The fact of its being cold blast iron makes it safer than it otherwise would be

MISCELLANEA.

THE contract for the construction of the viaducts and bridges for the Manchester Ship Canal has been secured by Messrs. Wm. Arrol and Co., the well-known Glasgow firm. There will be at least five viaducts and half a dozen bridges, and 8,000 tons of iron and steel will be needed.

THE longest railway bridge span in the United States is now the cantilever span in Poughkeepsie Bridge, 548ft. This is said to be the widest completed railway span in the world. The Forth Bridge will have spans of 1,700ft. The Rohri span of the Indus Bridge at Sukkur will be 820ft.

THE MANUFACTURE OF GLASS BOTTLES IN GERMANY.—The American Consul at Dusseldorf, in a recent report, describes the great Heye factory for glass bottles at Gerresheim, a few miles from Dusseldorf. Gerresheim contains about 3,000 inhabitants, and it is said that the town is the glassworks and the glassworks the town. On the hills adjoining the town are inexhaustible supplies of the yellow and white sand used in the manufacture, while the place is also excellently situated for communication with the rest of the world. A model town for the permanent workmen adjoins the factory. The capacity of the latter is about 300,000 bottles a day, and the daily average production is about 200,000. From 300,000 to 500,000 bottles are sent weekly to the United States, in consignments of 1,000 gross each, and only quite recently the Apollinaris Co. made a contract with Herr Heye for the delivery within a year of 19,000,000 bottles. The practice of exporting Rhine and Moselle wines in bulk, and bottling them at their destination, has added to the importance of the foreign trade in bottles. The number of persons employed never falls below 1,800, and sometimes amounts to 3,000, many being women, who are engaged usually in the packing department. The pay of the blowers is high, ranging from about 4s. to 6s. This work is kept up throughout the 24 hours, by three relays of hands, while the ordinary work is carried on for 11½ hours, with three rests, two of half an hour and one of a whole hour. A stock of 5,000,000 bottles is usually maintained on hand. The consul thinks that some secret exists in the composition placed in the furnaces, but general observation only revealed burnt and sifted sand, lime, and sulphur in certain proportions. The special excellence of the bottles made here is that they contain no ugly seams or ridges on the outside. This is said to be due to the fact that the iron pipe or tube used in blowing is repeatedly turned by the workmen during the process, thus giving the bottle a perfectly smooth and complete appearance. The consul inquired particularly on this point, and was told that English and American workmen refuse for some reason to perform this special extra labour of turning the bottle in the mould.

THE PNEUMATIC GUN.—Experiments which took place with Mr. Zalinski's pneumatic gun from Fort Lafayette, in New York Harbour, lately were only partially successful. The trials were made with one of the new 15in. guns designed for the new dynamite cruiser Vesuvius, recently built for the American navy. Six consecutive shots were to be fired, one with a projectile containing 500lb. of dynamite, the full capacity of the gun, and five with projectiles containing 200lb. of explosives. The longest range was to be 1,760 yards, and the projectiles were to fall within a parallelogram of 60ft. by 100ft., marked with buoys. The stipulations of the War Department required that 50 per cent of the shots should fall within the parallelogram. The day was clear and cold, and the conditions were favourable. The first shot was made with 200lb. of the explosive substance. There was a sharp report, and then a long black object was seen flying through the air. It mounted gradually till it reached a height of about 100ft., and then began to curve towards the water. It was about eighteen seconds in the air before it touched the water and disappeared, and a second afterwards a huge majestic pyramid of foaming water arose from 150ft. to 200ft. into the air, making a most gorgeous spectacle as it was lighted by the rays of the afternoon sun. The place where it descended was slightly outside and beyond the parallelogram. The initial velocity was about 800ft. per second and the distance over a mile. The next experiment was with a much heavier projectile, but I was unable to find out the precise weight because of the disinclination shown to give exact information. It is said by some observers to have been of 500lb. The gun was discharged about an hour after the first shot, the elevation being much greater, and the size of the projectile was seen to be enormous as it rose nearly 400ft. But it then began to turn over in the air, twisted about in its course, and finally tumbled point foremost into the water, 450 yards short of the mark. It exploded almost instantly, sending a tremendous volume of water hundreds of feet into the air with such violence that no vessel could have escaped destruction within a radius of a hundred feet. It was announced that the valve attached to the pneumatic apparatus for supplying the compressed air was defective, and caused a leakage, which gave the unsteady motion to the projectile. It was decided to discontinue the experiments until this defect had been repaired. They will be resumed shortly. The air pressure used for the first shot was 500lb. per square inch, and for the second 1,000lb. Although the trial was not a complete success, scientific observers agree that it was demonstrated that an enormous mass of explosives could be discharged safely from a gun and carried a long distance with comparatively accurate aim, and be exploded beneath the water at the end of its course.

FAST SPEED TELEGRAPHY.—On making inquiries at the Post Office Telegraph department, St. Martin's-le-Grand, information was obtained to the effect that 600 words per minute were recorded there on Monday, January 21st, by means of the Wheatstone automatic telegraph apparatus.

ENGINEERING SOCIETY, KING'S COLLEGE, LONDON.—At a general meeting of this society, held on Tuesday, January 29th, Mr. Schwartz gave his presidential address, choosing "Mine Ventilation" for his subject. The author first dealt with the flow of air through shafts, and described the various methods of conducting air from the pit bottom to the forehead of the mine in mines of moderate extent. He next went on to describe the circulation of air in large mines by means of bearing doors, and explained the formation of the double headways course and the use of brattices. After describing the various methods of coursing the air, he dealt with the rarefaction of the air of the upcast shaft by means of furnaces or exhausting cylinders, and concluded with a detailed description of some of the ventilating machinery now used.

THE COAL GAS EXPLOSION ON THE STEAMER BELLINGHAM. Judgment in the Board of Trade inquiry into the explosion of coal gas on the Shields steamer Bellingham in the North Sea in December last was recently given at Hull, by Mr. Twiss, stipendiary magistrate, and Captains Brooks and Bragg, nautical assessors. The first question put by the Board of Trade was in reference to the coal from Low Walker, which was shipped on board the Bellingham. Mr. Twiss, in giving judgment, said that from the evidence given by Mr. Willis, her Majesty's inspector of mines for the North of England, it had been proved that the coal shipped on board the vessel was liable to evolve explosive gas for some time after it had been worked. The cargo in question was taken direct from the seams where it was worked and shipped at once on board the vessel, and it would therefore emit gas for some time after shipment. The Court was satisfied that the coal was not properly stowed and trimmed in the after 'tween decks; that the after 'tween decks were not properly and sufficiently ventilated; and that surface ventilation was not provided, which would have been effectual, independently of the hatchways, in all circumstances of the weather. The Court found that the explosion was due to want of proper ventilation, which caused a large accumulation of gas in the space above the coal in the after part of the after 'tween decks, and to the storeroom hatch having been improperly opened, whereby the gas was allowed to pass from the hold up into the storeroom, and so through the pantry, and thence along the passage into the saloon, where a fire was burning, and by which, without doubt, it became ignited. The second officer most decidedly was not in default nor to blame; but the Court considered that blame attached to the chief officer for not having satisfied himself, during the storage of the coal, that there was a free and uninterrupted space on the surface of the coal in the after 'tween decks; but seeing he had no instructions from the master with respect to this, it did not find him in default. The Court, however, found the master in default for reasons already stated, and suspended his certificate for three calendar months.

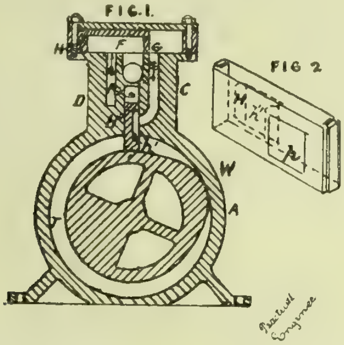
A FORMIDABLE WEAPON.—A remarkable machine for discharging dynamite projectiles, shells, and solid shot has, it is reported, been constructed by a Brooklyn citizen namad Hicks. According to the published description, this "firing" machine throws projectiles from the periphery of a rapidly-revolving wheel—uses, in fact, centrifugal force instead of an explosive. The most improved Krupp guns impart to the projectile an initial velocity of 2,300ft. per second, and Mr. Hicks says he can obtain an initial velocity of 2,900ft. a second by means of a 10ft. wheel when the latter is turning at the rate of 4,000 turns a minute. The range at that speed would be five miles, but as the wheel can be made to effect 6,000 revolutions a minute, there would be a corresponding gain in the initial velocity and range of the projectile. The motive power of the wheel is a steam engine. The wheel consists of two steel discs, thin at the circumference but thick at the centre, fixed several inches apart, and firmly joined by bolts. In the space between the discs, four clutches for holding the projectiles are placed equidistant round the circumference. Outside each disc is a double quadrant, used by the gunner in training the novel "gun" to the desired elevation. Combined with each quadrant is a mechanical contrivance, which, by pulling a lanyard, opens a clutch, and releases a projectile just at the point at which the gun may be trained. Two shots at opposite sides of the wheel are thus fired in an infinitesimal fraction of a second apart. There is a separate lanyard for each disc, each firing two of the four shots. A wheel, 10ft. in diameter, throws a 6in. shot, 20in. additional diameter of the wheel being required for each additional inch of calibre in the shot. Below the wheel there is a jackscrew brake for stopping it. The entire machine, including the steam engine, stands upon a single plate, which may be turned upon a turntable and adjusted like any naval gun carriage. The machine may also be placed on wheels and used for field service. The projectile specially designed to be used in the "Hicks" firing machine is a long cigar-shaped shell, with heavy solid ends, the intervening space being filled with camphorated nitro-gelatine (blasting gelatine), surrounded by gun-cotton, as in the Zalinski projectile. The fulminate is exploded by a needle running through to the pointed head of the shot.

ILLUSTRATED PATENTS.

SELECTED ABSTRACTS OF RECENTLY PUBLISHED SPECIFICATIONS.

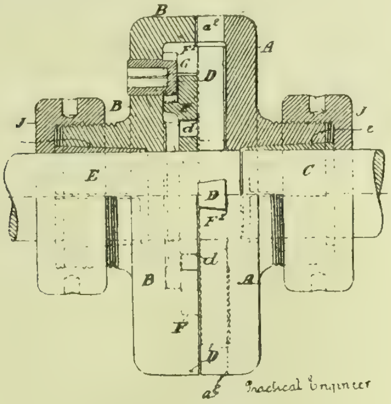
11,778. Rotary Engine, P. Jenson, London. (*W. H. Bright; McPherson, Kansas, U.S.A.*)

The piston barrel T works concentrically in the casing A provided with the sliding abutment H^1. This latter has ports h, h^1 (fig. 2) corresponding to passages F, G in the steam chest C, so that it acts as a cut-off valve, while the piston head W is passing beneath it. The direction of the steam is controlled by the valve H. The chamber D, in which the abutment works, has two small orifices, one R, communicating with the exhaust pipe O, the other opening into the steam supply pipe. This latter one is closed by a valve, whose stem, however, is struck by the abutment in rising, while simultaneously the orifice R is closed. Steam is thus temporarily admitted above H^1 to press it against the piston.—August 30, 1887. [8½d.]



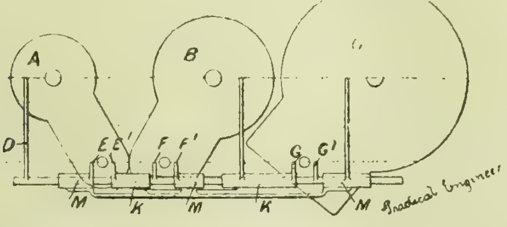
11,827. Clutches and Couplings for Shafting, R. Morris, Doncaster, and J. Wood, West Stockwith.

A pair of flanged discs A, B are secured by split bushes i and screw caps J on the ends of the shafts C, E respectively. A series of bars D, sliding in guides F^2 in the disc B, are adapted to enter dovetailed recesses a^2 in the flange of the disc A, and are moved in and out by pins d thereon engaging in eccentric slots in a disc F mounted on the end of shaft E and provided with a toothed segment gearing with the pinion G, by which it may be rotated; the said pinion is journalled in the disc B and has a square eye. The end of the shaft E enters the eye of the disc A.—August 31, 1887. [8½d.]



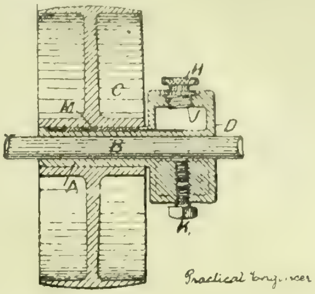
11,838. Valve Gear for Steam Engines, H. C. Lobnitz, Renfrew.

The gear is specially designed for triple-expansion marine engines with three cylinders working on cranks set at equal angles. The figure shows a diagrammatic plan of such an engine, A, B, and C being the high-pressure, intermediate, and low-pressure cylinders respectively. The valve spindles are arranged in one vertical plane, and each is worked through ordinary link-motion from arms on specially arranged concentric rocking shafts. The inner rocking shaft is worked by an arm D from the high-pressure piston rod, and carries arms F and G^1. The second shaft K is tubular and in two pieces connected by a bridge. It is worked from the intermediate piston rod, and carries arms E^1 and G. The third shaft M is also tubular. It is in three parts connected by bridge pieces, and is worked from the low-pressure piston rod. It carries arms E and F^1. The pairs of arms E, E^1, F, F^1, and G, G^1 operate the link-motions of the cylinders A, B, and C respectively. Each crank thus acts as a forward eccentric for one of the other cylinders and as a backward eccentric for the third. The rocking shafts may be actuated direct from the respective cranks by links, or by eccentrics on the main shaft, or they may be worked partly from the piston rods and partly from eccentrics.—September 1, 1887. [6½d.]



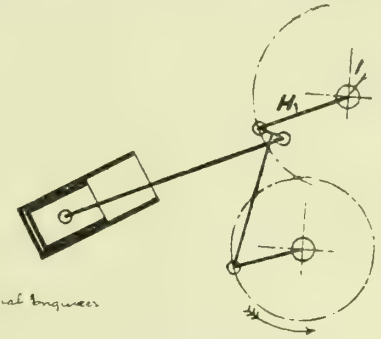
11,891. Lubricator for Loose Pulleys, D. Hartley, Bradford, Yorkshire.

The pulley C revolves on the sleeve A surrounding the shaft B and attached to the lubricator D. The lubricator D is provided with a filling hole J, closed by a screw plug H, and is attached to the shaft by a set screw K. The oil is conveyed from the lubricator to the bearing surface by a strip of felt, &c., placed in the channel M made on the outside of the sleeve A.—September 2, 1887. [8½d.]



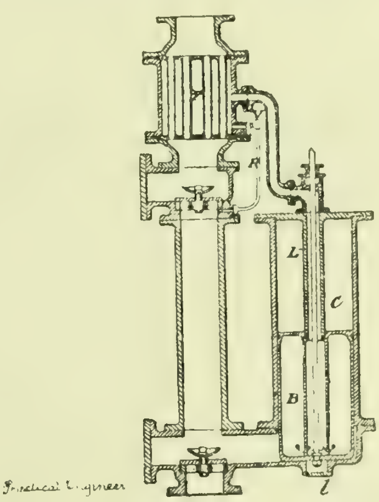
11,911. Gas Engine, J. Atkinson, Hampstead, N.W.

To vary the expansion in engines of the type described in Specification, No. 3,522, A.D. 1886, one of which is shown diagrammatically, and in which a four-stroke cycle is performed during each revolution of the crank shaft; the position of the pin I, on which the rod H oscillates, is made variable. This is effected by providing the pin with eccentric ends which may be adjusted in the engine frame by means of a worm and worm wheel actuated by hand.—September 2, 1887. [8½d.]



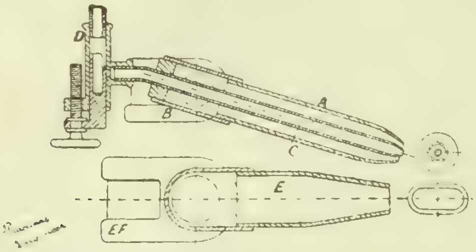
11,970. Steam Pumps, J. Tangye and R. J. Connock, both Cornwall.

Relates to the class of pumps in which the steam acts on one side of the piston while the liquid is pumped on the other, and consists in an arrangement of the engine for heating the cylinder surface by means of the exhaust, and in a special form of condenser. Heating cylinder surface, arrangement of engine for: The cylinder C is preferably somewhat longer than twice the stroke, and the piston B is slightly longer than once the stroke. The piston is hollow, and the exhaust is made to pass through it on its way to be condensed, or to the atmosphere. The underside of the piston is covered with wood or other non-conductor, in order to prevent actual contact between the liquid and the body of the piston. Two arrangements are shown in the specification for dealing with the exhaust after it has entered the body of the piston. In one of these, shown in the illustration, the piston slides on a pipe L, depending from the cylinder cover, or is provided with a tubular extension working in a pipe standing above the cover, through which pipe the exhaust passes to the condenser. In the other a tube dips down from the lower side of the piston into the liquid being pumped. This is provided with a valve through which the exhaust passes directly into the pump-column. In both cases the steam valve is situated on the cylinder cover, and the exhaust valve is a heat valve on top of the piston, with a spindle projecting through the cover. The valves are worked by a trip-gear off the cross-head. Condenser: This is a tubular surface condenser F placed in the discharge column of the pump, so that the cooling medium consists of the liquid pumped. A small pipe R with a check valve Y is added for placing the interior of the condenser into communication with the pump discharge, in order to permit of the escape of air and the water of condensation.—September 3, 1887. [8½d.]



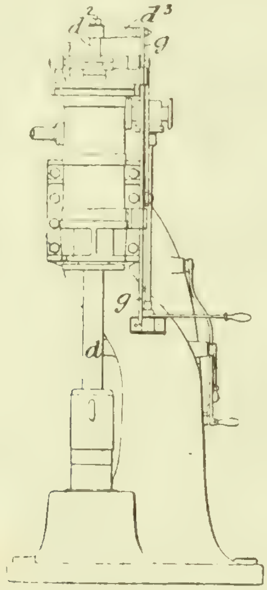
11,999. Spray Burner for Heating Purposes, J. W. Newall, Arnold, Bow, Essex.

In this burner an oil spray produced by a blast of air is caused to meet a secondary air blast at an angle. The oil is supplied through a regulator D to a tube C with a nozzle at its end. The air blast is supplied through an outer concentric tube A, and its force is regulated by a valve B. The oil nozzle projects a little beyond the air nozzle. The secondary air blast is directed through a flattened tube E, situated below and at an angle to the spraying tube. Its force is regulated by a valve F. The tubes A and E may be formed in one piece instead of being separate. The oil regulator consists of a tube D, with an internal plug hollowed at the top where it is provided with a V-shaped slot. The plug is adjusted by means of a set screw.—September 5, 1887. [8½d.]



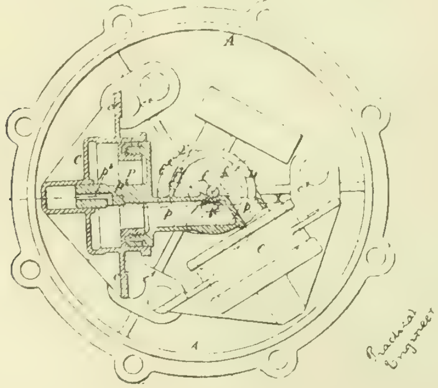
12,089. Steam and other Fluid-pressure Hammers, W. M. Wilson, Patricroft, Lancashire.

Consists in a method of preventing the piston from turning in hammers without guides; arranging the valve gear above the cylinder so as to leave the underside clear for forging, and, in single-standard hammers, throwing the cylinder out of line with the standard in two directions, so as to afford space for long forgings. Piston, turning of, preventing: For this purpose the piston has rods projecting through both ends of the cylinders, the lower one *d* concentrically, and the upper one d^2 eccentrically; both turned so that ordinary glands and stuffing-boxes only are required. Valve gear: On the upper piston rod is secured an arm d^3 to which is connected the roller bar *g* free to slide vertically in guides and carrying a roller. The latter actuates the tripper-lever and thus operates the valve mechanism. Standards: This springs from one corner of the base-plate, and is twisted as shown in the drawing.—September 7, 1887. [8½d.]



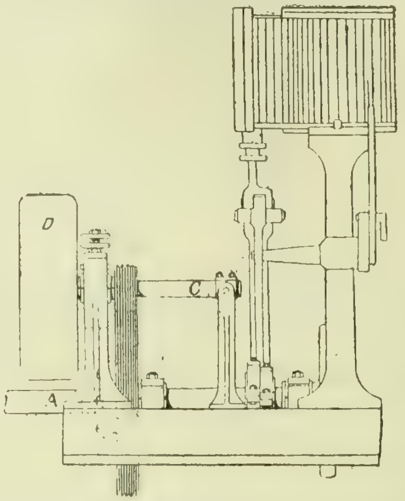
12,124. Hydraulic Motor, Meter, and Pump, W. A. G. Schönheyder, 81, St. Stephen's Avenue, Shepherd's Bush, Middlesex.

Relates to engines having several cylinders arranged radially round a common crank shaft. A three-cylinder engine is shown in plan in which C, C are two of the working cylinders, the third cylinder being removed and its piston only shown. The whole mechanism of the engine is enclosed in a water-tight casing A, which is formed in two halves bolted together and fitted with inlet and outlet pipes affixed on the underside. Each cylinder has a pair of wings *c*, *c*, the faces of which rest against the guides c^1, c^1 and thereby permit the cylinder to move in a direction transverse to its axis. The pistons P are rigidly connected to a central boss D by their piston rods, which contain passages *p* for the admission and discharge of the fluid to and from the cylinder. To guide the pistons an extension p^2 works in a recess communicating with the cylinder by the passage p^3. The boss D, which actuates the crank of the driving shaft, also acts as a distributing valve. On the facing F are three admission ports f^2, f^2, f^2 and one triangular outlet port *f*. On the under face of the boss D are three ports *p*, one communicating with each of the hollow piston rods. Each port p^1 passes alternately over an admission port f^2 and the discharge port *f* as the boss rotates, thereby alternately admitting fluid from the water-tight casing into its cylinder and discharging through the outlet pipe. When used as a meter, the crank shaft actuates a counter. If the shaft is caused to revolve by extraneous power, the apparatus will operate as a pump.—September 7, 1887. [8½d.]



12,125. Marine Engines, J. McLaren, Midland Engine-works, Leeds. (*A. R. Mackenzie; Port Mackay, Queensland.*)

Consists in a mode of applying a flywheel to marine screw engines in order to prevent racing. The flywheel D is mounted upon an independent shaft C driven at a higher rate of speed than the main shaft A by gearing therefrom. The latter is preferably friction gearing. This supplementary shaft is supported so as to be capable of being moved slightly for the purpose of putting it in and out of gear with the main shaft.—September 7, 1887. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

January 21st.

1051 Oil Stoves, W. H. Pasley and J. Hodgetts, Birmingham.
1052 Looms, J. T. Thornton, Halifax.
1054 Looms, F. S. Walker, Bradford.
1056 Electrical Battery, T. Pease, Liverpool.
1061 Lubricators, J. L. Grandison, Manchester.
1065 Springs, J. H. Boll, Yeovil.
1078 Removing Crustation from Boilers, H. Green and A. Green, Manchester.
1098 Hot-blast Stoves, O. Imray, London. (M. Boecker, Germany.)

January 22nd.

1125 Excavating Apparatus, J. Isles, T. S. Rhodes, and E. Yeadon, Leeds.
1131 Furnace Frames, S. Cutler and A. Dougall, jun., Westminster.
1132 Water Elevators, J. K. Leedy, N. W. Solenberger, and G. Smith, London.*
1159 Supplying Air to Steam Boilers, N. S. Hawkes, London.
1161 Steam Boilers, H. E. Newton, Middlesex. (W. Cowles, United States.)*
1162 Electric Governors, R. Kennedy, Glasgow.
1188 Lifting Machinery, Tangyes (Limited) and J. R. Williams, Middlesex.
1193 Wind Motor, W. H. Hall, London.
1198 Making Earthenware Pipes, A. Ramsden, London.

January 23rd.

1219 Engines, J. Tidswell, Bradford, Yorkshire.
1227 Smoke-consuming Apparatus, J. Proffitt and T. Foley, London.
1242 Earth-boring Apparatus, E. Przibilla and F. W. Klever, London.*
1244 Fog Signals, B. P. Stockman, London.
1248 Railway Couplings, W. P. Thompson, Liverpool. (A. Kunze, Wänring.)
1254 Machines for Polishing Stones, W. Hay, London,
1268 Circular Saws, W. Lorenz, London.
1269 Hydraulic Presses, C. D. Abel, London. (M. M. Rotten, Germany.)
1271 Coke Ovens, H. Simon, London.

January 24th.

1290 Safety Lamp, H. Harrison, Leeds.
1294 Gas Governor, W. Stoner, Hunslet, Leeds.
1310 Shafting, N. S. Parker, W. Mahood, and A. Granville, London.
1314 Steam Pumps, R. Holt, Rochdale.
1322 Water Heaters, J. Wright, London.*
1324 Mechanical Stoker, L. P. Garrett, London.
1331 Surface Condensers, T. Cooper, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10, can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from either of our offices on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

The Practical Engineer,

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office on Wednesday Morning *at the latest.*

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THE

PRACTICAL ENGINEER.

FEBRUARY 15TH, 1889.

INTERNAL FRICTION IN ENGINES.

IN the very general desire to construct steam engines which give the lowest consumption of fuel for every indicated horse power obtained, we fear some engineers forget that after all the indicated power of an engine is not the true measure of its capabilities for performing external work, but that from the indicated power must first be deducted the friction of the engine itself. The power indicated in an engine may be most satisfactory, the fuel consumed for that power exceedingly little, and the mechanism may be sound, well constructed, and reliable; yet the actual driving power may be capable of considerable increase. The energy lost in friction provides a field for further effort—one in which little has been done, and of which but little definite knowledge has yet been gained. In testing the power of an engine—for the purpose of determining, of course, the portion available for work—engineers have hitherto been content to take indicator diagrams at certain rated loads, and then to take diagrams while running at full speed, but without any load at all. The diagram running light is assumed to give the friction, or the portion of work required to drive the engine itself without external load; and this friction diagram is generally deducted from the total indicated power to get the actual, or, as it is often called, the brake power. Now, the actual or brake power of an engine is the real measure of its efficiency, and it is accordingly most important to clearly understand its absolute amount, and the ratio it bears to the lost work, or friction. So long ago as in Professor Rankine's time, it was surmised by that distinguished man, and by other engineers of the purely theoretical stamp, that this method was incorrect, and failed to give the friction of the engine at all loads. They supposed—and with great probability, it must be admitted—that the friction of an engine would vary in some manner with variation in its load; that when running light, and having in consequence but low pressures applied to its working parts, such as the piston and crank pin, the total friction would be less than when the full available pressure applied throughout the stroke acted to thrust the crank brasses hard against the crank pin, and the crank shaft against the main brasses—in fact, applied greater pressure to all the working parts. Now, this assumption appears exceedingly reasonable and likely. Friction, however, is one of those matters which at first sight seems very simple and easily understood, but which, when closely studied, fairly bristles with unexpected anomalies.

The question of friction and its actual—not assumed—amount is a most important one to the practical engineer. He should know precisely its amount and distribution in all the machines he constructs, and especially in steam engines, whose economy largely depends on success in reducing its necessary presence to the smallest possible quantity. Strange as it may seem, very few actual experiments have been made in working steam engines to determine this, partly, no doubt, from the difficulty of making such measurements, and partly from an innate belief that the subject was tolerably clearly understood.

The brake is less used by engineers than it should be, and but few steam-engine trials have been conducted in which the brake power, or real power, is compared with the gross or indicated power. The late Dr. Froude, we remember, conducted a series of such experiments upon large marine engines, and used a specially-designed water brake, which he placed on the end of the screw shaft, in place of the propeller, and meantime kept the ship in dry dock. The results were interesting, but the experiments were insufficiently numerous to arrive at definite conclusions. The Royal Agricultural Society's brake tests of engines in competition are familiar to all of us; however, they are not framed to study carefully the question of friction and its distribution, but to arrive at the consumption of fuel per brake horse power. Prof. Thurston, to whom we owe a considerable proportion of our exact knowledge on friction, has lately conducted a series of most important experiments on steam engines, in conjunction with other American engineers, and he has given the results obtained in several recently-published papers. His conclusions are most interesting, and very much at variance with those of the theoretical writers, while they completely vindicate the practice followed in the general use of the friction diagram.

The experiments were made on engines of widely-different types, and included non-condensing and condensing engines of small and relatively large dimensions. The smallest engine tested was of 6in. diameter cylinder by 12in. stroke, constructed by Prof. Sweet, and of the kind known in America as the straight-line engine. At its full rated power the friction was found to be 6 per cent of the indicated power, determined by a careful comparison between the brake and indicated power; and, running without load at full speed, the friction diagram gave exactly the power which had been previously found as the friction at full load. Under widely-varying loads it was always found that the difference between indicated and brake power was a constant one—that is, that the power consumed by the engine in driving itself was the same, whether the load was heavy or light. This was also proved to be true for a 12in. by 18in. automatic variable cut-off engine, constructed by the Lansing Engine and Iron Works Co., a 7in. by 12in. traction engine, a 21in. by 20in. condensing engine, and a compound condensing engine used to drive the dynamos of a Thomson-Houston electric-lighting installation at Lansing.

Now, it is an extraordinary fact that the friction of all these engines was constant at all loads; and why it is difficult to understand. In the compound engine we should certainly have expected to find an increased friction at full load, as compared with that at no load; but, strange as the result seems, the experiments are so numerous and consistent that we have no choice but to accept the apparently paradoxical conclusion.

Experiments were also made upon the distribution of friction within the engines, and it was found that in the small straight-line engine the main bearings absorbed 47 per cent of the total friction, the piston and piston rod 33 per cent, the crank pin 7 per cent, and the remaining 13 per cent was lost in the crosshead, valve and rod, and eccentric strap. In this case the slide valve was balanced, and only used 2·5 per cent of the total friction; but when the balancing arrangement was taken out, and the steam pressure allowed to act fully upon the back of the valve, the loss from this cause rose to 26·4 per cent of the whole—that is, the loss, from being insignificant, became most serious. With the 21in. by 20in. condensing engine, the main bearings absorbed 46 per cent of the total friction; in fact with all the engines roughly the main bearings were responsible for one-half of all the loss by friction, and the piston and piston rod together from one-fourth to one-fifth. From experiments upon the distribution of friction at varying loads, it was found that the friction of the main bearings diminished with increasing load, while the friction of piston and valves increased, the diminution in this one case just compensating for the increase in the other.

Thus in the smallest engine their co-efficient of friction was 0·10 running at speed, but without load, and with full load it became 0·06. In the first case the frictional loss was equal to one-tenth of the pressure applied, multiplied by the surface velocity of the shaft journal, while in the second case it only slightly exceeded half that amount. Compared with the friction of railway axle journals, these proportions are exceptionally high, and it is difficult to see why they should be so. The continuous and steady pressure may not be so favourable to lubrication as a varying one, and it may only be a case of insufficient lubrication; possibly better results might be obtained by pumping oil continuously into the bearings. However, be the reason what it may, the fact seems undeniable, that one half of the whole frictional resistance of an engine is due to the main bearings, and it should be the aim of engineers to discover means of reducing its amount to a more reasonable proportion. Next to the main bearings comes the loss due to the pistons and piston rods. Here it is difficult to see where improvement is possible. To us, indeed, the loss from rings and stuffing glands seems exceedingly low.

One lesson seems exceedingly clear, and that is, never use unbalanced slides, as efficient balancing reduces the possible loss from that source by nearly 90 per cent. We need hardly insist upon the importance of a minute study of the subject, as we think engineers will readily recognise it for themselves, more especially when they consider that few engines are constructed of the compound or condensing type where the friction does not exceed 12 per cent, and that to attain the highest indicated economy it is necessary to use a greater number of working parts than in common engines.

It is therefore necessary to be careful that in endeavouring to attain greater economy of fuel, as measured by the indicator, we do not overload the engine with moving parts, and lose more in friction than we gain in indicated power. It is quite possible to do this, and in our own experience we could point to many engines far too large for the work they have to perform, and purposely so proportioned in the mistaken idea that the greatest economy was to be obtained by the greatest possible expansion—by using, in fact, all the propelling power of the steam. The best examples of modern steam engines come very near indeed to their theoretically possible economy, so near that some use 14lb. weight of steam per horse power per hour where 10lb. only would be used if they were perfect.

There must always be practical losses, and it is now a question for engineers to decide as to which direction of possible improvement is the more hopeful—the increase of the thermo-dynamic efficiency of the steam, or the diminution by special devices of the present losses by friction. It is at least advisable that we should thoroughly understand where our losses are, and then we must endeavour to apply our ingenuity to effect a possible gain. Increased knowledge of the distribution of friction is therefore most desirable, and we hope that further researches may be conducted by engineers in this country which may result in great improvement in the existing state of our knowledge of this most important subject. The unexpected nature of the results obtained by actual test of the friction of engines, part by part, warns us against assertion without definite practical knowledge even in the most simple and apparently straightforward matters, and the lesson should be especially useful to young engineers, and encourage them to get information on practical matters from the only reliable source, the machine itself.

MOTORS FOR ELECTRIC LIGHTING.

The council of the Society of Arts have issued a list of their awards in connection with competitive tests made under their supervision on motors suitable for electric lighting. They have awarded four of the Society of Arts gold medals, one in steam engines to Messrs. Davey, Paxman & Co., and in gas engines one to the "Cycle" gas engine constructed by the British Gas Engine and Engineering Co., London, one to the "Otto" gas engine, by Messrs. Crossley Bros., Manchester, and one to the "Griffin" gas engine of Messrs. Dick, Kerr and Co., London and Kilmarnock. The "Cycle" gas engine is placed first on the list of gas engines. We hope in an early issue to give a full account of the comparative tests.

THE ELSWICK WORKS.

A VISIT was paid to these works recently by the First Lord of the Admiralty, Lord George Hamilton, accompanied by Captain Fisher, R.N., the Director of Naval Ordnance, with a view of ascertaining their capabilities for the construction of guns and ammunition, and of examining some recent developments of the science of artillery attack and defence.

These works have been considerably increased, and now occupy more than 80 acres of land. They are divided into four principal departments, viz., the engine-works, ordnance, steelworks, and the Elswick shipyard.

In passing through the engine department, the visitors witnessed the casting of the upper carriage and recoil cylinder of a 4·7 quick-firing gun. The chief attraction in this department was the process of constructing disappearing gun carriages for coast defence. These were intended to carry 6in., 9·2in., and 10in. breech-loading guns, and were being made for the English Government. The pit into which the gun sinks by its recoil is covered by a circular armour shield. The sighting is accomplished by means of two mirrors, fixed on the supporting arms, so that the artillerists remained concealed and almost in complete safety.

In the ordnance department, the method of strengthening the inner cylinder of a gun by winding successive coils of flat steel wire round it was seen, and in the same shop several large guns ordered by the Government were in progress of construction. The processes of boring, turning, and rifling were shown, and one shop contained a pit in which six gun barrels could be bored vertically. An 11in. breech-loading howitzer gun was seen, which was so mounted on its carriage as to be allowed to deliver its fire almost vertically. The gun may be fired at any angle from 45 to 75 degrees. The course of the projectile is a curve, which can be calculated with great nicety. The gun being completely concealed, as within a pit, by a system of range finding, conducted by an observer at a distance, who is able to communicate with those in charge of the gun by electricity, very extraordinary results may be obtained. Recently, with a gun used in this way, where the gunners could not see the object aimed at, the target was hit seven times out of twenty, and was grazed or barely missed several times more.

A neighbouring shop contained a naval turret, and also the mountings for two 120-ton breech-loading guns intended for Spezia Harbour. Two barbette platforms were shown, on each of which will be mounted two 68-ton breech-loading guns for the Italian armour-clad Re Umberto.

The next object of special interest was an improved Gatling gun. This gun will fire 104 cartridges in two seconds and a half, the projectiles following each other in a stream at a distance of 30ft. apart.

A large shop is set apart for the manufacture of all kinds of projectiles, and among them were some steel shells of the "Shrapnel" description for the 110-ton gun. Each of these contained 2,350 iron bullets, weighing 4oz. each, and a bursting charge of 8lb. of powder.

A 40-ton steam hammer was shown at work, and then the operation of hardening the lining of the barrel of a 68-ton gun. This is done by taking the glowing barrel from a furnace, raising it by a crane, and then lowering it into a well containing 100 tons of rape oil, in which it is left to cool. This is the largest tempering well in England.

The next shop visited contained some quick-firing guns, which were finished. Amongst these was the Armstrong gun, which was specially designed for defence against torpedo boats. The gun itself is entirely of steel, 40 calibres in length. The instant the gun is fired the men in charge swing open the breech, extract the cartridge, push in the new charge, and close the block. If the gunner pulls the trigger before all is ready, nothing happens, but the instant the block is closed, the action will fire the gun. The rapidity attainable is so great, that the gun has actually fired 10 rounds in 40 seconds, and in firing 5 rounds in 30½ seconds, every shot told upon a target six yards square, and 1,500 yards away. The projectile of the 4·7 gun weighs 45lb., and when fired with 12lb. of Chilworth smokeless powder attains a muzzle velocity of 2,350ft. per second.

Comparing the effects of the quick-firing system, we may assume that a torpedo boat is sighted at a distance of 1,500 yards by a war vessel, having a broadside armament of three service 5in. breech-loading guns, each capable of firing two rounds a minute. The torpedo boat could not hope to discharge a torpedo with much certainty at a longer range than 200 yards, and would therefore have to traverse a distance of 1,300 yards under fire before she could attack. Assuming the speed of an ordinary first-class torpedo boat to be 20 knots, the time occupied in traversing 1,300 yards would be about two minutes. Hence the war vessel, armed as supposed, would be able to discharge 12 shots at the torpedo boat before there was a chance of being herself torpedoed. But if, in place of the service guns, she was armed with three of the new Armstrong 4·7 quick-firing guns, she could in the same time fire 72 shots, each gun being capable of firing 12 shots per minute.

Between each two rounds of the 5in. service gun the torpedo boat would move 340 yards, and the aim would have to be correspondingly altered; while between the rounds of the quick-firing gun she would only move 30 yards, and only a trifling alteration would be required.

The men in charge of this gun are protected by a semi-circular shield of 1in. steel. Within this is a second transverse shield of 4in. steel, the idea being that the shells would burst upon the outer shield and that the fragments would be arrested by the inner one.

The steelworks and shipyard do not call for much remark, except for the magnitude of both undertakings. The steelworks contain five Siemens furnaces, capable of casting from 400 to 500 tons of steel per week, and one new furnace is in course of construction. There are four hydraulic forging presses, the largest with a power of 5,000 tons, capable together of turning out 320 tons of gun forgings per week. Two 1,000 I.H.P. pumping engines for forging presses are now at work, and a third is nearly completed. From these works three steel castings of 70 tons each have been turned out, and the large forging press is capable of dealing with steel forgings up to 150 tons in weight. In the Elswick shipyard there are two launching berths for the heaviest ironclads, from one of which Her Majesty's ship Victoria was launched. There are also eight slips for cruisers up to 5,000 or 6,000 tons. These are at present occupied by three cruisers and four gunboats for colonial defence and India respectively, and by another cruiser of 3,000 tons. Thus there are at present slips for building no less than ten ships simultaneously, which number could be increased if required.

A NEW ATLANTIC LINER.

IN May, 1875, the Germanic, the latest addition to the White Star Atlantic fleet, took her station on the Liverpool and New York service of the company, and, with the steamers which had preceded her, completed a fleet remarkable for uniformity in design and efficiency. As illustrating the regularity of their passages, it is worthy of note that the Britannic, twin sister to the Germanic, averaged for six voyages outwards 7 days 18 hours 26 minutes, and six voyages homewards 7 days 20 hours 56 minutes, a considerable advance as it appeared in those days upon the ten or twelve day passages, which were then the rule. In 1887, on her twenty-second voyage from Queenstown to New York, the Britannic crossed in 7 days 10 hours 53 minutes, then the fastest ever accomplished, and she excelled this in 1887, when she travelled from New York to Queenstown, on her 117th voyage, in 7 days 9 hours 40 minutes. Formerly this type of ship, with its long graceful lines, four masts, minute subdivision by water-tight compartments, saloon near the centre, forward, with revolving chairs, separate decks for the different classes of passengers, and accommodation replete with comfort for all, was *sui generis*. Now, however, it stands amongst many competitors who have equalled, and, in the matter of speed, outstripped it to an extent which has compelled Messrs. Ismay, Imrie, and Co., the managing owners of the White Star Line, to decide upon another forward movement.

Eight years ago the outlines of a new and advanced type of ship were agreed upon, and well-matured plans for twin-screw steamers were put in hand in the middle of 1887. It can scarcely be expected that an advance could be made a second time so great as that marked in 1870 with the Oceanic, whereby, as acknowledged by shipbuilders and naval architects, was inaugurated a new era of comfort, combined with enhanced safety and speed, in ocean travelling which has reached such surprising developments to-day. But through the experience gained and the improvements which have taken place in marine architecture and engineering much is hoped and expected from the Teutonic, and her sister ship the Majestic, now building in Belfast for the White Star Line by Messrs. Harland and Wolff. The first of these vessels was launched on Saturday from the Queen's Island Yard, Belfast, and her career may thus be said to have commenced, all public ceremony at the launch being dispensed with in accordance with the traditions of the White Star Line. Her sister, the Majestic, is still on the stocks, but is expected to be shortly launched and completed in time to bear her part in the work of the summer season. The length of these ships will be 582ft., constituting them the longest vessels afloat; breadth 57ft. 6in. depth 39ft. 4in., with a gross tonnage of nearly 10,000 tons. They are being built of Siemens-Martin steel, and will each be propelled by two independent sets of triple-expansion engines, constructed by Messrs. Harland and Wolff, driving twin propellers, with manganese bronze blades. In form and construction of hull they will possess all the distinctive beauty of outline and strength which characterised their predecessors, the Oceanic, Adriatic, Britannic, Germanic, &c., with the addition that, while they are so minutely subdivided by athwartship bulkheads, they are also constructed with a longitudinal bulkhead running fore and aft throughout the greater portion of their length, giving additional rigidity and strength to their structure, and greatly increasing the security of the ship in the event of collision. Though similar in hull and outline to the present White Star ships, and having two funnels only, the masting of the Teutonic and Majestic will be different. Three large taut pole-masts, entirely without yards, take the place of the familiar four masts with full equipment of square canvas, which did such good service in the earlier ships, the application of twin screws rendering the larger amount of sail power superfluous. There are, indeed, many nautical men who deem the ship provided with twin screws sufficiently secure without the addition of masts at all; but the owners of the White Star Line, whilst they are conscious of the advantage in speed which might thus be gained, prefer to retain sail power to supplement the engines, and so reduce every possible risk to a minimum.

When complete the Teutonic and Majestic will be so arranged that twelve guns can be mounted on each ship 48 hours after arrival in port, and it is believed that with their attributes of twin screws, high speed, and great strength and coal endurance, these two steamers will play an important part in realising the hope of many in times past of seeing the Royal Navy and merchant service bound together in one common scheme for the protection of our commerce and the defence of the Queen's dominions.

There is nothing particularly novel about the engines of the new steamers. They will be placed in separate compartments, divided by the longitudinal bulkhead, and on "beds" weighing something like 60 tons. The twin engines are placed pretty closely together to suit the propellers, the shafting being about 16ft. apart. The condensers are therefore on the outside of the engines. The cylinders are of cast iron, the low-pressure being 30 tons—the heaviest of the castings—and the condenser is of brass. The crank shaft is about 45 tons in weight, and the shafting, which is hollow, is 21in. in diameter. The engine columns are open in front. On the high-pressure cylinder there is one piston valve, and two each on the intermediate and low pressures. In the case of the City of New York there are four piston valves on the low-pressure cylinder, and it is only slightly greater in diameter. The following gives the diameters of the cylinders and piston strokes in inches, as well as indicated horse power:—

	H.P.	Med.	L.P.	Stroke.	I.H.P.
Umbria (one engine)	71	105	105	72	14,321
City of New York (two)...	45	71	113	60	18,000
Teutonic (two)	40	68	110	60	16,000

The remarkable feature about the boilers of the Teutonic is that they will work to a pressure of 180lb. to the square inch. This is very much greater than in any of the other Atlantic steamers. There are 16 boilers in all, placed four in each row athwartship and in eight compartments, divided by transverse and longitudinal bulkheads. Twelve of the boilers are double-ended and four single-ended. The furnaces vary from 3ft. 6in. to 3ft. in diameter. The boilers are made of plates $1\frac{3}{16}$in. thick, and the average breadth is about 5ft. 3in. In the double-ended boilers there are only six plates, and in the single-ended four plates. They will be worked under the system of forced draught invented by Mr. Jas. Howden, Glasgow. The result of the high pressure will be that there will only be consumed, according to estimate, 260 tons of coal per day, whereas the City of New York may burn, when at her maximum speed, 300 tons, and the Umbria 330 tons. The Umbria, of course, is worked with compound engines, and has more grate surface than the other vessels with triple-expansion engines. In the matter of grate surface the Teutonic will be found to have less even than the City of New York, which, with nine boilers, has 1,293 square feet; but in the matter of heating surface the new White Star boats will come very much nearer the Umbria with 38,817 square feet than the City of New York with 50,265 square feet. Indeed, the likelihood is that it will reach about 41,000 square feet in the case of the Teutonic.

INSULATION RESISTANCE OF ELECTRIC LIGHT INSTALLATIONS.

At the meeting of the Institution of Electrical Engineers held on Thursday, the 24th of January, a paper was read on "The Insulation Resistance of Electric Light Installations," by Professor A. Jamieson, F.R.S.E., M.Inst.C.E.

Speaking of the insulation resistance of land lines and submarine cables, the reader said that in the early days of telegraphy insulation resistance was not specified or tested in the manufacture of cables. A few expensive failures, however, brought this into prominent notice, and now not only were tests made during the manufacture of cables, but on the principal land lines of the British Postal Telegraph Department "daily tests" were taken.

For a line 100 miles long each insulator was expected to give a resistance of 500 megohms, whereas for a line 10 miles long 50 megohms were considered sufficient. The British Post Office standard was 200,000 ohms per mile.

The results of neglecting insulation resistance in electric lighting had been clearly shown in past times, where installations were not well insulated; the conductor had been eaten through, or a short circuit had occurred, and thus stopped the lighting for a time, and discredited not only the contractors, but the industry as a whole.

He pointed out the necessity for adopting a standard of insulation resistance, and thought that the following points would readily be admitted:—

1. That, owing to the comparatively low resistance of the conductor circuit of ordinary electric light installations on the parallel incandescent system, the minimum standard of insulation resistance does not require to be near so high per unit of length as in the case of submarine cables.

2. That it should be directly proportional to the electro-motive force of the generator, or difference of potential between the conductor and earth or between the forward and return conductors.

3. That it should be inversely proportional to the total length of insulated conductor, or to the total current, or to the number of lamps in circuit.

4. That, whatever rules or standards of insulation resistance may be adopted, they should be applied not only to all the conducting wires, but also to the dynamo, the lamps, and all the fittings, or, in other words, to the *whole* circuit.

Up to the year 1883, however, there had not been any rules published, and at that time the Admiralty officials requested that the insulation resistance of dynamos supplied to them should be tested by stroking the free end of a conducting wire over any part of the framing without showing any sparks when the machine was driven at its normal speed. This, however, was only a rough-and-ready test, and gave no indication either as to the precise locality of a fault or as to its value. The only test applied by contractors when wiring an installation was that of simply inserting a galvanometer between a battery and the leads, with the other end free. If the galvanometer showed no deflection, or a very small one, the section was passed as being all right. This method was good in its way, but only indicated a bad fault, and not the measured resistance.

In 1884 Messrs. Wm. Denny and Bros. used a small portable magneto-electric machine and sensitive bell, instead of the galvanometer and battery. If the bell rang, a fault was indicated; if it did not, then all was supposed to be right.

Professor Jamieson then went on to speak of a rule which he drew up in 1884, whilst testing the electric light wires and fittings of some ships.

This rule was used for the resistance or percentage leakage of current between the whole system of forward and return wires, and also between the dynamo armature with field magnet coils in circuit and the frame or body of the machine.

The author then quoted an example, and gave a table of insulation resistances, as required by his rule for 16 c.p. lamp circuits and dynamos. The leakage allowed by this rule in the case of 100-volt lamps, using ·64 ampere of current per lamp, was $C = \frac{E}{R} = \frac{100v}{10{,}000{,}000w} = \frac{1}{100000}$ ampere of leakage for every lamp in circuit. Each lamp, however, required ·64 ampere; therefore the leakage was $\frac{1}{64000}$ part the total current, or the percentage leakage $= \frac{1}{640} =$ ·0016 per cent. But since by the above rule the dynamo required to have the same insulation resistance as the lamp circuit, the insulation resistance of the whole circuit, including the dynamo, was half of that given by the formula and tables, and therefore the leakage was double, or $\frac{1}{32000}$ part of the total current, or $\frac{1}{320}$ per cent = ·0032 per cent.

The reader then mentioned the Phœnix Fire Office rules, established in 1888, which were based upon his own rule. There were several objections to the Phœnix rule, as it was doubtful whether it included the dynamo, as well as all the wires, fittings, and lamps.

In 1888 the Westminster Fire Office issued a set of rules in which they demanded that the insular resistance should in no case be less than 150,000,000 ohms per mile! Surely they had been blindly making extracts from a submarine cable specification. No contractor, he said, could be expected under ordinary circumstances to complete his work (including dynamos and fittings) to such a high standard.

The rules proposed by M. Picou and the Society of Telegraph Engineers and Electricians were then discussed, and the methods of carrying out the necessary tests described, and it was stated that the Wheatstone bridge test was the handiest and surest.

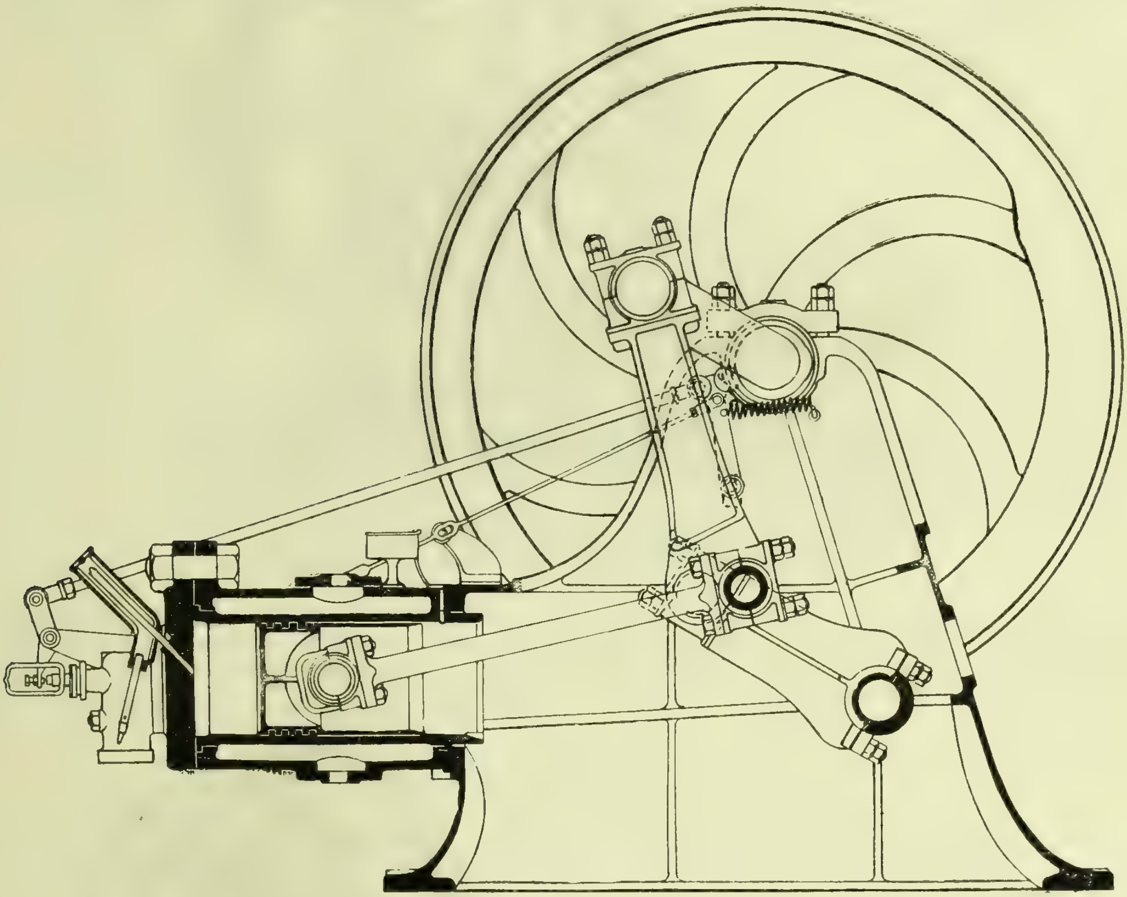


Fig. 1.

THE CYCLE GAS ENGINE.

It has long been known that better results are possible in the economical use of gas in compression gas engines, if expansion be carried further than was at first usual in the well-known Otto gas engine, and so far back as 1882 this fact was pointed out by Clerk in a paper read before the Institution of Civil Engineers in London. Many attempts have been made to carry this into practical effect, but the difficulties were great, and it is only quite recently that an engine has been constructed capable of expanding the gases to a greater volume than existed before compressing. It is very evident in an engine of the Otto type, which discharges its products of combustion at a pressure of about 40lb. per square inch above atmosphere, that if the piston could be made to move on further and reduce the pressure before opening the exhaust valve, a gain in power without an accompanying increase of gas consumption would be attained. In another part of this issue we give the results of the Society of Arts' experiments upon "Motors for Electric Lighting," and among the gas engine awards of Society of Arts gold medals, will be observed that to the cycle gas engine, which is placed first in the list of gas engines. This engine, which we illustrate on pp. 107, 108, figs. 1 to 5, is the invention of Mr. Atkinson, of the British Gas Engine and Engineering Co., London, and is manufactured by them. It is one of the first engines to succeed in expanding considerably, and in economy of gas consumption there is no doubt that it is superior to the world-renowned Otto engine, which has hitherto led in that point. The cycle engine, considered mechanically, is a most ingenious piece of mechanism, and is carried out in workmanlike manner. It is also as a heat engine an excellent conception, and one upon which its inventor is to be heartily congratulated. In two important particulars the engine differs from the well-known Otto: the crank shaft receives an impulse for every revolution instead of one for only two revolutions, and the whole of the products of combustion are expelled from the cylinder after each ignition. This is accomplished with a single piston and cylinder in a very simple manner.

Fig. 1 is a section of the engine showing cylinder, piston, crank shaft, the linkage, and connections. The action is most novel, and quite unlike anything we are accustomed to handle in steam-engine work. The piston is so connected to the crank shaft that it makes two double strokes—that is, two out and two in-strokes for every revolution of the crank pin—and it is arranged so that the first out-stroke, which commences from the bottom of the cylinder, takes in a charge of uniformly mixed gas and air. The following return stroke compresses that charge into a space at the end of the cylinder formed by the in-stroke being shorter than the out; then, while full in, the charge is fired in a compressed state, and the pressure rises to about 200lb. per square inch above atmosphere, under which the piston moves, and doing work and expanding the gases until the end of the stroke; then it returns again with the exhaust valve open, and discharges the products of combustion, this time going clear to the end of the cylinder. This completes the cycle of operations. In fig 1, the piston connects to a heavy link by one rod, and links to the crank pin by another connecting rod. The end of this rod has two pins, which if followed out give a peculiar effect. There are four positions, of which two are shown at figs. 2 and 3. In position 1 the piston is at the bottom of the cylinder just commencing to draw in the charge; in 2 the charge has entered, and the piston is about to return to compress it; in 3 (fig. 2) compression is complete, and ignition is taking place; in position 4 (fig. 3) the power stroke is just complete, and the exhaust stroke is about to be made. From an examination of the linkage our readers will have no difficulty in following the relative motions of the piston and crank pin, and they will observe that the toggle principle is used to give the double piston stroke for a single revolution. Fig. 4 is an external elevation of the engine, showing its general appearance in the 6-H.P. size. Fig. 5 is a 4-H.P. engine arranged in combination with an air-compressing pump, having Atkinson's patent easing gear for assisting when starting by hand.

The linkage allows within limits considerable change in the length of the four strokes, and upon the proportions of those strokes depends the expansion available in the engine. As constructed in this example, the working or explosion stroke is about double the length of the compression stroke, which gives a much greater range than has hitherto been used.

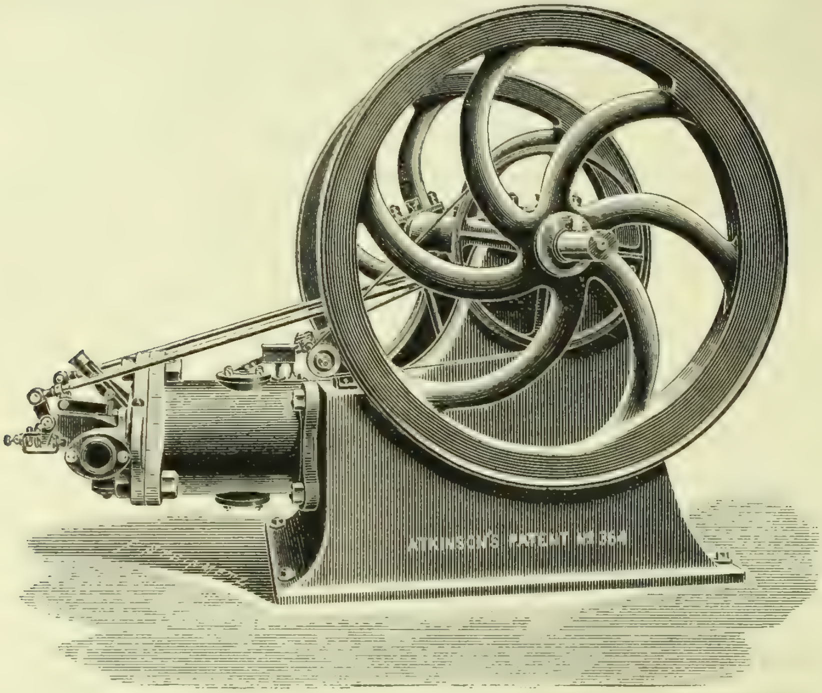


Fig.

We have before us a report by Prof. W. C. Unwin upon tests he has made on such an engine, and we observe that the exceedingly low consumption of 22·11 cubic feet per brake horse power per hour was attained, using London gas, a result, we believe, which considerably excels the economy of the well-known Otto, heretofore supposed to have been pre-eminent in this particular. Mr. Atkinson has also been kind enough to favour us with the results of a test recently made by Profs. Thurston and Barr, from which it appears that a 6-horse power nominal engine gave a brake power of 9·4 horse power, using 202·02 cubic feet of London gas per hour, or 21·49 cubic feet per brake horse power per hour, and this on an average of over two hours run.

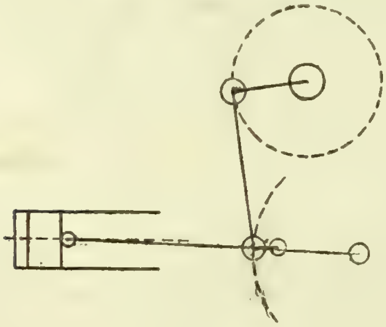


Fig. 2.

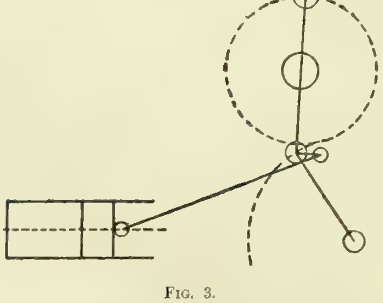


Fig. 3.

This is exceedingly economical, and utilises a very large proportion indeed of the total heat of the gas. Prof. Unwin has estimated the distribution of heat, and gives—

Accounted for by indicator diagram	20·62	per cent.
Given to jacket water	19·37	„
Lost in exhaust radiation, &c.	60·01	„
	100·00	„

This is better than the published results attained by any previous gas engine, the heat converted into work being, so far as we are aware, not more than 16 per cent in the best former experiments. We would call Mr. Atkinson's and Prof. Unwin's attention to one point, however. It appears to us that the heat given to jacket water is very considerably under-estimated, and is misleading in pointing out the loss to the sides of the cylinder from the explosion. The heat was measured by running water through the engine, estimating the weight so passed per minute, together with the difference of temperature. Now, the heat

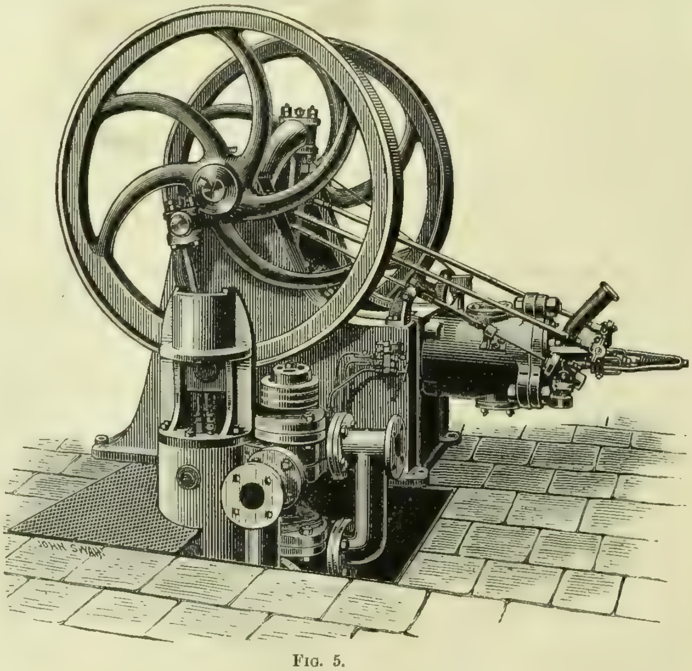


Fig. 5.

actually given to the jacket water is greater than this, as considerable heat is lost from the outer surface of the engine, which must, in the first instance, be given to that water or be conducted through the metal. A large portion of the heat lost by radiation must necessarily come from heat lost to the cylinder walls by the burning gases, and by that amount is the loss from cooling of the explosion under-estimated, and that by exhaust over-estimated. We are of opinion that this loss has been considerably under-estimated. The same remark applies to the test of Profs. Thurston and Barr, where the very small loss to water jacket is placed at 24·5 per cent of the total heat.

Our criticism does not affect the main point, which is, after all, the economy of the engine as tested by consumption per available brake horse power per hour, and on this the results are magnificent; still, it is important in distributing losses to properly apportion the quantities to the various items, otherwise, in endeavouring to improve further, energy and money may be lost in working at an erroneous source of possible gain.

These engines are now in use for many purposes, and have been made by the British Gas Engine Company in sizes up to 12-horse power nominal. Mr. Atkinson has laboured long and faithfully in this field of work, and we can conscientiously congratulate him upon the success he has now attained.

LESSONS IN MECHANICAL DRAWING.—XXVI.

By Prof. A. MacLay, B.Sc., C.E.

Miscellaneous Curves.—*Continued.*

Point Paths in Mechanism.

I have in former lessons given a considerable number of examples of (plane) geometrical loci, ranging over the more familiar curves of that kind; and along with these a smaller number of examples of mechanical loci or point paths. But I wish now to turn our attention entirely for a little to the latter class of loci, viz., to the paths described by certain points in mechanism of various kinds.

The word mechanism is no doubt familiar enough, and every student of engineering has some idea of what it means. Nevertheless, when the question is put in an off-hand way to a class, it generally gets very partial and even contradictory answers. Two such typical answers that come nearest to the mark are: (1) A mechanism is the essential moving part of a machine; (2) a mechanism is an ideal machine. But this leads to a further question, What is a machine?—one that is even more difficult to answer, and not by students only. For instance, Renleaux, in his *Theoretische Kinematik*, quotes no less than seventeen different definitions of a machine, by as many writers; and Professor Kennedy, in his translation of that work, adds some more.

We may look at machines in general from three different points of view—(1) object, (2) construction, (3) action; and when we further seek to find what is the general characteristic of all machines, under each of these three heads, the modern theory of machines gives us for answers: (1) To transform natural energy into particular kinds of work by (2) a combination of resistant bodies, whose (3) relative motions are completely constrained.

From our present point of view, viz., the *kinematic* (see Lesson XVII.), we have regard only to the two latter heads, viz., (2) the essential form of the pieces which make up the combination of resistant bodies referred to, and (3) their relative movements as determined by the arrangement of the pieces and the nature of the connections between them.

It is with the latter (3) that we are principally concerned in the exercises which follow.

We have to notice first, then, that the general characteristic of motion in machines is that the motions are all constrained, *i.e.*, that every point moves in a definite path, and cannot move in any other than the arrangement of the parts and the nature of the connection between them will admit of. That connection may be (*a*) *line contact*, *e.g.*, that between the teeth of wheels or between cams or wipers and pallets; (*b*) *surface contact*, *e.g.*, that between a piston and its cylinder or a nut on its screw. *Line* contact between the pieces is called *higher* pairing, and *surface* contact *lower* pairing. The vast majority of pieces in machines are connected in the latter way. When we look into this we naturally expect to find a great variety of ways in which moving pieces may be connected by surface contact. But it is a remarkable fact that there are only three such ways that give complete constrainment to the motion. These are:

1. The *solid and hollow prism*, constituting what is called the *prism* pair, from their form; or the *sliding* pair, from the fact that they permit only of a sliding motion, or motion of translation. Examples: A piston in its cylinder, a sliding block in its guides, a disengaging coupling on a shaft, and a lift valve in its seat.

2. The solid and hollow *revolutes* (solids of revolution), a cylindric pair or turning pair, permitting only of a turning motion or motion of rotation. Examples: The common pin and eye, a shaft axle or spindle in its journal bearings, a loose pulley on a shaft.

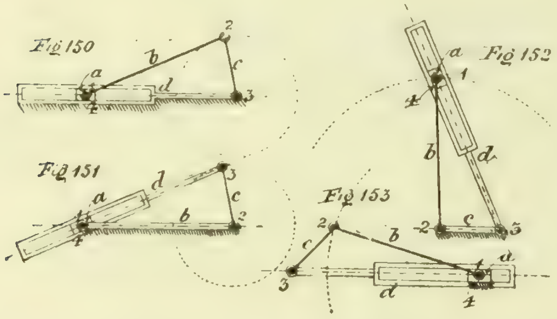
3. The common screw and nut, a twisting pair, permitting only of helical motion, *i.e.*, simultaneous sliding and turning, or, more exactly, simple translation combined with simple rotation proportional to the sliding. These constraining surfaces are called kinematic elements, and since the one is of no use without the other, as there must be a pair of them, each of its own kind, they are called kinematic pairs. They are further distinguished as the three kinematic *closed* pairs, since in their case the one working surface completely envelops or encloses the other; hence also the complete constrainment of the motion of adjacent pieces. Thus points (1) on the prism pair can only move in lines parallel to the guiding surfaces; (2) on the revolutes only in circles; (3) on the screw pair only in helices. Paths 1 and 2, as *plane* motions, fall within our present scope; paths 3, as *non-plane* motions, do not. But as the great majority of the point paths in machines are plane motions, this limitation does not restrict us much. In connection with these kinematic pairs, one other point should be noticed. The pairs can be inverted without altering the point paths, *i.e.*, it does not matter which element of a pair is carried by the fixed piece and which by the moving piece, the relative motion of the pair is not altered.

Thus, in the prism pair, the solid prism may move in the hollow one, or the hollow one may move on the solid one, but the motion is one of translation in either case, and the point paths are straight lines. Similarly representing the turning pair by a wheel or an axle, the point paths are circles if either be supposed to move relatively to the other.

Thus the paths which arise from the direct use of the lower pairs are very simple, but other paths can be obtained indirectly by lower pairing, when the pieces so connected are combined. For example, referring to fig. 103A (Lesson XIX.), we see a piece Q P^1, which has its motion determined by two turning and two sliding pairs at Q and R, give elliptic paths at P and P^1. Again, in the conicograph (of which fig. 109 is here reproduced for convenience of reference), the joints 1, 2, 4, and 6, in figs. 109 and 111, were simple turning pairs, joint 3 a turning pair superimposed on a sliding pair, and at joint 5 a sliding pair on a sliding pair, yet the path of point 5 could be made either an ellipse or an hyperbola, according to the relative position assigned to the pairs at 2, 5, and 6; and by exchanging the turning pair at 6 of fig. 111 for a sliding pair, as in fig 110, the path of 5 became a parabola.

A piece may carry a number of kinematic elements, but two are sufficient to constitute it a *kinematic link*. Thus, referring again to the conicograph, fig. 109, each of the bars, 1-2, 2-3, 3-4, 4-1, carries either a pin or an eye, *i.e.*, one of the elements of a turning pair, at each end, while bar 1-3 carries a slot as guide for sliding blocks at 5 and 3, and a forked eye at 1. In each of these cases the one element is of such a kind as to permit of the desired motion of its neighbour element, and prevent every other kind of motion. Or, referring to fig. 150 of the present lesson, bar *b* carries an eye at both ends, 1 and 2, bar *c* carries a pin at 2 and at 3, bar *d* carries an eye at 3 and a hollow prism guide at 4. Each of these bars, then, in virtue of carrying a pair of elements, forms a kinematic link. But there is a fourth link in fig. 150, viz., the block *a*, for *a*, in addition to being a solid prism suitable for movement in the prismatic slot in bar *d*, and thus forming one element of a sliding pair, carries a pin which is the complement of the eye on *b* at 1.

Now, with reference to the possible motions of the pieces, *b* can only move relatively to *a* by turning round 1, and to *c* by turning round 2, *c* relatively to *b* by turning round 2, and to *d* by turning round 3, *d* relatively to *c* by turning round 3, and to *a* by sliding on it; and lastly, *a* can only move relatively to *d* by sliding along in it, and to *d* by turning about 1. It will also be seen that the bar *d*, which in fig. 150 is the frame of the machine, and the block *a*, are just as much kinematic links as are *b* and *c*, the only parts which would be recognised as links in the common acceptation of the term. So also in the previous example, fig. 109, there is a link which is apt to be overlooked. We may suppose a bar to carry the pins which form the turning centres at 4 and 6. These centres in fig. 109 are fixed, but in carrying these two pins this supposed bar 4-6 carries two elements of the two turning pairs of 4 and 6, and is therefore as much a *kinematic link* as are any of those which actually move. It is the *fixed link* of Reuleaux, and corresponds to the *frame* of the machine of Rankine and the older writers.



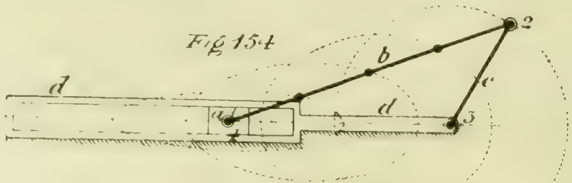
A series of links or combination of pairs of elements, such as either of the foregoing illustrations, constitutes a *kinematic chain.*

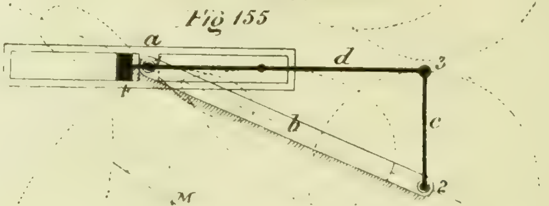
Two links joined by any particular pair of elements can, as we have just seen, have only the kind of motion permitted by that pair, *i.e.*, the motion of the one is perfectly definite relatively to the other. But if a third link be added, the motion of the third is indefinite relatively to the first, unless under a certain condition. Definite motions only occur when the links are so arranged that an alteration in the position of any one link relatively to the one next to it is accompanied by a definite alteration in the position of every other link relatively to the first. When a chain satisfies that condition, each link has only one relative motion to each other link, and the chain is then known as a *constrained closed chain.*

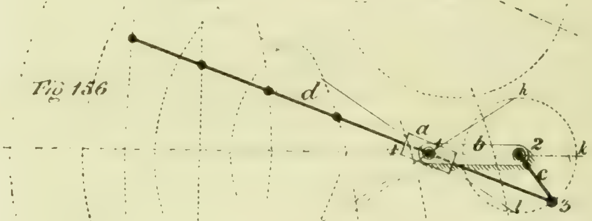
For example, referring again to fig. 109, if link 2-3 be added to links 4-1 and 1-2, it is easy to see that while each adjacent pair of links have definite motions relatively to one another, the two outer ones would have no such definite relative motion; but let them take their places as part of the closed chain formed by the whole instrument, then the motion of every link is perfectly definite relatively to every other. Lastly, let us fix one link of the chain. Then all the links move not only in a definite manner relatively to one another, but in a definite manner relatively to other objects around. The motions are now all of that completely definite and determinate kind which occur in machines. The chain could now represent a machine, so far as its motions are concerned. It is now, in that respect, *the ideal form of a machine*, or, in other words, it is now a MECHANISM.

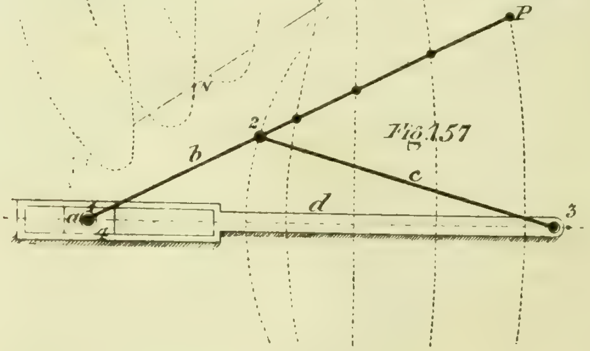
In connection with the fixing of one link, a very important principle becomes apparent, viz., that a number of mechanisms may be formed out of the one chain. Thus figs. 150 to 153 show the different mechanisms which may be formed out of the four-link chain of fig 150. Fig. 150 includes, as has been already noticed, three turning pairs and one sliding pair.

1. If we fix the link *d*, we get the mechanism of the ordinary type of steam engine. Link *d* would be the frame, consisting of bed-plate, guides, and pedestal bearing, *a* the guide block, *b* the connecting rod, and *c* the crank.









2. Suppose now that we fix the link *b* instead of the link *d*, we again get a familiar mechanism (fig. 151), for if we invert the sliding pair at 1, and make the block *a* move in the guides as it does in fig. 158, instead of the guides sliding on the block as in fig. 151, we then see the mechanism of the oscillating cylinder engine.

3. In the next place, let the crank *c* now become the fixed link, and we again get a different mechanism (fig. 152), and one which is also familiar as a means of obtaining a quick return motion in machines.

4. Lastly, if we fix the guide block *a*, we get the mechanism shown in fig 153, one which is also used, but which is not so common as the other three.

Two or three points are worthy of the student's attention here. For one thing, he will see that the idea of a fixed link is a very important one. It shows the identity of the chain in the variety of the mechanism, and by fixing in turn each link of the chain, we see that we may form as many mechanisms out of one such chain as there are links in it. Another point to be noticed is the reciprocal nature of the relationship between these pairs of elements, which permits of the inversion of the pair without alteration of the relative motion, showing identity where we otherwise see variety.

The example of a chain, which is used in the present lesson, is that known in Reuleaux's system as the *cylindric slider crank chain.* The mechanisms derived from it each consist essentially of three parallel cylindric (turning) pairs, and one prismatic (sliding) pair. The chain is very concisely represented by the formula $(C_3''P\perp)$, where C and P are the symbols for cylinder and prism respectively; the suffix 3 represents the number of cylindrical pairs of elements; the double accent above the C shows that these pairs are parallel to one another; and the symbol $\perp$ in this connection means that the axis of the prism pair is set at right angles, or normally to the axes of the cylindric pairs.

Referring again to the figs. 150—153, which show the four mechanisms derived from this four-link chain, and taking them in the same order as before, they would be distinguished from one another thus: (1) a turning slider crank $(C_3''P\perp)^d$; (2) a swinging block slider crank $(C_3''P\perp)^b$; (3) a turning block slider crank $(C_3''P\perp)^c$; and (4) a swinging slider crank $(C_3''P\perp)^a$; the names being according to the characteristic motion of each, and the letter placed outside the bracket shows on which link the chain has been placed.

Exercises.

The Slider Crank.

Ex. 178, Fig. 154.—Link *b* is a coupling rod, connecting a sliding block *a* with a turning crank *c*. The lengths are $b = 6\frac{3}{8}$in., $c = 2\frac{1}{2}$in. Find the paths of points on *b*, situated at $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ of the length of *b* from centre 1.

An example of a *turning* slider crank before referred to as the mechanism of the ordinary type of steam-engine. The piston rod and piston are kinematically simply an extension of the link *a*, and the cylinder is part of the fixed link *d*. The particular symbol for this steam-engine mechanism is $(C_3''P\perp)\frac{d}{a}$, *i.e.*, the chain is placed on link *d* and driven by link *a*. For the point paths, assume a number of positions of the crank *c*, find the relative positions of the block *a*, and draw in the centre lines representing the corresponding positions of the connecting rod *b*. Then mark off the positions of the three points whose paths are to be described. Point 1 describes a straight line, 2 a circle, and the paths of the intermediate points are elliptical, but approximate more to the straight line or the circle, according as the describing points lie nearer to 1 or 2 respectively.

Ex. 179, Fig. 155.—Link *a* represents the cylinder of an oscillating engine, *d* the piston and piston rod, *c* the crank, and *b* the frame. The dimensions are: Stroke $2\frac{1}{2}$ft., distance from centre of piston to centre of crank pin 3ft. 3in. Draw the path of (*a*) the centre of the piston, (*b*) the middle point of the piston rod. Scale $\frac{1}{6}$.

A *swinging block* slider crank, the block in this instance being the cylinder and the slider the piston and piston rod, which are kinematically one link, the one having no motion relatively to the other. The particular symbol in this instance would be $(C_3''P\perp)\frac{b}{d}$. It is the same mechanism as fig. 151 by the inversion of the sliding elements on links *a* and *d*, viz., by putting the open prism on *a* and the slide one on *d*. For the point paths, assume a number of different positions of the crank pin centre, and draw lines through them and the centre of oscillation. Measure along these lines for successive positions of the describing points.

Ex. 180, Fig. 159.—Link *d* swings about centre 1 and slides in the swinging block *a*. Link *c* is a turning crank, and link *b* is fixed. The dimensions are: Length of $d = 7\frac{1}{8}$in.; of $c = 1\frac{1}{4}$in.; distance between centres 1 and 2 = 2in. Find the paths of several points on the swinging link *d*.

The same mechanism as the last, viz., a swinging block slider crank, but the paths are those not of points situated between centres 1 and 2, but beyond centre 1. Notice that in fig. 156 the path of the second point from the outer end of the link is approximately a straight line through a considerable range of the links' motion. Compare with Ex. 171, fig. 148, Lesson XXV. If arc *hkl*, fig 156, approximates to the loop on the conchoidal curve, fig. 148, then it is evident that some point on the link *d* will describe an approximately straight line.

Ex. 181, Fig. 157.—The swinging link *b* connects the sliding block *a* with the swinging crank *c*. The dimensions are: Length of $c = 3\frac{1}{4}$in., of $b = 7\frac{1}{2}$in., of *b* between centres 1 and 2 = 3in. Find the paths of a number of points lying between centre 2 and the point P.

The same mechanism as in fig. 153, for although the chain is now placed on link *d* instead of *a*, as in that figure, the motions obtained are the same. The point paths on the prolonged part of the link *b* (fig. 160) are of the same kind as those which would be obtained on the link *c*, produced in fig. 153. This mechanism could also be derived from that of fig 157 by reversing the ratio of the links *b* and *c*, or by attaching the link *c* to some intermediate point of the link *b*. This alteration of the lengths of the links *b* and *c* now reduces the turning crank *c* to a swinging link, hence the name *swinging* slider crank.

When the lengths 1-2, 2-3, and 2-P are all equal, the link *c* again becomes a turning crank, and we get the grasshopper parallel motion of Scott Russell (see also Ex. 97, fig. 124, Lesson XXI.).

LAUNCHES AND TRIAL TRIPS.

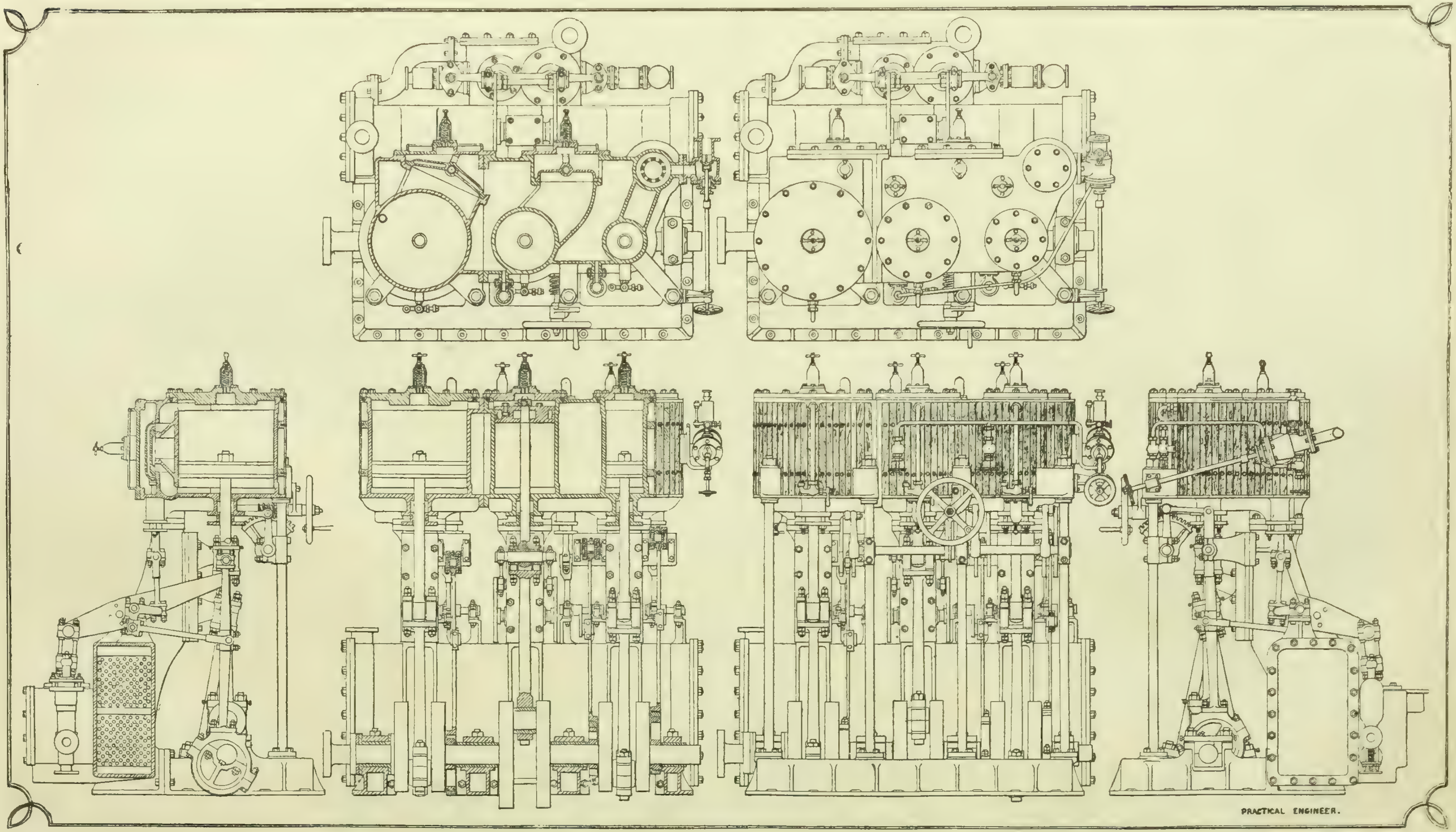
On Tuesday, the 29th ult., Messrs. Caird and Co., Greenock, launched the first of four new cargo steamers for the Peninsular and Oriental Steam Navigation Company. The new steamer was named the "Bombay," by Mrs. Hall, wife of Mr. Hall, chief officer of the Oriental. The dimensions are: Length, 350ft.; breadth, 42ft.; depth moulded, 29ft. 9in.; of 3,400 tons gross, and to carry 5,000 tons dead weight on a draught of 24ft. The Bombay is constructed generally of steel, to Lloyd's three-deck rules for the 100 A1 class. She has a straight stem and an elliptical stern, and is to be rigged as a double top-sail schooner. She is provided with a topgallant forecastle, and with a bridgehouse for the accommodation of 30 first-class passengers. Electric light is to be fitted throughout the vessel, while the steamer will also be supplied with all the latest and most approved appliances for the loading and discharging of cargo. The Bombay will be furnished by the builders with inverted direct-acting triple-expansion engines, of about 2,000 indicated horse power, and with two double-ended boilers, to sustain a working pressure of 180lb. to the square inch. The other three vessels of the same fleet being built by Messrs. Caird and Co. are the Shanghai, the Canton, and the Hong Kong, all of which are to trade between Bombay and China.

On Tuesday, 29th ult., Messrs. S. M'Knight and Co., shipbuilders, Ayr, launched from their yard an awning-deck steel screw steamer, built to the order of Mr. Joseph Wright, executor of the late Mr. John Bacon, Water Street, Liverpool, for his passenger and cattle trade between Liverpool and Wexford. Dimensions: Length, B.P., 180ft.; breadth, 27ft.; depth of hold to awning-deck, 20ft.; classed 100 A1 at Lloyd's and to Board of Trade requirements for passenger service. The engines are triple-expansion, and will be supplied by Muir and Houston, Kinning Park, Glasgow. The vessel and machinery have been constructed under the superintendence of Mr. W. C. Lang, consulting engineer, Liverpool.

On Thursday, the 31st ult., Messrs. Robert Stephenson and Co. Limited, Liverpool, launched from their shipyard at Hebburn, a finely modelled screw steamer for the Mediterranean and New York Steamship Company, of Liverpool and New York, of which Messrs. Phelps Brothers are managers. Messrs. R. Stephenson and Co. Limited have a sister vessel on the stocks for the same owners. The dimensions of the vessel are as follow: Length, 310ft.; breadth, 39ft.; and depth, 27ft. 6in. She is of the three-decked type, and has been built to take the highest class at Lloyd's. She will have a Board of Trade passenger certificate, and also an American passenger certificate. The hull is constructed entirely of steel. There is a cargo poop aft, and long bridge amidships, with commodious cabins for captain, officers, and passengers. Being intended chiefly for the fruit trade, very complete arrangements have been made for thoroughly ventilating the cargo hold, no fewer than 15 of Gibbs's patent ventilators being fitted with shafts communicating with the 'tween decks and lower holds. Five powerful steam winches are placed at the hatches; there is one of Harfield's steam windlasses on the forecastle, and Alley and Maclellan's steam stearing gear is fitted in the wheelhouse amidships. The rudder is of solid cast steel, and the anchors, which are of Hall's stockless type, are also of cast steel. She will be fitted with triple-expansion engines, of Messrs. Stephenson's make, capable of indicating about 1,400 H.P. It is expected she will obtain a high rate of speed. Both ship and engines have been surveyed during construction by Mr. George Hepburn, consulting engineer, of Liverpool, and the fitting out of the ship is being overlooked by Captain Jenkin. The vessel was named the "Pocahontas," by Mrs. Alexander Hepburn, of Grosvenor Place, Newcastle.

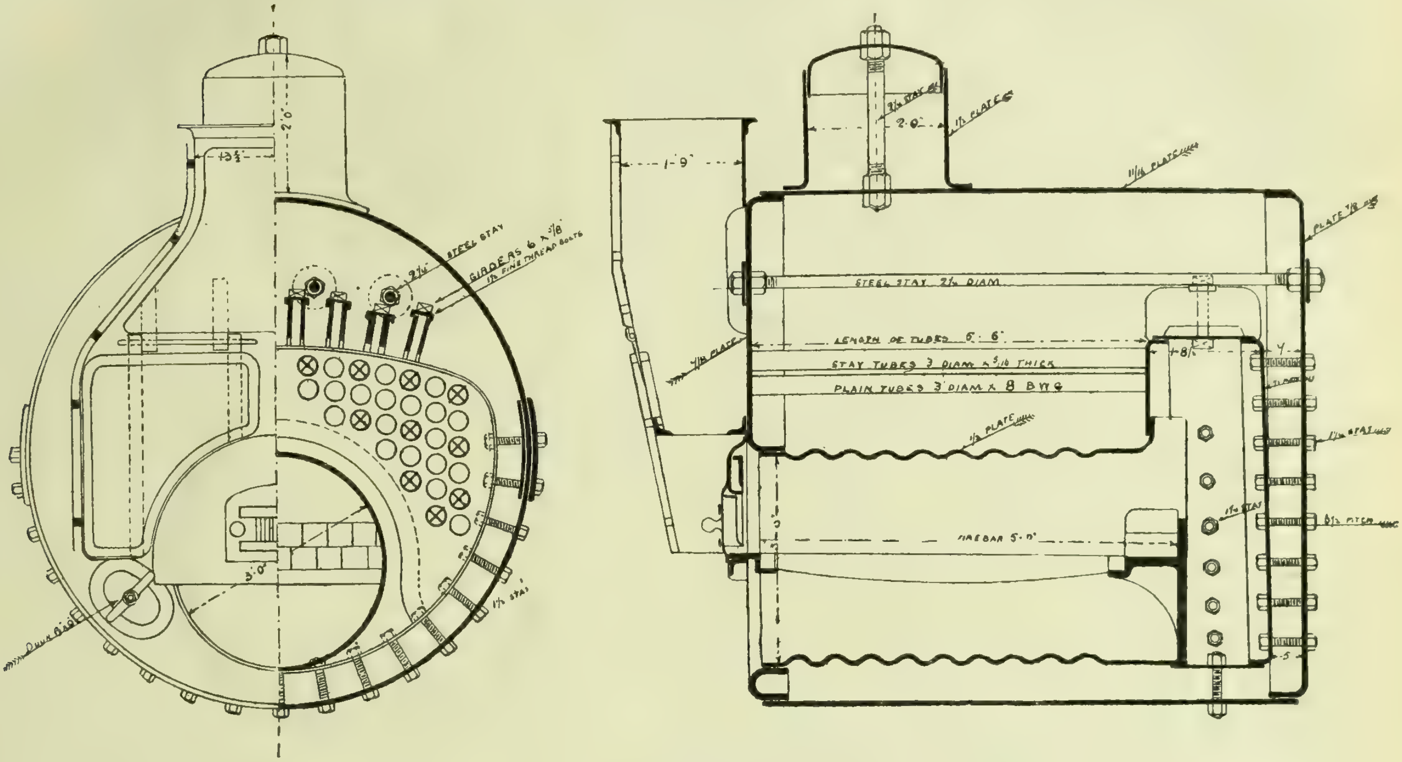
TRIPLE-EXPANSION ENGINES OF THE STEAM YACHT MALOOM.

CONSTRUCTED BY MESSRS. MUIR AND HOUSTON, ENGINEERS, GLASGOW.



BOILER OF THE STEAM YACHT MALOOM.

CONSTRUCTED BY MESSRS. MUIR AND HOUSTON, ENGINEERS, GLASGOW.



TRIPLE-EXPANSION ENGINES OF THE STEAM YACHT MALOOM.

On the adjoining page we give illustrations showing the engines of the yacht Maloom in section and detail, in full front view, end view, full plan, and sectional plan through cylinders, showing relative position of slide valves. From these details will be seen the construction of the engines and the arrangement of Hackworth valve gear for reversing with a single eccentric for each valve, by use of which a considerable saving in fore and aft space is secured. The boiler is shown on this page, and the illustration has marked upon it the principal dimensions. It is entirely of steel, is well stayed, and exceeds the requirements of Lloyd's for a working pressure of 160lb. per square inch.

The proportions of steam space, heating surface, and grate surface are such as to give good steaming and considerable economy; the mountings are specially constructed for high pressures, and, with the exception of the spring-loaded safety valves, are of brass. The main steam pipe is of solid-drawn copper, tested by hydraulic pressure to 320lb. per square inch.

On a trial trip, running at 180 revolutions per minute, the engines developed 129·37 I.H.P. with a boiler pressure of 160lb. per square inch; the pressure in the first receiver was 48lb. per square inch; in the second receiver 9lb. per square inch; and the vacuum was 25in. The power developed in the high-pressure cylinder was 34·43 I.H.P.; in the intermediate 46·68 I.H.P.; in the low pressure 48·26 I.H.P. These illustrations supplement those in last week's issue, and complete our notice of these engines.

Engineering Society, King's College, London.—At a general meeting of this society, held on Tuesday, February 5th, Mr. Virgoe read a paper on "Geology as Applied to Engineering." The author first dwelt on the advantages of a knowledge of geology to engineers, viewing geology from two aspects—stratigraphically and economically. He then considered the bearing of geology on railway construction, dealing with cuttings, tunnelling, and embankments more especially, and on the construction and maintenance of roads. He then set forth the advantages of a knowledge of geology in coal mining, showing how to deal with the water that issues from the porous strata above the coal measures, and concluded with a few remarks on water supply.

THE USE OF PURE WATER IN STEAM BOILERS.

(BY AN OCCASIONAL CONTRIBUTOR.)

Feed-water usually contains a considerable quantity of solid matter in solution and suspension, the former consisting of carbonate and sulphate of lime, and salts of magnesia and the alkalies, and the latter of organic and other insoluble impurities. Something can be done to diminish the quantity of total solids by preliminary heating, filtration, and other processes, both chemical and physical, but the only absolute method of obtaining pure water is by distillation and condensation. Water so obtained is absolutely free from solids in solution. Distillation is, in fact, the only infallible means of removing solids, and thereby avoiding danger resulting from their presence in the boilers.

When any given quantity of water is evaporated, the solid matters are precipitated, and fall partly to the bottom of the boiler, whilst part adheres firmly to the heated plating, flues, and tubes nearest to the point at which they were freed by evaporation.

A boiler evaporating 1,000 gallons per hour of a fresh feed-water containing 30 grains of solids per gallon would collect upwards of 100lb. of deposit, partly scale, in twenty-four hours, and in a short time, if not periodically cleaned, be of little use as a steam-producing machine, and it would then become positively dangerous to those in its vicinity. Mr. Parker's report shows what are the results with salt feed-water. The effect of deposit on plates exposed to heat one side, and with scale between the plates and the water to be evaporated, is that in proportion to the thickness of the scale it prevents by its non-conducting properties the heat being imparted to the water, and increases the fuel necessary for steam-raising to the extent of 20 per cent for a layer of scale one-sixteenth inch thick. It is also liable, and in many cases actually does cause overheating of the plating sufficient to make it incapable of sustaining even the ordinary working pressure. The recent very expensive and serious accidents to the boilers of the Astrea, Ethelwolf, and Winstanley, in marine, and also many recent and equally alarming explosions of land boilers, afford ample proof, were this needed, of the truth of these statements, which may, however, be easily verified by reference to official documents.

Corrosion, especially internal corrosion, is of all evils the most deadly with which steam users have to contend, and this has been fully appreciated by all who have given the matter practical consideration and attention. The Board of Trade returns, and the recent and well-timed note of warning issued by Lloyd's Committee, embodying an exhaustive report by the engineer-in-chief, clearly show and explain the results both of corrosion and deposit, the latter assisting the former, when present, by hiding it and rendering detection difficult.

Internal corrosion sometimes assumes the form of general deterioration, through which the plates and the water space of the boiler become thinned more or less extensively. It also causes blotches, and the plates suffer in patches of greater or less dimensions, while the rest of the surface remains intact. Pitting is its commonest and perhaps most dangerous form. Boilers are also liable to suffer from grooving, which, though caused in the main by mechanical action, progresses much more rapidly when assisted by bad, acid, and corrosive feed-water.

Deposit, as is well known, causes great and unnecessary waste of fuel, collapses of furnaces, and even explosions--in many cases with serious loss of life. Corrosion is the more dangerous when hidden under a coating of scale, and the necessity of keeping boilers clean, whether land or marine, cannot be too strongly insisted upon; besides, it is a course which, if persisted in, will in the end yield an ample monetary return from the better fuel consumption, greater reliability, and the decrease in cost of repairs, which always seem to crop up at the most inconvenient times, not to mention contingent claims under the Employers' Liability Act, where life is lost or injury sustained.

Many lives are lost and injuries sustained through carelessness in working or supervision, which could be obviated by the use of pure feed-water, which is now certainly and economically obtainable. The chief engineer surveyor of Lloyd's Register, in the report to which we have referred, forcibly and clearly explains this to all whom it may concern, and he strongly recommends that all boilers working at a high pressure should have means of making up the loss from leaky glands, &c., by evaporation or condensation.

He adds that in working marine boilers at the present high pressures a great amount of ignorance is often displayed by the engineers to whose care they are entrusted, and he states that nearly all the cases of collapsed furnaces, leaky tubes, &c., that have come under the notice of Lloyd's officers since the introduction of the high pressures are traceable to improper treatment. To this we may certainly add one more cause, the use of bad water, forming a thick scale, which is allowed to remain. Both are due to improper treatment, and both are preventible by using pure feed-water. The day is past when boilers can be treated in an indifferent manner, and looked after and cared for in the perfunctory fashion which used to carry them through with more or less safety at a pressure of not more than 60lb. on the square inch; but with pressures of 150lb. to 175lb., there is in many directions much more than the difference appearing in the mere increase of pressure required for satisfactory performance and safe working.

SNELGROVE'S ELECTRICAL BELL.

In electric bells, as generally constructed, there exist several somewhat serious defects, the principal being an indefinite chattering stroke, instead of distinct and well-defined separate stokes; and next the need of a greater battery power than is convenient. The electric bell we illustrate on this page has been designed by Mr. Snelgrove to overcome those defects, and it is now manufactured by the well-known firm of Messrs. W. and T. Avery, of Birmingham. Its principal points of departure from the ordinary forms consist in the construction of the contact breaking and making arrangements, in the form and action of the armature attracted by the electro-magnet, as well as in the arrangement of the electro-magnet itself. Fig. 1 shows in detail the various parts, and fig. 2 gives an exterior view of the bell ready for use. Referring to fig. 1, the armature A, a long flat bar, moves upon two links, and is parallel to the electro-magnet pole pieces M during its whole travel. It thus remains even at its utmost distance comparatively near the pole pieces, so that the intensity of the forces acting on it is not seriously diminished in its extreme position, and at the same time a considerable range of stroke is given to the bell hammer H. The battery wires are coupled up to the binding screws YZ, the current passes by the pillar P and spring S and oscillating switch OS, through the electro-magnet, attracts the armature A, which continues to move towards the pole pieces until the projection seen upon it strikes the other side of the jaw of the oscillating switch. Then the contact piece in the end of the spring S presses not upon the metal part of the end of OS, but upon the insulating piece V let into it, and as this breaks the circuit, the hammer is free to fall by its own weight; but as the projection on the armature must now move to the opposite side of the jaw of OS before displacing it, there is no renewal of the attracting force until the hammer is permitted to recede its full distance from the bell, and in striking it therefore gives a series of distinct, separate, and powerful strokes, instead of the usual rapid chatter. The binding screw X is arranged to connect with the base plate and pass the current through the electro-magnet independently of the motion of the oscillating switch OS, and when the wires are coupled to it and Y

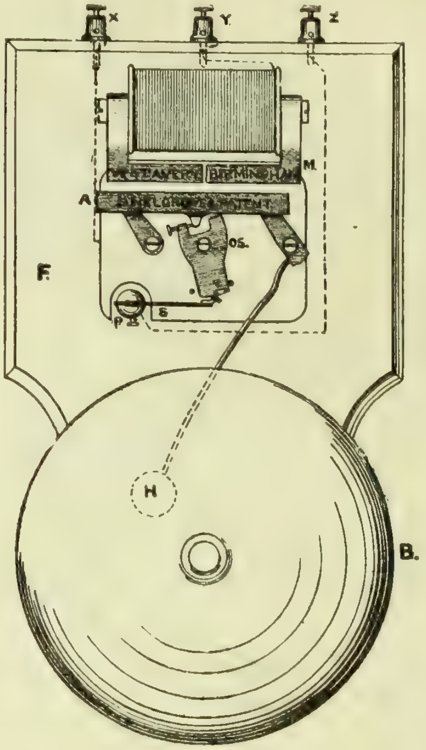


Fig. 1.

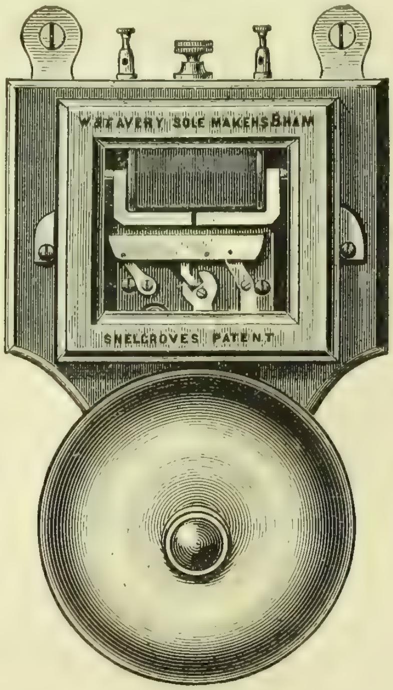

W. & T. AVERY SOLE MAKERS B'HAM
SNELGROVES PATENT

Fig. 2.

instead of Y and Z, the bell will give only one stroke to each depression of the button. It can thus be used for signalling if required. The frequency of the strokes can be adjusted within limits by a screw in the jaw end of OS, or by increasing or diminishing the battery power used. The long armature A, kept close to the pole pieces M, greatly reduces the battery power necessary for giving so powerful a stroke. The bell is very ingenious and well adapted for its work, and should, we believe, find a ready use.

SILICON IN CAST IRON.—II.

I. A Comparison of the Composition of Foreign and American Ferro-silicon.

To make this comparison we have selected from the stock of irons in our possession, and with which we are familiar, having repeatedly tested them, the following examples :—

"Govan" ferro-silicon, from a prominent Montreal firm, the analysis being published by them. (Marked *a* in Table I.)

A foreign ferro-silicon, obtained from a well-known New York broker, and analysed for our tests by Fleming. (221 in Table I.)

The ferro-silicon used by Professor Turner in making his tests, the analysis being published by him. This iron we have not ourselves tested. (Marked *b* in Table I.)

The only American ferro-silicon with silicon as high as 10 per cent that we have heard of as being made regularly is the "Pencost" brand, the producers of which kindly furnished us with all the metal that we needed for our experiments.

Nos. 403 and 401 of the table, representing American ferro-silicon, are of this iron. These irons were analysed for our tests by Mr. Orton and Professor Lord.

We add, for purposes of further comparison, four analyses of two well-known brands of Ohio softeners, namely, "Wellston" (*c* and *d*, analysed by Britton) and "Globe" (No. 178, analysed by Setterwall, and *e*, analysed by Orton).

We could add analyses of other high silicon irons, both foreign and American, that we have in our possession ; but for the present purpose these will suffice. The following table gives the analyses referred to.

Table I.

	No. of Test.	Kind of Iron.	Silicon.	Combined Carbon.	Graphitic Carbon.	Manganese.	Phosphorus.	Sulphur.
Ferro-silicons.	*a*	Foreign, "Govan"	10·55	1·84	·52	3·86	·04	·03
	221	„ (New York Broker)..	10·62	..	..	2·32	..	..
	b	„ used by Prof. Turner.	9·80	·69	1·12	1·95	·21	·04
	403	American, "Pencost"........	12·08	·06	1·52	·76	·48	tr.
	401	„ „	10·34	·07	1·92	0·52	·45	tr.
Softeners.	*c*	American, "Wellston"	6·67	..	2·57	..	·50	tr.
	d	„ „	5·06	..	..	..	·75	·05
	178	„ "Globe"..........	5·89	·30	2·85	1·00	1·10	.02
	e	„ „	6·64	..	..	..	·99	tr.

The points which attract attention in this table are :

1. The large proportion of combined carbon in the foreign irons. If this carbon remains in the combined state after the ferro-silicon is added to the foundry mixture, it will tend to harden the resultant casting. The carbon of the American ferro-silicon is in the graphitic state to begin with, and therefore such irons should be the superior softeners.

2. Manganese in the foreign irons runs much higher than in the American. It is the general belief that manganese acts more powerfully than silicon and in an opposite direction, causing carbon to assume the combined state. If this is the case, a large part of the silicon in the foreign irons would be needed to neutralise the effect of their contained manganese, leaving much less silicon to exert a softening influence upon the combined carbon of the hard iron which it is expected to soften than would be the case if the manganese were absent.

In the American silicon irons the manganese is so low that the silicon is free to act directly on the combined carbon of the iron to which it is added.

3. The foreign irons are nearly free from phosphorus, while "Pencost" contains about one-half of 1 per cent, and the other American irons which we have mentioned contain about 1 per cent.

We may remark that in most foundry mixtures phosphorus will not run below one half of 1 per cent, and therefore the effect of the phosphorus, added by the use of American ferro-silicon, will not affect the mixture. Such a small quantity of these high silicon irons is needed to produce desired results, that if they contained no phosphorus whatever this use could not reduce phosphorus in the mixture one-tenth below its former amount.

Again, perhaps a small percentage of phosphorus in foundry-iron may do more good than harm.

4. We observe the high percentage of silicon which these irons, both foreign and American, contain, as compared with the American softeners made in former years. This increase in silicon percentage has led to the name ferro-silicon.

II. Is the Silicon in the Pig Retained in the Iron when Re-melted ?

The high silicon irons are made in a furnace at a very high temperature, and it has been asserted that when re-melted in the foundry, at a much lower temperature, the iron will drop much of its silicon, which will be carried off in the slag.

The introduction of these high silicon irons has led to a discussion as to the relative value of softeners, with high or low silicon, and also as to the relative economy in the use of a 10 per cent metal, as compared with an iron in which the silicon reaches only half that percentage. We wish it distinctly understood that we discuss in this paper, not the question whether the silicon is oxidised by the blast of the foundry cupola or not, or how much may be lost in that way, but simply whether re-melting at a lower temperature will release a portion of the silicon, and if so, in which iron—that is, high or low silicon iron—the loss is the less. We have made a number of tests to arrive at the truth.

We secured seven pigs of "Pencost" ferro-silicon, containing silicon ranging from 4½ to 12 per cent. These pigs (except the first one) were made at the same furnace and from the same stock, and under the same general conditions, which would insure a similar composition in each, except as to the silicon, and the change in carbon which the variation in silicon would produce.

Sets of test-bars were made from each of these pigs and tested by "Keep's Tests," the crucible temperature being about the same as that of the foundry cupola. These test-bars were then again re-melted and a second series of bars was cast and tested. Both the first melts and the re-melts were then analysed, with the results shown in the following table :

Table II.

Silicon in Original Pig of Pencost Ferro-silicon.	No. of Tests.	Silicon in Test-bars, 1st Melt.	No. of Test.	Silicon in Test-bars, 2nd Melt.	Actual Loss of Silicon from 1st Melt.	Actual Loss of Silicon from 2nd Melt.	Percentage Loss from 1st Melt.	Percentage Loss from 2nd Melt.
4·36	397	4·35	405	4·25	·01	·11	·22	2·52
6·76	398	6·75	406	6·57	·01	·18	·14	2·66
8·09	399	8·07	407	7·99	·02	·08	·24	·99
9·42	400	9·27	408	9·31	·15	gain	1·59	..
10·34	401	10·29	409	10·24	·05	·05	·48	·48
11·34	402	10·83	410	10·76	·52	·07	4·58	·64
12·08	403	11·68	411	11·48	·40	·20	3·31	1·71

An examination of these results reveals that on the first melting the irons having less than 10 per cent of silicon lost on an average 0·55 per cent, while those containing 10 per cent and over lost 2·80 per cent of the silicon held in the pig.

On the second melting the losses are twice as great in the low as in the high percentages. From these observations we conclude that though the absolute loss is greater in the higher numbers, it is still so small in all cases as to be unworthy of consideration.

To further prove the question, whether irons high in silicon can hold their silicon when melted at low temperature, a series of pigs, from an Ohio furnace now out of blast, were tested, and the pigs and bars analysed. These pigs were all made from the same mixture of ores, and represent all the grades of iron made at the furnace. The results appear in the following table :

TABLE III.

No. of Test.	Grade of Iron.	Silicon in OriginalPig.	Silicon in 1st. Melt.	Loss of Silicon.
35	Silvery flaky..................	6·99	6·92	·07
34	" "	6·86	6·80	·06
33	" "	6·82	6·75	·07
36	" (open)	5·66	5·63	·03
39	A. 1 Foundry	5·15	5·20	+ ·05
37	B. 1 (Hot)	4·66	..	..
38	B. 1 (Cold)....................	4·05	4·00	·05
40	No. 2 Foundry	3·64	3·44	·20
41	No. 1 Mill	3·57	3·59	+ ·02
42	White	1·97	1·98	+ ·01

These tests show great uniformity in the losses of silicon, which are in all cases trifling.

A careful study of these two series of tests of Ohio silicon irons, the silicon ranging from 2 to 7 per cent in the ordinary softeners, and from 5 to 12 per cent in the "Pencost" ferro-silicons, or, taking both tables together, from the white iron, made so by low silicon, to the whitish iron produced by an excess of silicon, leads us to conclude—

1. That silicon pig iron loses practically none of its silicon in re-melting, through being melted at a lower temperature.

2. That there is practically the same actual (not proportional) loss from irons, with comparatively low silicon, as with high, and therefore one is as economical as the ether, so far as the silicon is concerned.

Before leaving the question of loss in silicon, due to the lower temperature in re-melting, let us compare the losses in foreign with the losses in American ferro-silicons. In the following table we exhibit the determinations of silicon in a 16 per cent ferro-silicon (396), imported by a prominent New York broker; a 12 per cent metal (213), imported by the same firm; and a 10 per cent metal (214), imported by a Montreal broker.

These samples are sufficent to represent foreign irons, and we introduce Nos. 403 and 401, as representing American ferro-silicons.

TABLE IV.

Number of Test.	Kind of Iron.	Silicon in Original Pig.	Silicon in First Melt.	Silicon in Second Melt.	Percentage loss in First Melt.	Percentage loss in Second Melt.
396	Foreign (New York Broker)	16·32	14·47	..	11·33	..
213	,, ,, ,, ...	11·99	10 84	..	9·60	..
214	,, "Govan"	9·85	9·81	..	·40	..
403	American, "Pencost"..............	12·08	11·68	11·48	3·31	1·71
401	,, ,, ...	10·34	10·29	10·24	·48	·48

These results show distinctly that these foreign irons lose in re-melting more than the American irons with which they are compared. We will not endeavour to account for this in the present paper.

ARMOUR-PLATE EXPERIMENTS.—Experiments have been concluded on board the Nettle, at Portsmouth, with the view of determining the respective merits of compound armour and of solid steel armour as a protection for battleships. The 10in. plates were attacked by steel and Palliser projectiles, at a range of 30ft., and although two of eight solid steel armour-plates underwent the critical ordeal with satisfactory results, the superiority remained with the steel-faced armour now adopted in the Navy.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STEAM ENGINE EFFICIENCY.

To the Editor of "The Practical Engineer."

SIR,—Referring to "L. C. D.'s" lap in slide valve in low-pressure cylinder, I should advise him to have 1⅜in. on each end. The cut-off would then take place at four-tenths of the stroke (if valve has ¼in. of lead), and give an opening to steam port of 1in.; also exhaust ⅝in. inside lap added to front end, back nil. The exhaust will commence to open at one and a half tenths, and close at two and a half tenths of stroke. His present cut-off takes place at seven-tenths of the stroke; therefore the steam is not expanded to its lowest economical point. There are many opinions on the subject of the cut-off, both in high-pressure and low-pressure cylinders respectively. However, if I were working out proportions for a compound tandem engine, I should arrange the low-pressure cylinder to cut-off at four-tenths, the high-pressure cylinder according to circumstances of pressure and load. I enclose a few tracings of diagrams for insertion, taken from a compound tandem engine with slide valves to both cylinders, after additional lap of 1in. to each end of the valves in low-pressure cylinder. To show "L. C. D." and "W. A." that there is something to be gained in carrying a reasonable amount of steam lap upon low-pressure cylinder valves of a compound engine, I can put "L. C. D." in communication with the firm who have the engine, if desirable. The diagrams on fig. 1 were taken before altering valves, and fig. 2 after an additional lap of 1in. The alteration produced a great improvement in the running and power of the engine. The ratio of cylinder I should recommend for "L. C. D.'s" load, viz., 132 I.H.P., would be 4·35 for the 100lb. pressure; dimensions of cylinders, 11in. and 23in. respectively, cut-off to take place at one-third to four-tenths in high-pressure cylinder, the low-pressure cylinder about four-tenths—eleven to twelve expansions. I may say that "L. C. D." is working under great disadvantages without an economiser. If he put down a good economiser, it would save about 84 cwt. of coal per 57 hours out of 23 tons 10 cwt. 1 qr. I presume he uses that in 57 hours. "W. A." says that there is nothing to be gained by equalisation of the work in each cylinder. If he examines the above diagrams, he

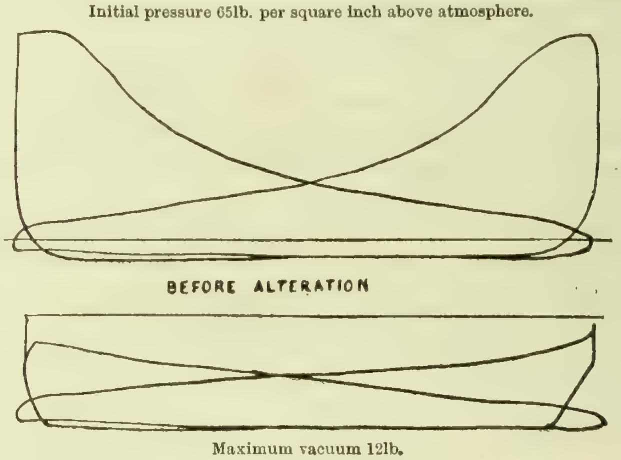


FIG. 1.

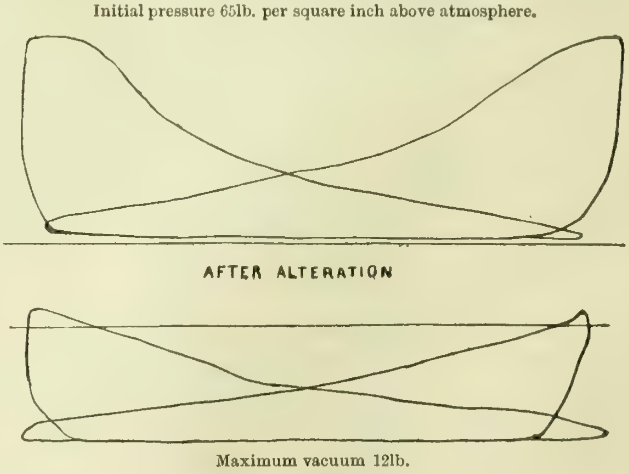


FIG. 2.

will find there is something to be gained. Wherever "W. A." shows me indications from high-pressure cylinder of a compound engine proving that the expansion line gets below the atmospheric line, I guarantee to economise steam and give a more equal temperature throughout the stroke by altering.—Yours, &c., R. BRAMALL.

Bradford.

To the Editor of "The Practical Engineer."

SIR,—In reply to "Bolton," I beg to say that I never made such a broad and unconditional assertion as to the impossibility of equalising the work done by two cylinders of a compound engine as attributed to me by him in his letter on steam efficiency in your last week's issue; the conditions referred to by me, as preventing such a consummation in the case of "L. C. D.'s" engine, being the high pressure of the steam and high grade of expansion adopted in the high-pressure cylinder of that engine, in which much more than half the total available pressure of the steam is expended; so that under the above conditions no like or equal quantity of work can be got out of it in a second cylinder.

I may also state that, after all the prescriptions tendered to bring about economy and efficiency, it has not yet been shown or proved that the engine alone is consuming 3lb. or even 2lb. of coal per hour per horse power developed. The diagrams indeed point to a high degree of economical efficiency of the steam in the engine; and perhaps it is futile to attempt to cure a disorder which has not been shown to exist.
Yours, &c., W. A.

To the Editor of "The Practical Engineer."

SIR,—In your issue of the 8th inst., you published an excellent letter by A. Evans, the first paragraph of which is well worth reading and thinking over by all men in charge of steam engines and boilers. In the latter part of his letter, A. Evans advises me to reduce the load on safety valve. Will he kindly say to what extent? and I should also be glad if A. Evans, or some other correspondent, would explain in detail wherein the gain would be, if any, from lapping up of low-pressure valves over and above what would be gained from reducing the condensation taking place between high and low pressure cylinders, owing to the passages between the cylinders being kept at a higher temperature; for is it not a fact that if I get an initial pressure on low-pressure piston almost equal to the back pressure on high-pressure piston, and the cylinders being in proportion as 1 : : 3·08, that that back pressure must have been retarding the movement of high-pressure piston 3·08 times longer than it can be maintained on low-pressure piston? I should like this to be explained, as there is a great difference of opinion between some of my friends and myself on this subject.

I would have tried the experiment suggested by "H. B.," in your issue of the 1st inst., had it been so simple a matter as he appears to think it would be. The low-pressure eccentric is placed between crank-shaft pedestal and high-pressure eccentric, and is not only not fastened on shaft with pinching screws and dies, but by a key, the head of which is against high-pressure eccentric sheave, and this is close against back of bevel wheel which drives governors, so that it means taking bevel wheel and high-pressure eccentric entirely off the shaft before I can get to low-pressure eccentric. This eccentric also works exhaust valves of high-pressure cylinder, and moving it forward on shaft would entail altering the length of rods to exhaust valves of high-pressure cylinder, so that I want to be sure I am moving in the right direction before I make any alteration in this part of the engine.
Yours, &c., L. C. D.

INCREASE OF PRESSURE IN COMPOUND ENGINES.

To the Editor of "The Practical Engineer."

SIR,—Referring to "J. B. B.'s" letter, page 83, he asks the question, "Are our cylinders of suitable proportion?" The ratio of cylinder is 2·45, and to indicate about 320 H.P., with 75lb. boiler pressure, the cut-off would be about ⅜in. in high-pressure cylinder. Taking the absolute initial pressure at 90lb., the terminal pressure would be 33·7lb., and the low-pressure cylinder cut-off would be six-tenths, to develop about equal powers. The receiver pressure may be found thus: We have the high-pressure cylinder full of steam at 33·7; the capacity of the low-pressure is 2·45 times that of the other, and at the point of cut-off six-tenths of 2·45 = 1·47. Now divide 33·7 by 1·47, which gives the receiver pressure as 23lb., nearly. We have next to find the mean pressure in high-pressure cylinder, 90 × ·744 = 67, nearly; subtract from 67 − 23lb. back pressure = 44lb. mean pressure high-pressure cylinder. Initial pressure for low-pressure cylinder 23lb., cut-off six-tenths, 23 × ·907 = 20·86 − 4lb.; back pressure in condenser = 16·86 × 2·45 = 41·3, a little less than high-pressure cylinder. This may be improved by a little earlier cut-off in the low-pressure cylinder. The mean of the two cylinders, in terms of high-pressure cylinder, is 42·65lb., and I invariably find that three-fourths of this gives the actual average pressure as near as possible, which in this case would be, say, 32lb. I.H.P. for both cylinders, at 45 revolutions = 326.

Now, assuming that the pressure is increased with the same boiler and grate and heating surface—if such a thing be advisable or practicable—and the same weight of water is evaporated, the relative volumes of steam at 75 and 100 is 298 to 240, or thereabouts; the cut-off would be, say, three-tenths in high-pressure cylinder, and half-stroke in low-pressure cylinder; this, worked out in the same manner as before, gives a mean pressure of 48lb. in high-pressure cylinder, and 19·68lb. in low-pressure cylinder, which × 2·49 = 48·2. Showing equal results, three-fourths of 48 = 36lb., a result in favour of the increased pressure of 4lb. mean, which would certainly give more revolutions, and indicate at least 375 H.P. The question of the proportion of cylinders is, however, still unanswered; the initial pressure on high-pressure cylinder would be over 16 tons, and in the low-pressure cylinder about 10 tons, whereas, if a cylinder of 18in. diameter was substituted for the high-pressure cylinder, and the cut-off at half-stroke in high-pressure cylinder, and six-tenths in low-pressure cylinder, a much better result would be obtained; the initial pressure would be about the same in both cylinders, the ratio of cylinders being 1 to 4, and much better working, with less severe strains.—Yours, &c., MAC.

QUERIES AND REPLIES.

11. COMPOUNDING ENGINE.—Could any reader kindly inform me of the best rule to apply for compounding a vertical engine, 12in. cylinder by 24in. stroke? The steam pressure is 60lb., and the high-pressure cylinder to cut off at five-eighths of the stroke. Is there any rule stating at what part of the stroke the low-pressure cylinder should be cut off, and how much should the area of the casing of the low-pressure cylinder be in order to act as a receiver?—C. E.

Answer.—"W. A.'s" arrangement gives cylinder ratio 1 to 4·89; he also carries the steam full stroke in low-pressure cylinder. The receiver pressure in this case would be 5lb., and more than twice the work would be thrown upon the high-pressure cylinder, whereas for 60lb. pressure, 1 to 3, or diameter low-pressure cylinder 20¾in., cutting off at five-eighths in each would give about an equal result.—MAC.

2. VARNISH FOR PAPIER-MACHE GOODS.—Would some reader kindly inform me how to make the black varnish that papier-mache goods are coated with? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished?—J. T. L.

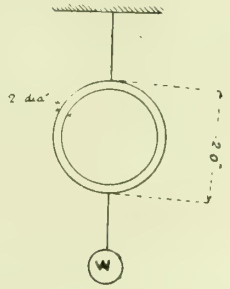
7. BLACKLEAD PENCIL MAKING MACHINERY.—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery?—B. B.

12. MOST ECONOMICAL TYPE OF ENGINE.—Will some reader kindly inform me which type of engine is best for factory purposes, as we think of replacing our present engine by one of the most improved and economical type. What dimensions should give 250 I.H.P., and which is best beam, vertical or horizontal?—T. H. P.

13. LEAKAGE IN BOILERS.—I have charge of a 7ft. 6in. Lancashire boiler, recently put down. The shell is made with two plates to a ring, longitudinal seams, butt joints, with covers on both sides. The seams in the lower part of the boiler are just above the seating blocks; the seams on the left hand of the boiler in the side flue leak at the ends of the cover strips on the outside belts of plating, there being leakage at every joint except the front end angle-irons and the flanged back end. We have had them fullered and made right twice now, and the boiler-maker says they will leak again, and he cannot tell the reason why. Every other part of the boiler is quite tight. Boiler is fed from a well, all the sediment is held in suspension, there being no scale and very little deposit. Economisers are used; we burn 30 tons per 65 hours; draught takes under bottom first splits at front and down sides; bottom flue is 3ft. 6in. by 1ft. 6in. Can any of your readers account for this leakage, which to me is most extraordinary? Feed valve is at right-hand side, with 10ft. of internal pipes.—ENGINE-MAN.

14. CONDENSATION IN RECEIVER OF COMPOUND ENGINE.—Will some reader kindly inform me what is about an average condensation to lose from one cylinder to the other? I have a pair of compound horizontal engines, side by side, cranks set at quarter centres, high pressure 18in., low pressure 28⅝in., 5ft. stroke, 34 revolutions, driving 223 horse power, cut-off in high pressure cylinder five-tenths of stroke, with 23lb. of back pressure. I only get 15lb. of steam on low-pressure cylinder. I lose 9lb. from one cylinder to the other. I have a receiver betwixt the two cylinders of the same area as the high pressure in cylinder. Is my receiver too large? What must I do to get a little more steam on low-pressure cylinder? I shall be much obliged if someone will answer me as soon as possible.—J. P., Chorley.

15. STRENGTH OF RING.—Will some reader show how to find the strength of a ring made of 2in. diameter wrought iron, and 2ft. outside diameter, which has a weight suspended from its lowest point, and is supported by a chain fixed above, as shown in sketch? I wish to see the calculation, ultimate strength, safe load, &c. How would it resist collapse if the tensions became compressive pressures? STYLEX.



TO CORRESPONDENTS.

BRADFORD.—When illustrations are sent it takes some time to prepare blocks. In sending further diagrams, do not colour them, as then the drawing requires to be re-copied before reproduction for insertion.

BRONTES.—"The Conservation of Energy," by Balfour Stewart, in the International Science Series, will give you much useful information on the subject of the distribution of energy in nature. Sir Wm. Thomson has read many valuable papers on the subject, to be found in the Philosophical Transactions of the Royal Society, now in all the public reference libraries.

MISCELLANEA.

Messrs. Palmer and Co., the Tyne iron manufacturers and shipbuilders, contemplate the establishment of a large steel foundry for turning out the heavier castings required in marine engine work and gun making.

The Electric Light at Windsor Castle.—After several trials it has at length been decided to use the electric light at Windsor Castle. The machinery at the Palace is now in working order, and a portion of the corridor will, it is understood, be illuminated by a series of incandescent lamps on the return of the Court from Osborne.

A New Carbine.—The new repeating carbine which is just now being distributed to one or two French cavalry regiments is as much praised as the Tramond-Lebel rifle. The cartridges are the same for both arms, there being scarcely any smoke on firing. The whole Republican cavalry is to be supplied with the new carbine when the Budget permits this to be done. It has a calibre of eight millimetres (about ·32in.), and its mechanism is such as to be unaffected by the shakings of the trot or gallop, and that whether the magazine be full of cartridges or empty.

London's Coal.—Last month there were sent into the Metropolitan coal district 1,248,000 tons of coal. This is one of the largest quantities so taken into that district, and it shows the vastness of the consumption of coal in London, and also the dependence of that city on the coalfields of the United Kingdom. The canals carry in some 900 tons only; the sea-borne coal is 518,000 tons; and the largest portion is borne in by five railways—the Midland, London and North-Western, Great Northern, Great Eastern, and Great Western, in the order named.

The Southwark Subway Electric Railway.—Messrs. Mather and Platt, of Manchester, have contracted to supply the City of London and Southwark Subway Company with the requisite service for working their line by electricity. There will be three carriages in each train, holding in all 100 passengers, a train to pass each station every three minutes, with a maximum speed of about 25 miles an hour. The plant consists of a permanent station of electric dynamos for generating the current, with engines of 1,000 h.p., and boilers of the best and newest type; Edison-Hopkinson dynamos and motors of a new type for the traction cars; also of complete electric lighting plant for stations, carriages, and signals.

Contracts for Armour-plated Turrets in the Meuse. The Belgian Government has just adjudicated contracts for 147 armour-plated turrets for the new ports which are being erected at Liege and Namur. The Gruson works, in Germany, have secured a contract for 93 of these turrets, while the Creusot works have received an order for eight turrets, each to contain two 12 centimetre guns; the Saint-Chamond factory is entrusted with the construction of four turrets for 15 centimetre guns, and 10 for 12 centimetre guns; and lastly, the Chatillon-Commentry works have to deliver 32 turrets, which will be armed with 12 centimetre guns. The armour plates are to be made entirely of rolled iron, to the exclusion of cast iron or steel.

Paper from Sugar-cane Fibre.—We are told that some works have been started at New Orleans for producing paper from the fibrous portion of the sugar cane, and it is likely to prove a very profitable enterprise. The bleached paper is said to be of excellent quality, and can be sold as low as about 21f. per 100 kilos. The stems of 500,000 kilos. of cane produce about 10,000 kilos. of paper, which, at the above price, leave a net profit of about 2,100f. It is, in fact, surprising that this industry has not come into existence before, considering the excessive production of sugar and the increasing consumption of paper. The mechanical and chemical treatment of the cane is very simple, since the saccharine matter tends to destroy the silicates.

The Vulcan, the new torpedo depôt ship, the keel of which was laid at Portsmouth on the 18th of June last, is being advanced at a rate of progress which promises to beat any previous record. Her total displacement is 6,620 tons, and of the weight of hull, which is estimated at 3,170 tons, no fewer than 1,508 tons have been placed on the blocks. The dockyard hands are at present fixing the cast-steel struts, which support and form a bearing and thrust for the outer lengths of the propeller shafting. Each strut weighs over six tons, and is a very massive casting. The stern post, which is of a peculiar shape, being much curved and very difficult from its special form to successfully cast, is fixed in position. It is also manufactured of cast steel, and is made in the shape of the letter U, placed on its side in order to afford space and support for a balanced rudder, with which the Vulcan is to be provided. The castings have all been made on the Clyde, and are of excellent workmanship. Although the Vulcan is 14ft. less in beam and 25ft. more in length than the Trafalgar, which was her immediate predecessor on the building slip, as much as possible of the previous launching ways will be utilised, whereby considerable expense will be saved. Satisfactory, however, as the progress of the Vulcan is, it might have been greater had the same means been provided in the Royal dockyards as are in use by private shipbuilding firms for lifting and transporting the heavy frames and other weights. In the case of the Vulcan all the heavy gear has to be raised and carried about by means of improvised wooden shears, derricks, and poles, with multitudinous adjuncts in the shape of blocks and tackle, whereas an overhead travelling crane, technically known as a "traveller," would greatly expedite the work and save both labour and time.

Bellite.—A number of interesting experiments were made on the 5th inst., in a suburb of London, with the new explosive called "bellite." In colour it resembles sulphur, and in shape it suggests a thick yellow candle. It is certainly a very powerful explosive, and at the same time it is easily controlled. Several journalists were rather doubtful at first about handling and applying fire and force to such a dangerous agent, but after the first experiment had been made they became on friendly terms with it. A lighted match was applied to it in the hand, it was crushed to powder by the blow of a pile driver, it was thrown into a portable furnace, and still the "bellite" would not explode. The only thing that "bellite" can be put into active operation by is a detonating cap, which is fired by a time fuse. When fired it emits no flame, and its force is upward and downward more than lateral. Neither does the explosive give off any noxious gases, so that for blasting purposes it is especially suitable. Mr. Carl Lamm, the inventor of this wonderful explosive, also intends to adapt it to warlike purposes.

Electric Lights and Telephones in Helsingfors.—The rapid and ever-increasing spread of electricity throughout the Grand Duchy ought to attract more attention on the part of British electric companies. In Helsingfors, Finland's beautiful and flourishing capital, we find all the principal hotels and most of the recently-constructed houses provided with the electric light, and it is projected to give up gas and use electricity for lighting the harbour, quays, &c. At Zammerfor, too, the "Birmingham of the North," the Thomson-Houston International Electric Company have lately introduced their system with great success in the manufactories and workshops of the place. It is doubtful whether there is a town in the world of corresponding size better provided with telephones than Helsingfor (population 65,000). Two rival companies have thrown lines over the house tops like so many gigantic cobwebs, and the telephones were used for the purpose of conversation by the various subscribers no less than 4,571,535 times in 1888, as against 3,141,983 in 1887.

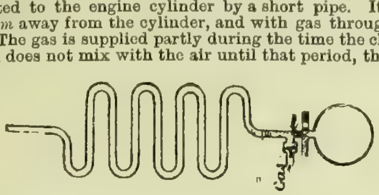
Trial of a Petroleum Steamer.—The tank steamer Darial, lately launched from the Low Walker shipyard of Sir W. H. Armstrong, Mitchell, and Co., was taken to sea on trial, her compartments being laden so as to immerse the vessel equal to her loaded conditions, in which she is capable of carrying over 4,100 tons dead weight. The vessel has been built to the highest class veritas, and the arrangements of her tanks, &c. are on Swan's patent principle, the numerous vessels already constructed of the same type having been found eminently successful. The machinery is on the triple-expansion system, by the Wallsend Slipway and Engineering Co., and the boilers are fitted with mechanical draught, which on the trial worked in the most efficient manner. The Darial is the last of three sister ships built to the order of the Kerosene Company, of London, the managers of whom (Messrs. Lane and McAndrew) were represented on the trial by Mr. McAndrew. The Darial in all respects is fitted with the latest improvements, and everything throughout the trial worked in the most perfect manner, and on return to port the vessel at once proceeded to the Commissioners' spouts to take in her bunker coal, after which she will proceed on her first voyage to Batoum.

Newspapers and Printing in India.—Some interesting statistics have been compiled by the officials of the Indian Home Department with reference to the number of presses, and the various newspapers, periodicals, and books published in India. In the year 1885-6—the year dealt with in the return—there were 1,094 presses worked in India. Of these 294 were in the North-West Provinces and Oude, 229 in Bengal, 228 in the British territory in Bombay, and 20 in the native states, 200 in Madras, 71 in the Punjab, 26 in Burmah, 16 in the central provinces, 5 in Berar, 4 in Assam, and 1 in Goorg. The number of newspapers printed in English during the same year was 127, as against 117 in the previous year, and of newspapers printed in the vernacular or bilingual 227, as against 259 in 1884-85. The Punjab is not reckoned in the calculation, as the returns do not separate the English and the vernacular papers, but give a total of 67 for both. By far the greater number of the vernacular newspapers are published in the Bombay Presidency, which supports no less than 104, the North-West Provinces and Oude coming next with 72, and Bengal next with 54. In Madras there are only 29, and in Goorg no newspaper, either in English or the vernacular, is published. The number of periodicals published in India—excluding the Punjab—was 384, of which 102 were English and 182 in the vernacular. In the Punjab there were 122 periodicals published during the year. Bombay is again at the head of the list of native periodicals with 88, while in Madras 40 English periodicals were published, and only 21 in the vernacular. The number of books published in the vernacular was much larger than in 1884-85, when it was 6,726. In 1885-86 the number was 7,990, of which Bengal contributed 2,414, Bombay 1,855, the Punjab 1,527, the North-West Provinces and Oude 1,251, and Madras 718. On the other hand, the number of books printed in English has decreased—734 as against 770 in the previous year. Of these Bengal contributed 317, Madras 154, Bombay 168, the Punjab and the North-West Provinces and Oude 39 each.

ILLUSTRATED PATENTS.

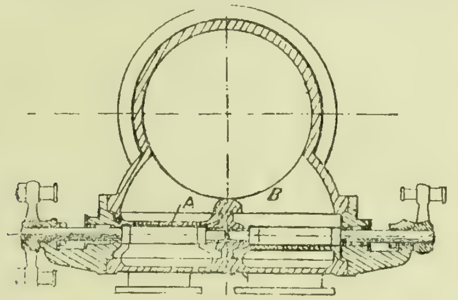
12,187. Gas Engines, C. D. Abel, 28, Southampton Buildings, London. (*The Gas Motoren Fabrik Deutz, Deutz-on-the-Rhine, Germany.*)

The improvements are in the charge reservoir and in the method of charging it. The reservoir may be in the form of a serpentine pipe as shown, or of a chamber connected to the engine cylinder by a short pipe. It is charged with air from the end *m* away from the cylinder, and with gas through a valve at the cylinder end *l*. The gas is supplied partly during the time the charge is entering the cylinder, and does not mix with the air until that period, the object being to prevent explosions. The inventi n is described in connection with an engine in which the air is compressed by the front of the piston, and the gas by a separate gas pump. The valve of the latter is controlled through "hit-and-miss" mechanism by the inertia of a weight on the slide valve. The slide valve for admitting the charge to the cylinder works on the back of that for controlling the suction and delivery of the air pump. The exhaust valve is worked by a tappet or the admission slide. A relief valve is provided.—September 8, 1887. [8½d.]



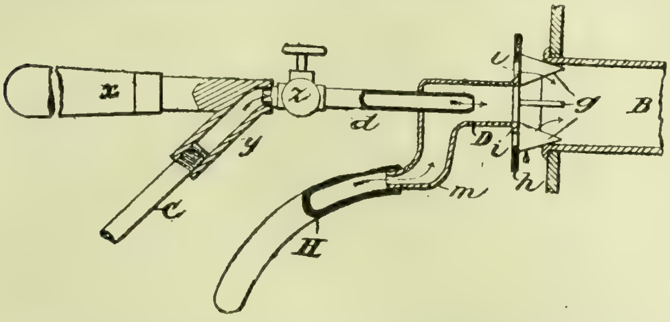
12,200. Corliss Valves for Engines, W. Musgrave, Globe Works, Bolton, Lancashire.

Relates to a special arrangement of such valves. The admission and exhaust valves are arranged at each end of the cylinder with their axes in one straight line at right angles to the axis of the cylinder. The respective valve chamber are separated by a web or partition, and the ends of the valve spindles are supported in bushes carried by this web. The figure shows a section through one pair of valves, of which A is the admission, and B the exhaust valve.—September 9, 1887. [6½d.]



12,246. Cleaning Boiler and other Tubes, H. L. Currier, 138, Broad Street, Lynn, Massachusetts, U.S.A.

A sand-blast is employed to remove the scale and other deposits from steam boiler and other tubes. A convenient form of nozzle for this purpose is shown. The steam, compressed air, or other motive fluid is supplied by a pipe *c* screwed into the branch *y*, and passes through the stop valve Z to the central nozzle *d*, which is slightly contracted at the end. This projects into the enlargement D, at the rear of which is a branch *m* connected to the sand supply pipe H. The outer end of D is flanged, and on this flange are a number or triangular guide pieces *g*, *g*, by which the apparatus is kept central with the pipe B. To the flange, but at some little distance off, is connected, by ribs, a ring *h*, which rests against the end when the appliance is employed in cleaning large tubes. Air can then enter through the slots *i*, *i* left between the connecting bars. A handle *x* is attached to the fitting, and is insulated when steam is used. A nozzle with an annular motive jet surrounded by the sand-opening is also described.—September 9, 1887. [8½d.]



12,419. Electric Railways, S. Z. De Ferranti, 120, Fellows Road, Hampstead, Middlesex.

Relates to the arrangement of low-tension conductors in sections and to charging them from high-tension mains, and to the arrangement for mounting the motors on the locomotives and to charging the field magnets of the motors from secondary currents. Means are described for regulating the speed of the motors, and an arrangement of the field magnets of the motor is shown. Fig. 1 shows diagrammatically the arrangement of conductors and means for charging them. A is the alternating high-tension dynamo, B, B the high-tension conductors, C, C the low-tension conductors in sections. D, E are two transformers; D is the main transformer which normally has its primary and secondary circuits broken at G, and E is a small transformer whose primary is always in connection with the conductors B, B. An electro-magnet F, either in the primary or secondary circuit of E, closes the switch G, and so throws into action the transformer D when a train enters the corresponding section of the conductors C, and so closes the secondary circuit of E. The switch may be operated mechanically by the train. In this case the train tilts a lever to close the circuit, and the switch is held closed by an electro-magnet as long as the secondary circuit is completed by the train. As soon as that circuit is broken the primary circuit is broken, the switch being moved by a weight or spring. To vary the speed an induction resistance is used, which is constructed like a gramme ring with a series of contacts, so that the driver may throw more or less of the coils into the circuit. Where there are several motors to the train the speed may be regulated by varying the arrangements of the connections. Or the speed may be varied by using an armature with several windings. One arrangement of the motor on the car is shown in fig. 4, in which the driving wheels C, C are mounted on short axles D, D in frames F, F. E, E are springs interposed between the body of the carriage and the frame F. G is the armature shaft of the motor, which is mounted in the frame B attached to the under side of the carriage. The shafts D are provided with cranks K, and the shaft G has two cranks H, and the pin of each crank H is linked to the pin of a crank K. By this means freedom is allowed for the vibration of the carriage. In another form the axis of the armature is made hollow and is supported on friction rollers, and the axle of the driving wheels traverses it and is connected to it by coiled springs or other suitable flexible coupling. Secondary batteries are used for exciting the field magnets and for driving the motor over a short distance whenever necessary.—September 13, 1887. [11½d.]

FIG. 1

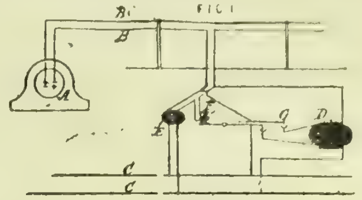
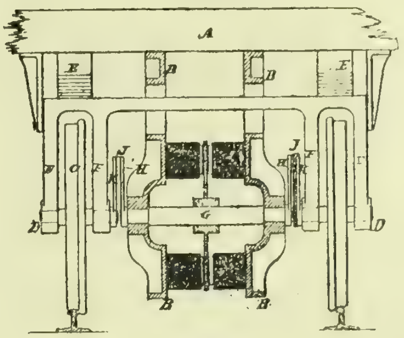
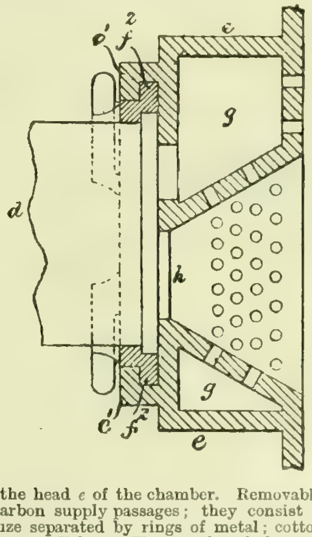


FIG. 4.



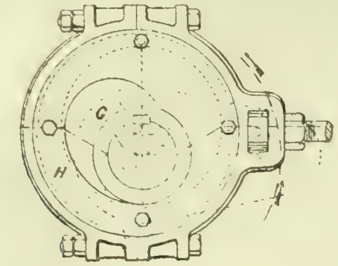
12,432. Petroleum Engine, W. D. and S. Priestman, Holderness Foundry, Hull, Yorkshire.

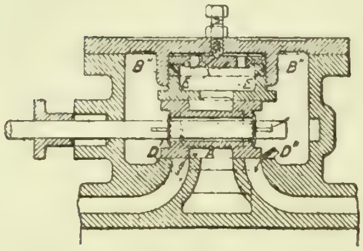
The chamber for heating the carburetted air is an improvement on that described in Specification No. 11,269, A.D. 1886, and is made of thin corrugated metal of good conductive capacity; the jacket, through which the exhaust passes, is made of the same material. The vapour enters the chamber from the vessel *d* through the conical aperture *h*, and mixes with a supplementary air charge entering through the perforations from the chamber *g*. The vessel *d* is attached by a kind of bayonet joint; projections f^2 on its flange interlocking with the lips e^1 on the head *e* of the chamber. Removable filters are placed in the air and hydro-carbon supply passages; they consist of boxes containing several layers of gauze separated by rings of metal; cotton wool, &c., may be placed between the gauze. Valves: The mouths of the ports in the plug of the valve, for admitting air and hydro-carbon to the mixing apparatus, are elongated for the better regulation of the flow of the fluids. A shield, on the cylinder cover, causes the exhaust gases to sweep over the admission valve before escaping through the exhaust valve in order to remove any deposit from the former. September 13, 1887. [8½d.]



12,465. Steam and other Fluid-pressure Engines, J. Spence, Lorne House, Dunfermline, Fifeshire.

Relates to the construction of the slide valve, balancing the same, and a compound eccentric for reversing, in engines where the reversing is effected by interchanging the functions of the steam and exhaust passages. Slide valves, balancing: The valve has a working face, back and front, and works between the port-face D^1 and a flanged ring E, fitted and packed into a socket B^{11} on the chest cover. The central cavity A of the valves communicates with the interior of the ring, whereby the valve is relieved from pressure in whichever direction the steam may be passing through the engine. Compound reversing eccentric: The principal eccentric sheave G is secured fast upon the crank shaft at 90 deg. with the crank. In the arrangement shown this is the inner sheave. Upon this he movable sheave H is mounted so as to be capable of a sufficient movement to throw the effective centre either away from or towards the crank into the positions required for taking steam through the interior, or from the exterior of





the valves. The movement is limited either by segmental stops or by curved recesses in the flanges of the movable sheave taking against the boss of the fast sheave. The specification shows several ways in which the movable sheave may be divided for putting the eccentric together.—September 14, 1887. [8½d.]

12,479. **Armoured Ships**, Sir E. J. Reed, Broadway Chambers, Westminster.

The protective deck slopes towards each end of the vessel from the platform, out of which the turret rises in the case of a turret ship, and may be horizontal, curved, or inclined transversely to meet the side armour about the water-line. A single turret vessel is shown in fig. 1, the thick line showing the protective deck and the hatching the position of the side armour. Fig. 13 shows a double turret ship, in which the turrets are arranged *en echelon*, the armour in this case being differently disposed at the two sides, as indicated by the full and dotted lines.—September 14, 1887. [8½d.]

FIG. 1

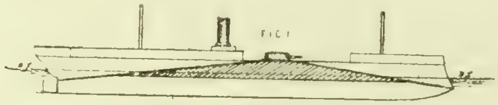
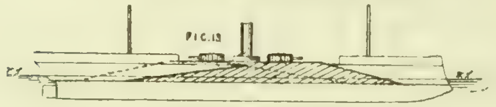
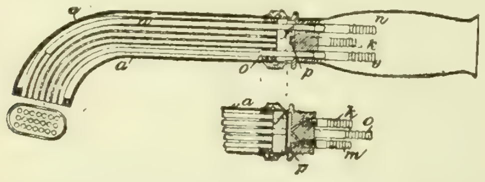


FIG. 13



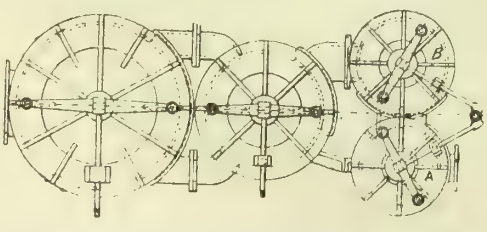
12,519. **Burner for Gases and Vapours**, J. Orchard, 100, High Street, Kensington, and H. Lane, 115, Palmerston Buildings, London.

Relates to an apparatus for burning a mixture of gases, such as oxygen and hydrogen, or of a gas and hydro-carbon vapour or spray. It may be employed for welding or brazing metals, as or in combination with a blowpipe, or for other purposes where a high temperature is required. It may also be employed for lighting. The gases or vapours are introduced into the mixing chamber *f* through the tubes *k*, *m* which lead into two passages converging towards a common opening covered by a shield *p*. The shield is provided with perforations in opposite directions, so as to give the gases a rotary motion. Other openings or slots may be formed in the shield *p*. The mixing chamber may be divided into several compartments by diaphragms fitted with shields. The mixed gases pass from the chamber *f* through a series of small metallic tubes arranged within a casing *a*, through which fluids may be circulated by the tubes *n* and *o* for the purpose of cooling or warming the mixture.—September 15, 1887. [8½d.]



12,544. **Compound Steam Engines**, W. Allan, Scotland House, Sunderland, Durham.

Consists in arranging some or all of the cylinders in pairs transversely to the crank shaft, and connecting the piston rods of each pair so arranged to one crosshead and one crank. The figure shows a plan of a quadruple-expansion marine engine, in which the high-pressure and second cylinders A and B form a pair, as above described, while the third and fourth cylinders are arranged in the ordinary manner.—September 15, 1887. [6½d.]



SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

1335 Steam Boilers, G. Tangye, Middlesex.
1340 Hot-air Engines, C. Wells, Middlesex.
1341 Electrical Indicator, C. Wells, Middlesex.
1342 Gas Engines, C. Wells, Middlesex.

January 25th.

1354 Increasing Combustion of Fuel, W. Horsfall and G. Darley, London.
1360 Regulation of Steam, A. W. Cooper, Forfarshire.
1380 Safety Lamps, J. Müller, Manchester.
1412 Injectors, W. A. Weber and J. O. Westphal, London.

January 26th.

1464 Engine Packing. T. T. Cowell, London.

1888.

19035a Ampere Gauge, Sir William Thomson, Glasgow. [Note. This application having been originally included in No. 18035, dated 11 Dec., 1888, takes under Patents Rule 23, that date.]

January 28th.

1484 Metallic Hinges, S. T. Onions, Wolverhampton.
1486 Feeding Apparatuses, G. Daverio, London.
1490 Safety Fasteners, D. Hutton and R. Sorley, Glasgow.
1507 Returning into Boilers Exhaust Steam, C. Vandercelst, France.
1508 Gas Retorts, L. H. Green, London.*
1529 Holding Drilling Tools, R. F. Ward, London.
1535 Construction of Dynamos, I. A. Timmis, London.
1536 Coiled Springs, I. A. Timmis, London.*

January 29th.

1541 Adjustable Rotary Screw Calendar, J. Goodman, London.
1544 Tube Expanders, R. W. Tayler and W. R. Tayler, Bury St. Edmunds.
1546 Worm-wheel Steering Gear, J. F. Ryan, Belfast.
1549 Valve Gears, P. R. Bjorling, Gloucester.
1551 Sighting Liquid Level, W. Brierley, Rochdale.
1552 Looms, W. Shaw, Manchester.
1554 Lubricating Furnaces, S. Banner, Newcastle-on-Tyne.
1556 Steam Engines, J. Head, Middlesbrough.
1559 Cut-off Gear, B. V. Nordberg, London.* [Date applied for under Section 103 of the Patents, &c., Act, 1883, 3 Aug., 1888, being date of Application in the United States.]
1561 Machines for Punching, Slotting, &c., J. S. Pessenger and G. Haseltine, London.
1571 Galvanising Iron and Steel, T. B. Saunders, Bradford, Yorkshire.
1572 Projectiles, A. C. MacLeod, London.
1575 Machine Bands or Belting, M. Bird and S. Wickens, jun., London.
1589 Magazine Guns, A. H. Russell, London.*
1590 Casting Steel Pipes, W. E. Koch, London.*
1593 Petroleum Engines, C. Wells, Middlesex.*
1595 Automatic Mechanical Stop Motion, R. Jex-Long, Glasgow.
1596 Rolls and Pinions, R. C. Totten, London.
1598 Drawing Metal Tubes. W. Lorenz, London.
1603 Engines Operated by Petroleum Vapours, A. E. Tavernier and L. B. Schlesigner, London.
1605 Reels, W. Garrett, London.*
1607 Spring Motors, J. Rice and J. Sugg, London.
1609 Pipe Wrenches, H. H. Lake, London. (D. R. Porter, United States.)*
1611 Multiplex Electric Telegraphy, M. W. Dewey, London.*

January 30th.

1623 Automatic Flushing Cistern, W. Chandler and C. A. Chandler, Middlesex.
1628 Destructor Furnaces, John Bradbury, London.
1634 Tool Holder, J. Clark, London.
1651 Guide Pulleys, J. Barbour, Belfast.
1653 Interlocking Apparatus, W. F. Burleigh, London.
1655 Screwing Machines, J. Maiden, T. Maiden, W. Maiden, and E. F. Cowley, London.*
1666 The Asbestos Lamp, J. B. Williams, Kent.
1671 Metallic Navigable Aerial Ship, E. Edwards, London. (J. J. Gloton France.)
1689 Screw-down Valve Taps, T. D. Gadd, London.
1691 Injectors, H. Holden and R. G. Brooke, London.

January 31st.

1695 Leather Rolling Machines, E. E. Sheldon, A. Mills, and J Masters, Birmingham.
1696 Hot-air Sizing Machines, W. Turner, W. Stancliffe, and T. Wilkinson, Preston.
1699 Machines for Cutting the Teeth of Files, A. Shardlow, Sheffield.
1707 Grooved Pulley Wheels, W. T. Thorp, Derbyshire.
1715 Cam for Cop-spinning Mules, W. Lord and W. Butterworth, Rochdale.
1723 Centrifugal Pumps, H. A. Entwistle, London.
1728 Ejectors, J. Gresham, London.
1744 Steam Boilers, R. Tatham, Manchester.
1762 Manufacture of Steel, Sir L Bell, London.
1766 Sifting Machines, H. Seck, London.*

February 1st.

1785 Automatic Air Valve Drain Tap, J. Dallas, Dundee.
1787 Steam Generators, J. Blake, Manchester.
1793 Starting and Stopping Gear, A. H. Wallis, Hampshire.
1802 Pulleys and Guides, O. Howl, Staffordshire.*
1816 Non-vibrating Wheels, A. C. Haynes, London.
1825 Galvanic Compounds, F. J. Clamer, London.*
1831 Slide Valves, W. P. Thompson, Liverpool. (P. Caillard and V. Caillard France.)
1841 Exhausting Engines, J. Lyle, Glasgow.
1847 Purifying Water, E. Harrison, London.

February 2nd.

1857 Lubricators, O. Jeyes, Birmingham.
1889 Suspended Railways, T. A. Appleing, London.
1993 Air Generators, A. J. Boult, Middlesex. (L. Bontemps and P. Boutet, —.
1902 Bearings for Shafts, S. Z. de Ferranti, London.
1910 Hydraulic Speed Governor, R. Marggraff, London.*
1912 Gas Engine, H. H. Lake, London. (O. Madsen, Denmark.)
1915 Step Bearings, C. A. Johansson, London.

Publishers' Announcements.

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Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

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Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than Tuesday Evening.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER.

FEBRUARY 22ND, 1889.

OUR ENGINEERING COMPETITORS.

OUR readers may have observed for some time past the attitude of scornful depreciation assumed by our contemporary the *Engineer* towards foreign engineering rivals, and to the methods of engineering education which have been established in other countries, and are in process of adoption in ours. In last week's issue, under the heading of "Other Mechanical Engineers," we read with some amusement a most indiscriminate laudation of our own engineering, and a correspondingly contemptuous valuation of that of our foreign rivals. It is a most unwise proceeding to underestimate the strength or ability of an opponent, and although the British are admittedly the leading engineers in the world, yet it should always be remembered that they have become so by strenuous effort and by a healthy spirit of discontent with their own performances. It would be foolish to substitute for this a complacent content which would tend to discourage further effort, and might allow our foreign rivals to equal, or even surpass us.

From our point of view this would be most undesirable, but we cannot improve our chances or make the struggle less hard by obstinately closing our eyes to facts, and denying to the engineers and inventors of other nations whatever credit may be justly due to them.

In engineering, especially mechanical engineering, other nations have profited largely by our experience, and no doubt have learned more from than they have taught to us. From Britain has originated the steam engine, with many of its improvements in principle and detail, the locomotive, the marine engine, the steam hammer, the hydraulic press, hydraulic hoisting and hydraulic tools generally, machine tools, and exact systems of mechanical standards and measurements—indeed, most of the important modern mechanical inventions; but other nations have nevertheless contributed largely to our success. Thus the Giffard injector was a French invention of beautifully simple construction and admirably ingenious principle; its success was immediate and enormous, and it would be difficult to see how we could improve upon it in principle or imagine anything more convenient for locomotive and many other purposes.

The Bourdon pressure gauge, which we see upon every steam boiler, is another French invention almost indispensable to engineers. We were very well content to use steam engines of wasteful construction and with comparatively inefficient governing mechanism until the American engineer, Corliss, taught us how to economise steam under all variations of load, by the invention of his beautiful automatic cut-off governing arrangements and valve gear. To another American engineer, Porter, we are indebted for the most common and popular form of governor in almost universal use throughout Britain. Direct-acting steam pumps, with steam driven valves, are also of American invention, and so is the duplex steam pump, a form much admired by English engineers, if we may safely judge by the number of firms who now make it. We could point out many other important improvements in steam engines and their connections and details which we owe to our foreign competitors, but we may now turn to one of the most modern branches of engineering, namely, electrical engineering, of which the dynamo machine represents the engineer's part. To our great discoverer, Faraday, is due our first knowledge of the mysterious principle which renders possible the transformation of mechanical into electrical energy, and to an Englishman, Wilde, the credit of constructing the first considerable magneto-electric machine with permanent magnets; to Mr. Varley, also English, we owe the discovery of the dynamo principle, or the method of using the residual magnetism in electro-magnets for exciting the machine at starting, and so dispensing with the use of permanent magnets. On the other hand, however, the machines best known now contain important improvements in detail, originated by the Siemens Brothers, and others by Gramme, a French engineer.

We have been accustomed to look upon the late Sir C. W. Siemens as almost English, because of his long residence and work among us, but, nevertheless, we cannot deny Germany the credit of producing such a man. In electrical engineering we are quite equalled if not surpassed by the Germans, French, and Americans; in iron and steel manufacture we are largely indebted to Siemens, as well as to our own Bessemer and Bell. If the reaping machine is of Scotch origin, the combination of reaper and binder is certainly American. To America we owe things so widely different as the sewing machine and the armour-clad turret, the telephone and the Westinghouse brake, the type-writer and the Maxim gun. In many other branches of engineering our foreign rivals have been of the greatest service to us, and have invented improvements of the most important kind. They have profited largely by our inventive ability and our success in engineering mechanism, but it would be idle to deny that we also have profited by them. Our contemporary must be strangely unfamiliar with the engineering works of England and Scotland if it fails to find frequent evidences of our indebtedness to many clever foreign engineers, as well as the results of our own strenuous effort and development.

In connection with the question of scientific training, our contemporary has surely forgotten that the greater number of our most successful inventors have been men of the highest ability and education. In many cases they had not the advantage of a formal scientific training, but this want they minimised by diligent study and practical experiment. Watt, Murdock, Bramah, Maudslay, Roberts, and Elder, representing the steam engine, gas lighting, the hydraulic press, slide rest, planing machine, and compound engine, were all highly-educated men, and were familiar with the best science of their day in their various departments. The late Sir C. W. Siemens was a leading scientific authority as well as an inventor and manufacturer. Of living eminent inventors, Nasmyth and Bessemer rank among the foremost in exact physical and chemical knowledge of their subjects. A knowledge of first principles is not a disadvantage to the practical man, but is absolutely indispensable to all mechanical engineers who aim at places in the foremost rank of their profession, whether as inventors or constructors, and to them a good education in youth in the best science of the day is invaluable. It cannot displace the education of the workshops, which is in its way as rigorous and exact as any formal education; but it can greatly help and supplement knowledge gained by direct practical work, and greatly increase the chances of success in life. Of course, education, scientific or otherwise, cannot give mechanical genius, or atone for the lack of it in engineering, but it will greatly aid genius where it exists, and it is quite as necessary to those who form the rank and file of our great industrial army. It is pleasant to feel that the great body of our young engineers are busied with the task of acquiring a knowledge of the science of their work with an earnestness and diligence never before shown in any previous time of our country's history, and knowing that, we do not fear for our future engineering supremacy. Exact knowledge makes better practical engineers and designers—not worse—and gives greater power of appreciating the manual training in the workshop, and acquiring thorough practical manipulation.

In conclusion, we regret that the *Engineer* should display so narrow and insular a contempt for foreign engineers, and be so insensible to the advantage we have derived by the adoption of their numerous and clever devices. Such a tone is calculated to bring upon us the derision of our foreign rivals, besides giving good ground for complaint of injustice at British hands.

The engineers of Britain, knowing how much good work they have done for the world at large, and how much other nations have learned from them, can surely afford to be just, and give credit where it is due. A country—the country of a race of engineers such as ours—has no need of petty argument or misstatement to feel secure in her proud position as the home of the leading engineers of the world.

TORPEDO BOATS AND BRITISH COAST DEFENCE.

Admiral Sir Edward Fanshaw, K.C.B., presided at the Royal United Service Institution, Whitehall Yard, when Mr. John Donaldson, M.Inst.C.E., of the firm of Messrs. Thornycroft and Co., the torpedo-boat builders, Chiswick, lectured on the "More Recent Improvements in Torpedo Boats." The lecture was illustrated by elaborate diagrams and pictures, showing every peculiarity of the latest vessels, external and internal.

Mr. Donaldson first alluded to the early days of torpedo boats, only a few years ago, when the ordinary steam launch was converted into a torpedo boat by being fitted with a spar torpedo. This proved a ready and, in the hands of men of enterprise and resource, a most efficient means of offence, which had done considerable service, too, in recent wars. The speed of these boats was not great. Yet, such was the panic on board the ships attacked, that the casualties were small as compared with the results attained. The tactics were those of surprise and attack, in which speed was of less importance in the attack than in the subsequent escape, and these tactics continued when the fast torpedo-boat made its advent in a vessel armed with the spar and the towing torpedo. The introduction of the Martini gun for the protection of ironclads made these vessels unapproachable, and it was considered that the days of the fast torpedo-boat were numbered. With the introduction, however, of the Whitehead torpedo the fast boat took a new departure. The fitting of the latest vessels was as remarkable as the advance in size, for the boats, which had tubulous boilers, had vast steering power, could rapidly turn and manœuvre, and carried a powerful armament of machine guns, as well as of torpedoes. Mr. Donaldson described vessels built for the Spanish and French Governments—vessels 147ft. 6in. long, with 14½ft. beam, and a displacement of 98·75 tons on a draught of only 4ft. 11in. These vessels, in all of which the torpedo armament was of two torpedo tubes in the bow, had four 3-pounder quick-firing guns, one on a turret, and one at each side. Four torpedoes were carried, and on one three tons of ammunition were carried. The guaranteed speeds were 25 knots on the measured mile, and 24 knots on a run of two hours, and all the vessels on the trial trips made over the 25 knots, going in fact to 26 knots. But one at Cherbourg did not reach the speed. The reason was found in the inexpertness of the crew, and Mr. Donaldson urged the necessity of the boats being under trained crews. The lecturer gave the results of trips round from Cherbourg to Toulon, when the French vessel, the one previously tried at Cherbourg, gave every satisfaction to the French authorities. Admiral Krantz, Minister of Marine, spoke highly of the sea-going qualities of the vessel (the Coureur), the working of her machinery, and the utilisation of fuel. He also described the Danish vessels built by his firm, and the particulars of machinery and armament, these differing from the British, French, and Spanish, in order to provide for the special needs of Denmark, where hard weather was to be expected.

These vessels were 137ft. in length, and the Danish Government had ordered new vessels of a size to enable them to be transported on the railway. The vessels built for the Indian Government, and tried in the Thames some few months ago, were, it was shown, quite equal to the conditions laid down, and in the opinion of the naval inspector were completely satisfactory for the purpose designed of port defence. As a comparatively untried weapon, he said, the torpedo boat had been the subject of much discussion. Started orignally as a coast defence armament, the torpedo boat had been studied under all sorts of conditions, from lying in harbour and being blockaded, to keeping the sea and assisting in the blockade. The result of these studies was best seen in the large numbers of these boats which now entered into the composition of all the more important navies. In our own navy coast defence by torpedo boats was not so much studied as it should be, both from the direct and the indirect advantages which might accrue from it. So long as this country was strong and able to keep its enemies away from these shores, torpedo boats would not be required to prevent the seaboard towns from being harassed by the enemies' cruisers; but it must be remembered that some of the enemy might escape from blockade, and to guard against the depredation of our ports there should be a few torpedo boats at our principal mercantile ports, as well as at the naval ports. He feared that he was right in saying that at present there was not a single torpedo boat at any purely mercantile port in this country, and the numbers in the naval ports were far too few to meet the demands which might be made upon them, should we, unhappily, be involved in war. He suggested that a distribution of torpedo boats around our coasts would be for the encouragement of our naval volunteers, in whose hands he presumed the vessels would be placed, as had been suggested by Mr. Arnold Forster. Such encouragement would give us a naval volunteer force which would be a rare reserve for the nation, better than any conscription could give us, and if the boats were placed in their hands in times of peace, the men would be thoroughly trained to their work for any emergency in case of war.

The discussion which followed was joined in by Sir Nathaniel Barnaby (who spoke in high terms of the advance which the construction of these boats had made, and the necessity of them for coast defence), Mr. Baden-Powell, Admiral Boys, and Mr. Kennedy (of the India Service), and it was generally agreed that there was an important future for these vessels in the defence of ports, towns, and estuaries. The cost of the vessels to India was stated to be about £12,000 each, and the crew from 16 to 18 men and officers. Thanks were voted to Mr. Donaldson.

THE INSTITUTION OF CIVIL ENGINEERS.

At the ordinary meeting on Tuesday, the 12th of February, the President (Sir George B. Bruce) being in the chair, a paper was read on "Some Canal, River, and other Works in France, Belgium, and Germany," by Mr. L. F. Vernon Harcourt, M.A., M.Inst.C.E.

A journey to Frankfort-on-the Main, in August, to attend the Third International Inland Navigation Congress, gave the author an opportunity of visiting several works on the Continent, which were described in the paper.

Hydraulic Canal Lifts.—The two large hydraulic canal lifts, recently erected at Fontinettes, on the Neuffossé Canal, in France, and at La Louvière, on the new Central Canal, in Belgium, were visited. They both consisted of two counterbalancing troughs resting on central hydraulic rams, 6ft. 6¾in. in diameter, and moved by an excess of water introduced into the upper trough, and by hydraulic machinery supplying water to the presses under the rams to aid the ascent. The troughs at Fontinettes were each 129ft. 7in. long, 18ft. 4½in. broad, and contained 6ft. 6¾in. depth of water, so as to be available for vessels of 250 tons. The troughs at La Louvière were 141ft. long, 19ft. wide, and held water to a depth of 10⅔ft., being designed to admit vessels of 400 tons. The total weight lifted was 785 tons at Fontinettes, and 1,037 tons at La Louvière; whilst the heights of the lifts were 43ft. and 50½ft. respectively. The lifts were designed by Messrs. Clark, Standfield, and Clark, Mr. Lyonel Clark being the resident engineer. They resembled the Anderton lift in principle (though on a considerably larger scale), except that the troughs descended into a dry pit, which rendered the counterbalance more perfect, but necessitated a pair of lift gates at the lower end of each trough, as well as at the upper end. The Fontinettes lift, opened in 1887, supplemented a flight of five locks, which had become inadequate for the large increasing traffic between the North Sea ports and Paris. The Louvière lift was the only lift hitherto constructed out of a series of four lifts designed to surmount a difference of level of 217ft. in the last five miles of the Central Canal of Belgium, in the course of construction, for connecting the waterways near Mons, and consequently of Northern France, with the waterways of Brussels, Charleroi, and Liége.

Weirs on the Meuse.—All the weirs on the Meuse below Namur were needle weirs, with the Kummer arrangement for releasing the needles, and supplemented with long overfall weirs, parallel to the stream, to adjust variations in level of the river, and to prevent the submergence of the footbridge of the needle weir by a sudden flood, before the weir-keeper could release the needles. The weirs above Namur consisted of needle weirs across the navigable pass, and shutter weirs across the shallower passes, which served, with the aid of large butterfly valves in the panels of the shutters, to regulate the discharge.

Gileppe Reservoir Dam.—This dam, completed in 1875, across a narrow gorge of the valley of the river Gileppe, retained a head of water of 147⅔ft. and formed a reservoir 197⅘ acres in area, and containing about 16 million cubic yards of water, for supplying the cloth manufactories of Verviers. It was only a few feet less high than the Furens dam, in France, and the Villar dam, in Spain, but considerably wider at the top and base than those dams. The dam was carried into the solid rock at the base and sides, and the supply conduits passed through the rock, on each side, about 250ft. beyond the ends of the dam.

River Main, between Frankfort and Mainz.—The river Main had been made accessible for the Rhine traffic up to Frankfort by the construction of five locks and weirs, raising the minimum navigable depth to 6½ft. These locks, with lifts of from 5ft. 11in. to 8ft. 10in., had an available length of 246ft., a width of 34½ft., and a depth of 8ft. 2½in. of water on their sills, to allow for a possible future deepening of the river; and vessels of 1,000 tons could get up to Frankfort. A needle weir was placed across the river, from the rock on the left bank to the timber pass on the right bank; and one portion of this weir, with its sill 10ft. 2in. below the ordinary water level above the weir, served as a navigable pass in flood-time. The timber pass, 39⅓ft. wide at the bottom, was closed by the upper paddle of a drum weir, 5ft. 7in. high. This drum weir, forming an extension of the system established on the river Marne, could be readily opened for the passage of rafts of timber, and closed against the rapid rush through the weir as soon as the raft had passed; and it also served, when required, to regulate the discharge of the river. The works were carried out by the State, at a cost of £275,000, and were completed in 1886, and no tolls were levied on the river navigation.

Port of Frankfort.—The port of Frankfort consisted formerly of quays along both banks of the Main, through the town. It was enlarged by the completion, in 1887, of a haven near the first weir below Frankfort, formed by an embankment extending into the river, parallel to the right bank, and enclosing a basin 1,840ft. long and 246ft. wide, left quite open at the lower end, to serve as a refuge for vessels against floods and floating ice. Quays surrounding the basin, and provided with sidings, together with a warehouse and sheds, on the right bank, duly equipped, furnished facilities for trade. A quay also, below the town, 1,160 yards in length, provided with sidings and other appliances, was added to the port in 1888, and devoted mainly to heavy goods. These works, together with other recent extensions of quays, cost the town about £350,000. The haven and quays, and also the sewering of the town, and the sewage-disposal works below the town, on the left bank of the Main, completed in 1886, were designed and carried out by Mr. W. H. Lindley, M.Inst.C.E. The improvement of the river, and the development of the port, had resulted in an increase of the imports to Frankfort from 11,000 tons in 1883, to 250,000 tons in 1887, and over 400,000 tons in 1888; and an increase in the exports from Frankfort of from 1,900 tons in 1885, to 7,100 tons in 1886, and 46,600 tons in 1887.

A brief description was also given of the large new terminal railway station, opened at Frankfort in August, 1888, receiving eighteen lines of way, covered with a glazed arched roof in three spans, and lighted by electric arc and glow lamps.

Rhine Ports of Gustavsburg, Mainz, and Mannheim.—An attempt was made by the railway company owning the port of Gustavsburg, at the confluence of the Rhine and the Main, to prevent the diversion of the traffic to Frankfort from the railway to the river Main, by enlarging the port and improving its facilities for traffic. New basins had been formed; the quays had been provided with ample sidings; and sheds, cranes, and other appliances had been established, to attract trade.

The port of Mainz, a little lower down than Gustavsburg, on the opposite side of the Rhine, had been improved by the extension of the river quays, the formation of a basin, surrounded by sidings and provided with warehouses, and the construction of a haven, at a total cost of £445,000. The Rhine also, a little below Mainz, was being regulated by training works, commenced in 1886, to improve the depth of the navigable channel in some shallow places.

The port of Mannheim was the southern limit of the large navigation up the Rhine, just as Frankfort was the terminus of this navigation towards the east. It was most favourably situated at the confluence of the Rhine and the Neckar, so that a large extent of very accessible water frontage was obtainable along both rivers, which had been improved by an alteration of the course of the Rhine, by cutting off a sharp bend, and forming a trained extension of the Neckar, to join the straightened channel of the Rhine. Basins and quays, in the triangular space between the two rivers and the town, increased the accommodation of the port, and, together with the old channel of the Rhine, afforded refuges for vessels from floods and ice. The quays of the basins and river banks were well supplied with sidings, warehouses, sheds, and mechanical appliances ; and the total length of wharfs and quays in the port was $4\frac{1}{3}$ miles. The traffic of the port of Mannheim had increased from 252,000 tons in 1856, to 583,000 tons in 1876, and to 1,796,000 tons in 1886 ; and the combined trade of Mannheim and Ludwigshafen, on the opposite bank, amounting to 2,433,000 tons in 1886, nearly equalled that of Ruhrort, and would soon exceed the trade of all the other Rhine ports. The rapid growth of the river traffic at Frankfort and Mannheim showed the great advantages of extending deep water communication inland, and the important position held by ports at the terminus of large navigations.

HYDRAULIC MACHINERY EMPLOYED IN THE TRANSMISSION AND CONCENTRATION OF POWER.—II.

THERE is, in general, no true economy in the employment of inferior metal in the construction of parts of machines in which great strength is required, since the loss of strength due to the inferior quality of the metal is far from compensated for by a slightly diminished first cost of the machine. In low-pressure hydraulic machines the thickness of the castings is frequently dictated by the exigencies of manufacture, and not by the working stresses to which they are subjected ; but in the case of cylinders of medium pressure, and still more so in the case of the cylinders of high-pressure machines, which are frequently worked up to their full test pressure, or say one-half their probable initial breaking load, metal of first-class quality should invariably be employed. The cast iron for such purposes should be of at least such quality that a test bar 1in. square, cast on end, will not break with a tensile load of 9 tons, and a bar 1in. by 2in., placed on edge and carried by supports 3ft. apart, should sustain 30 cwt. in the centre without fracture. The metal, when cast into the actual shapes in which it is used, will in general have a considerably lower resistance to fracture than that of the test specimens, and it will not be wise to exceed a test stress on the metal of the complete machine of say $3\frac{1}{2}$ tons per square inch. With respect to the working stress and factor of safety, as it is commonly called, we shall have something to say further on, as also as to the peculiar and dubious character of the stress sustained by thick cylinders under internal fluid pressure.

With regard to wrought iron, there is little to be remarked having special reference to hydraulic work. When used for cylinders, it must of course be thoroughly sound, and should not be designed for a higher test stress than 8 tons per square inch distributed, and if the thickness of the metal be considerable a lower stress may be advisable; a point we intend to discuss further on. For rolled Staffordshire bars of fair quality, a test stress of 10 tons per square inch is not too high, if applied in simple direct tension.

Steel is a material which has only lately come into general use for hydraulic cylinders, but the success which has rewarded the efforts of the steel founder in the production of thoroughly sound and reliable steel castings is causing steel to rapidly replace cast iron in the construction of cylinders for high pressures. The breaking strength in tension of the metal employed is usually stated at 24 tons per square inch, but this is not probably obtained in the actual cylinder casting, the test stress on which it will be well to limit to 8 tons per square inch for cylinders of moderate thickness. For sound hammered steel cylinders, or hydraulic forged, a test of 10 tons per square inch of metal will not be too high.

Solid drawn steel tube forms an excellent, indeed the best material available for high-pressure hydraulic tubes.

For the rams of hydraulic presses and hoists, rolled or hammered steel is frequently used, and sometimes steel castings, but there is a difficulty in getting the latter sufficiently sound on the surface for use in high-pressure work. Indeed even in the case of hammered steel it is necessary to allow ample metal in the forging to permit of a substantial first cut being taken off over the surface (the rough should be at least $\frac{3}{8}$in. larger in diameter than the finished ram), as otherwise it is impossible to eradicate the unsoundness due to the surface blowholes invariably found in the ingot. These, although closed in by the subsequent hammering, which leaves an apparently sound face in the finished use, are not really welded up, but reappear in the shape of an unsound surface on the first cut being taken off in the lathe.

Malleable cast iron, toughened sometimes by the addition of a little scrap steel, is used with success for small short cylinders. Its ultimate strength, 1in. thick, does not exceed in general 15 tons per square inch, and for $\frac{1}{2}$in. thick about 20 tons per square inch. The test stress may be taken at 8 tons per square inch if the metal does not exceed $\frac{3}{4}$in. thick. It is, however, a treacherous material, very liable to unsoundness, and should only be used for small and unimportant work.

The alloys of copper, tin, and spelter are of the greatest importance to the hydraulic engineer, owing to their freedom from corrosion by water. Hence they are used almost to the exclusion of any other metal for barrel linings, plungers, valves and valve seats, screwed caps and plugs, &c., &c. Brass also forms an excellent sheathing for the outside of rams, and its use for that purpose is highly conducive to the durability of leather packings, while in all cases in which a cylinder is bored to receive a leather-packed piston it should also be lined with brass or gun metal, unless there be special circumstances which militate against their use. For the smaller class of pumps gun-metal castings are almost exclusively employed. The castings so used are in general somewhat, but not greatly, tougher and stronger than good cast iron. A test stress of four tons per square inch of metal may be permitted for gun-metal pump barrels. For hydraulic pressures exceeding four tons per square inch, steel should be used in place of gun metal. The portion of the brass foundry occupied in the production of hydraulic castings should be separate from that in which the commoner descriptions of metal are cast. Very annoying inequalities in the strength and closeness of the metal, due either to carelessness or wilful neglect on the part of the workmen, are otherwise extremely liable to occur. For pump plungers the rolled alloys, such as Kingston metal and rolled phosphor bronze, are very reliable. These and similar alloys, in the form of rolled rods and solid drawn tubes, can now be procured of the strength of steel, and at very moderate prices. Phosphor and manganese bronze castings are also used for pump barrels, and are said to have an ultimate breaking weight of about nineteen tons per square inch of metal, but as far as the writer's experience extends this cannot be depended on in the actual castings. The test stress for phosphor bronze pump castings may be taken at six to seven tons per square inch of metal. Rams are coated with copper by electro-deposition by the Broughton Copper Company, of Manchester, and other firms, at very moderate cost. The finished thickness of copper usually applied is $\frac{1}{32}$in. If the durability of the sheeting so formed can be relied on, its great gain in the first cost as compared with brass sheeting should bring this plan into favour.

Leather and one or two other materials of special utility for hydraulic work will be dealt with in connection with their applications.

Having considered the safe test stresses of the materials employed in hydraulic work, we have now to consider the not less important question as to what proportion the actual working stress should bear to that stress.

Very hazy notions on this subject have been held up to recent times, and, indeed, are still held. Great importance used to be attached to the determinations of the so-called "elastic limit" of a material, by which term was intended that stress at which the metal began to take noticeable permanent set. It was demonstrated by Mr. Hodgkinson, however, that cast iron had no definite "elastic limit." By experiments with long cast-iron bars (15ft. long), he showed that cast iron takes a permanent set with the smaller loads, increasing gradually, as the load is increased, up to the breaking point. Ductile wrought iron and mild steel have, however, a definite "elastic limit" of stress, or rather they have a definite "breaking down" point. This will be better understood by reference to the annexed diagram (fig. 1), which represents the extension of a mild steel bar 1in. square, 10in. long, under loads progressing in strain up to the breaking point. The writer has carried out a very large number of experiments with mild steel bars, and has invariably found the stress and strain diagram (drawn automatically by the bar itself) to have the characteristics illustrated by fig. 4. From O to A the extensions of the bar are very nearly proportionate to the stress applied; in other words, they follow Hook's law, *ul tensio sic vis.* A is the true elastic limit. From A to B is a transition stage ; the extension is no longer proportionate, but increases more and more rapidly. The extension between O and A is a very minute portion of the length of the bar, and is exaggerated in the diagram so as to make it capable of representation. When the stress reaches the amount indicated by the point B, the bar extends without increase of load a distance of $\frac{1}{8}$in. or more in a specimen 10in. long—it, so to speak, "bucks down." Hence B has been termed the "bucking down point" of the bar. The "elastic limit," as ordinarily found by the aid of a pair of dividers, may be anywhere between A and B, or even below A.

The specimen now extends from B to C without increase of load. In diagrams taken with apparatus of too sensitive a nature in the writer's opinion to be reliable, and also in diagrams taken by apparatus in which the load on the specimen is measured by the water pressure in the hydraulic cylinder of the testing machine, the line B C appears as a jagged line.

There can be little doubt, however, that these apparent fluctuations in the load in the specimen are due mainly to imperfections in the recording apparatus, owing to the rapid stretch of the specimen from B to C. With apparatus designed by the writer, in which the actual load, as measured by the dead-weight lever, is recorded, the line between B and C is found to be almost, if not quite straight and horizontal. C is usually a very well marked point, from which the extension of the bar increases very rapidly with increasing load. At D, the maximum load which the bar can sustain without immediate fracture is reached. From D to E the load on the bar materially diminishes, until the bar, having stretched to E, suddenly breaks.

The whole subject is a very interesting one, but since we are concerned, not with the behaviour of metals under test, but with their use in hydraulic machines simply, we must be brief. Our present object is to point out that the so-called "elastic limit" is not in itself a quantity of much importance, since it can be raised at pleasure. For instance, if the bar, the behaviour of which under test is illustrated by fig. 1, had been subjected to a preliminary load of 22½ tons, we know by the results of many experiments that, in being subsequently tested, its "elastic limit," instead of being above 18 tons per square inch, would have been found to be more than 22½ tons to the square inch, and no such stage as that between B and C would be observed. Hence a steel or iron master, who has to do with an engineer who has great faith in a high "elastic limit" as a measure of the strength of a bar—and there are such engineers—has merely to watch his opportunity and apply a stress equal to the prescribed "elastic limit" before the inspector commences his test, and he will be sure of the bar passing the test as far as regards the "elastic limit."

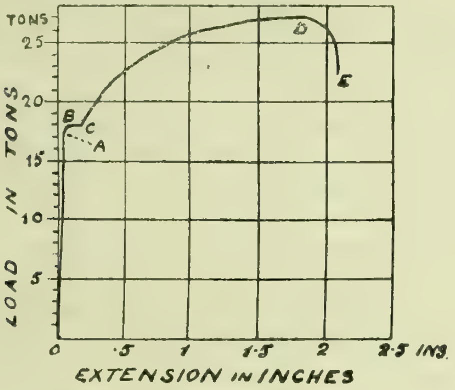

FIG. 4.

But not only can the "elastic limit" be raised; it can also be lowered by manipulation. Bunschinger has recently shown that by compressing a bar of wrought iron endways, powerfully, its elastic limit may be reduced to as little as 5 tons per square inch without affecting sensibly its ultimate breaking weight.

Hence we must discard the "elastic limit," at any rate taken by itself, as in any way measuring the value of the bar for constructive purposes. In comparing the quality of two bars, it is necessary that the specimens should be of equal length and equal diameter. The important points, then, to be observed as determined by tests, are the ultimate breaking weight and the ultimate extension.

Having thus disposed of the claims of the "elastic limit" to be considered as a basis from which to determine the relation between test stress and working stress, we have next to consider from what sound basis their relations may be determined in the special case which we have to consider, viz., that of hydraulic machinery. This we propose to consider in our next article.

LANDORE-SIEMENS STEELWORKS.—On February 13th, at the City of London Auction Mart, Tokenhouse Yard, Mr. C. P. Whiteley, of Queen Street, Cheapside, offered for sale the steel and iron works, blast furnaces, &c., of the Landore-Siemens Steel Company, near Swansea. The steel produced has a European reputation. The works were capable of turning out about 1,500 tons of finished steel per week. The biddings commenced with an offer of £40,000, and reached finally £101,000.

MATERIALS OF ENGINEERING.—XII.

ALLOYS OF COPPER (*concluded*).

THE alloys of copper are the earliest known both in the unwritten and the written history of our race, as witness the ancient bronze celts, swords, and hammers; and until very recent years these alloys were mostly confined to the brasses and harder gun-metal mixtures. Now, however, their number is legion, and is continually on the increase, while their great utility is beyond question.

All these are of so very variable composition that no definite statements can be made respecting them except by taking the principal ones *seriatim*. Taking the bronzes first, perhaps the most elaborate and reliable series of experiments ever made thereon in this country are those of the late Dr. Anderson, at Woolwich. He gives, as the result of experiments extending over a period of 15 years, the average tenacity of bronze at 31,280lb., or nearly 14 tons per square inch; visible permanent set begins at 15,164lb., and the average ultimate elongation per inch in length is ·290 of an inch. The composition of good tough bronze should be not less than 90 of copper to 10 of tin, and the proportion of copper is often increased to 90½ or 91 in the 100 parts.

Brass is an alloy of copper and tin, to which lead and zinc are sometimes added. The proportions of the constituents and the characters of the resulting alloys are practically infinite in variety, but they are all softer and weaker, though cheaper than the bronzes. If composed of two parts of copper and one of zinc, the average ultimate tenacity is stated by Dr. Anderson to be 28,900lb., or nearly 13 tons per inch. But this is much too high for the ordinary commercial mixtures, whose strength may range from 8 to 10 tons.

Muntz metal usually contains 60 per cent of copper and 40 of zinc. Its tenacity is high, according to Dr. Anderson, 22 tons per square inch, nearly equal to the best wrought iron.

Manganese bronze, alloyed in various proportions, yields a material which is strong, ductile, tough, or hard. It is believed that the superior strength of this alloy over that of the common brass is partly due to the beneficial action of the manganese on the oxides of tin and zinc, removing them by reason of its affinity for oxygen. The alloy presents a fracture as finely granular as steel. It can be forged or rolled hot or cold from the cast ingot. A number of experiments on manganese bronze made by Messrs. Armstrong, Mitchell, and Co. have shown an average ultimate breaking strength per square inch ranging from 29·4 tons to 31 tons, and an elongation in 2in. of about ·35 of an inch. Numerous other tests, given on the authority of Mr. Parsons, show that this material, as cast in sand for propellers, has a tenacity of from 24 to 28·4 tons per square inch. Mr. Parsons claims that the resistance of this material to compression is greater relatively to its tensile strength than is the case in the other bronze alloys, and that its transverse strength is therefore greater than the tensile strength would indicate, and that the mean tensile strength of manganese bronze is about 60 per cent greater than that of the best gun-metal cast in sand, while its transverse strength is about 100 per cent greater. Thus he instances some Admiralty tests made at the works of Messrs. Maudslay, Sons, and Field, in which the two materials were compared with a view to the selection of that best suited for propellers. Gun-metal bars, 1in. square and 12in. between supports, were deflected 1·59in., and took permanent set of 1ft. ·46in. with a load of 26 cwt.; while similar bars of manganese bronze required a load of 52 cwt. to deflect them 1·7in., and to impart a permanent set of 1·47in. Mr. Parsons states that when the material is required to resist a tensile stress it is rolled or forged hot, and that as delivered from the rolls its mean tensile strength is about 30 tons per square inch, with an elastic limit of 20 to 23 tons, and an elongation of 23 to 25 per cent. If cold rolled, however, its ultimate tensile strength rises to about 40 tons per square inch, with an elastic limit of 30 to 34 tons, and an elongation of about 10 per cent. If annealed, the ultimate strength is slightly reduced, and the elastic limit is reduced to about 15 tons per square inch, but the elongation is increased to 30 or 35 per cent.

Aluminium bronze is another alloy of copper for which great strength and ductility are claimed. The following are among the results of tests made on this alloy by W. H. Harris, chief engineer of the United States navy, and are instructive as illustrating the very wide range in characteristics which this, in common with some of the other copper alloys, possesses. A specimen having the composition of copper 63, zinc 33·3, aluminium 3·33, silicon 0·33, showed an ultimate tensile strength of 70,400lb. per square inch, an elastic limit of 55,000lb., an elongation in 15in. of 0·4 per cent only, and reduction of area of 4·33 per cent. But another alloy having copper 92, aluminium 7·5, silicon 0·5, had a tensile strength of 59,100lb., an elastic limit of 19,000lb., and an elongation of 15·1 per cent, with a reduction in area of 23·59 per cent. Another, containing copper 91·5, aluminium 7·75, silicon 0·75, showed a tensile strength of 67,600lb., an elastic limit of 24,000, an elongation of 13·0 per cent, and reduction of area of 21·6½ per cent. Thus it is seen that the qualities of these alloys are fully under control, so that very high tensile strength with slight ductility, or the reverse, are obtainable. Thus a tensile strength as high as 57·9 tons has been obtained in aluminium bronze, and with a tensile strength of 33·4 tons, an elongation of 56 per cent in 2in. Professor Unwin gives, as the result of a test on a specimen bar ½in. in diameter, a tenacity of 36·78 tons per square inch, an elongation in 10in. of 33·26 per cent, a contraction of 39·87 per cent, and an elastic limit of 17·74 tons per square inch. An aluminium bronze containing about 90 parts of copper to 10 of aluminium can be forged hot or cold, but does not weld. Mr. Anderson gives as its average tenacity, deduced from the Woolwich experiments, 73,185lb. per square inch, and its maximum tenacity as 96,320lb.

Phosphor bronze, composed of copper, tin, and phosphorus, is a most valuable alloy, and in its various grades is used for a large number of purposes. It is employed for gearing, pumps, bolts, steam fittings, tubes, bearings, bushes, wires, &c. It is both cast and rolled. Like the other alloys, it can be obtained hard like steel, or tough and ductile like wrought iron. Its chief value consists in its endurance both under shock and frictional contact. Professor Unwin, as a summary of various tests, gives the tensile strength of phosphor bronze as ranging from about 22 tons, with 30 per cent elongation, to 33 tons, with 3 to 4 per cent elongation. In the Glasgow Exhibition there were samples of castings in this material which well illustrated its durability in machine parts subjected to much wear. Slide valves, an eccentric strap, a rolling mill bearing, worm wheels and worms, all of which had been in use for considerable periods with comparatively little wear, were shown.

Delta metal is a comparatively recent alloy, that appears in a fair way to occupy an important place among the materials of engineering. It is prepared in various grades, both cast and forged. Tests made thereon by Mr. Kirkaldy gave the following results: A specimen cast in sand, of area equal to 1 square inch, stood an ultimate stress of 20·9 tons, and an elastic stress of 7·9 tons, and also an ultimate percentage elongation of 19·1 in 10in. A rolled bar of the same section gave an ultimate strength of 33·9 tons, an elastic strength of 21·8 tons, and percentage elongation of 21·6 in 10in. A similar bar annealed gave 29·8 tons ultimate stress, 9·6 tons elastic stress, and an elongation of 34·7 per cent in 10in. In the Glasgow Exhibition I was shown a small bevel wheel of Delta metal, which was stamped hot in a die, and the attendant informed me that, provided a sufficient number of such wheels were ordered to cover the cost of the die, they could be supplied at a mere trifle over the cost of gun-metal wheels. The specimen shown me was as clean, smooth, and sharp as though machine-cut.

Delta metal is composed of copper and zinc, with iron in small quantity. Like phosphor-bronze, it will withstand the corroding action of sea water, and would doubtless be largely used for screw propellers but for its cost. This is not, however, so great as might appear at first sight, because less weight is necessary, the strength and toughness of the material permitting thinner blades being used, while they last very much longer than either steel or iron, the power of Delta metal to resist corrosion being, in comparison with iron and steel, roughly about as 38 to 1.

Of the various white metals, Babbitt metals, or white brasses, we can only say that their value is very great as anti-friction alloys, and that their composition varies almost infinitely. In these the proportion of copper is very small, seldom exceeding about 20 in the 100, often not more than 2 or 3 to 10 in the 100. Lead and tin are the chief ingredients, usually with considerable proportions of antimony. The softer alloys of this character have to be retained in place, in iron or brass castings, else they would become squeezed out under pressure. J. H.

THE FORTH BRIDGE.—At the half-yearly meeting of the Forth Bridge Railway Company, the other day, it was reported that the total expenditure on the works to the 31st of December was £2,588,328. Lord Colville, in moving the adoption of the report, said there was every indication that the estimate of the engineer that the bridge would be finished by October of this year would be realised.

THE CABLE RAILWAY ON THE NEW YORK AND BROOKLYN BRIDGE.*

THE New York and Brooklyn Bridge is 6,017·33ft. in length. The railway is double line, laid to the 4ft. 8½in. gauge, with steel rails weighing 52lb. per yard. The inclines vary from level to over 3¾ per cent, or 1 in 26½. The total length of cable within the rails, for actual train service, amounts to $2\frac{1}{10}$ miles. It is driven continuously in one direction by one of two stationary steam engines at the Brooklyn terminus. The cars are each connected to the cable by a roller-grip, and they are run singly or in trains as may be required. They are moved and placed by locomotives at each terminus. The cable is driven by means of winding drums and their accessories.

Steam is generated in six water-tube boilers, each of which has 54 water tubes, 4in. in diameter, 18ft. long, with a 3ft. drum overhead. Each firegrate is 3ft. 10in. wide, 7ft. long, and consists of revolving self-stoking firebars. The chimney is 129ft. 4in. high, 5½ft. square at the top. Steam is supplied for three electric-lighting engines, besides the cable service.

The two steam engines are horizontal, having each a 26in. cylinder, with a stroke of 4ft. They are connected to the outer ends of the main driving shaft by clutches, working one at a time, making 57 revolutions, or 456ft. of piston per minute.

The rope passes over two large drums, 12ft. in diameter, on axes nearly horizontal, in each of which there are four semicircular grooves for the rope, ¾in. deep. The drums are 17ft. apart, slightly inclined to each other, the shafts making angles of 1 in 128 with the horizontal, so that the several rope grooves of one drum may be directly opposite to those of the other. The drums are placed one at each side of the main shaft, 5ft. clear of each other. A smaller drum, 5ft. in diameter, occupies this interval, and runs loose on the shaft. Beside it a toothed wheel, 5ft. in diameter, is keyed on the shaft, and gears into a 12ft. toothed wheel keyed on the shaft of the driving drum. Thus the drums are kept exactly at the proper distance apart, and are driven by the engine through reducing spur gear, making 23¾ revolutions per minute, and moving the rope at a speed of 895·35ft. per minute, or 10·17 miles per hour. Allowing for wear and tear of grooves and slipping, the speed is usually taken as 880ft. per minute, or 10 miles per hour. The cable is of crucible steel, 11,500ft. in length. It is, when new, 1½in. in diameter, and it consists of 114 wires, nearly $\frac{1}{10}$in. thick, laid in six strands around a central strand of hemp. It weighs 3½lb. per foot of length. Tension cars are employed to prevent the cable from slipping, and to take up slack. Between the rails the cable is supported on pulleys placed 30ft. apart, in which the groove is packed with leather and indiarubber beltings laid radially.

The cars are 48ft. 10in. long over all; the body is 39½ft. long, 9ft. 7in. wide, and 13ft. 8in. high above the level of the rails, on a four-wheel bogie at each end. The wheels are of paper, steel tired, 30in. in diameter. The car, without load, weighs $16\frac{5}{8}$ tons. The entrances at the ends are 3ft. 5in. wide, with double sliding doors, and at the middle of each side a 2ft. 8in. opening, with a single sliding door. Forty barred seats are placed in line along each side, with an aisle 4ft. 8in. wide. When fully occupied—seats and standing room—the car has carried 150 persons. The car is lighted by eight argand lamps, burning mineral oil. In cold weather the car is heated by a hot-water heater, with ten lines of 1¼in. wrought-iron pipes under each line of seats.

The grip is so devised as to maintain automatically the relative positions of the pieces subject to wear. It is fully described in the paper. The brakes are applied to every car wheel, by hand or by vacuum. Five locomotives are employed on the terminal service, having cylinders 11in. and 12in. in diameter, with a 16in. stroke. Four are in constant use. The automatic car coupler is applied to the whole of the wheeled stock.

The indicator power exerted by the driving engine was observed during the entire working day, 19½ hours, April 26th, 1886. The power ranged from 303·1 H.P. to 12·9 H.P. minimum and negative; the average for the whole day was 96·2 H.P.; for five hours of the busiest time the average was 150·5 H.P. To drive the plant without trains the power was 47·7 H.P.

The steel wire of which the cable is constructed has a breaking stress of from 140,000lb. to 190,000lb. per square inch. The first cable was in use 3 years 43 days, during which time it hauled 226,273 miles, 837,895 cars, and 48,960,000 passengers, making a total weight of above 12,000,000 tons, of which 9,000,000 tons of cars were hauled $\frac{2}{10}$ mile, and 3,000,000 tons of passengers were hauled $1\frac{1}{32}$ mile, making a total service of nearly 22,000,000 ton miles (exactly 21,777,710 ton miles). The paper is illustrated by twenty-seven plates.

Inst. C.E. Abstracts.

REFUSE PETROLEUM AS LOCOMOTIVE FUEL.

At one of the meetings of the Institution of Mechanical Engineers a paper was read by Mr. Thos. Urquhart, locomotive superintendent Grazi and Tsantsin Railway, South-East Russia, on the use of petroleum refuse as fuel in locomotive engines. It was given as a supplement to the author's previous communication in 1884, and was intended to bring before the institution the more recent results of his experience in the use of petroleum refuse as fuel on an unprecedented scale.

Since November, 1884, the whole of the 143 locomotives under the author's superintendence, besides 50 stationary boilers, had been fired with petroleum refuse, which was used for all steam-generating purposes, and also in almost all metallurgical operations under his care.

The petroleum refuse was fed into the firebox by means of a spray injector, and the fireboxes were lined with brickwork, not only in locomotive furnaces, but in Galloway and marine boilers, as well as horizontal and vertical boilers. For the latter, even when quite cold, the fire was started with petroleum alone, without any wood, by a method described. The cost of altering locomotives for petroleum was given according to two different plans—for six and for eight wheeled engines. The cost of working was given for the six-wheeled engine, per engine mile, as 7·64 pence with coal in 1882, reduced to 4·43 pence for petroleum refuse in 1887, being a saving of 42 per cent; while for the eight-wheeled engine the reduction was from 11·02 pence for coal in 1882 to 5·84 pence for petroleum refuse in 1887, a saving of 47 per cent. This cost per engine mile included transport, storage, superintendence, and depreciation of tanks, pumps, pipes, &c., required in using the liquid petroleum refuse.

The equivalent of 100 tons of coal in 1882 was 55 tons of petroleum refuse in 1887, being a reduction of 45 per cent in weight of fuel for the six-wheeled engines, while for the eight-wheeled engines the saving of weight was 49 per cent. With a first-class locomotive and a skilful driver, the author had no hesitation in saying that 50 tons of petroleum refuse were equal to 100 tons of first-class coal in steam-raising. He had conducted several trials in the comparative consumption of anthracite and petroleum refuse, and had obtained those as average results. The working expenses of the railway on which he was engaged had been brought down from £191,442 in 1882 to £152,278 in 1887, being a reduction of £39,164 in the locomotive department.

The effect of petroleum fuel on boilers was not so great as he had at first imagined, and five years' experience had shown him that since its introduction the cost of repairs had been considerably diminished from what was previously required when firing with anthracite, which was particularly destructive to the fireboxes and tube ends. The petroleum flame produced in reality no more detrimental effect on the firebox and tubes than a wood flame did, owing to the protection afforded to the more important parts by the fire-brick lining. Moreover, petroleum refuse did not contain any sulphur, so common in all coals, and so injurious to the metal of firebox and tubes.

In the locomotives he now used the fire door was plated up both inside and outside, the water admitted thus adding more effective firebox heating surface, and obviating all possibility of flame leakage at the fire-door ring. A manhole in the bottom of the ashpan afforded access to the interior of the firebox for repairs and inspection.

A special construction of boiler for petroleum firing had been suggested, but he was of opinion that the present form of locomotive boiler could not be improved on for working at high pressures, and giving great power in a comparatively small space. A new design of boiler, without internal firebox, had been introduced by Mr. Stephen Verderber, in 1879, on the Hungarian State Railways, which consisted of a cylindrical shell, forming the boiler proper, and of an external firebox or furnace, lined with fire-brick. The firebox was completely separated from the boiler proper, and the only way in which it contributed directly to the evaporation of water was by its radiation of heat to the tube plate.

Having occasion to renew the worn-out copper fireboxes of two locomotives, the author had adopted a modification of this furnace, and from his observations he would have no hesitation in using the plan for all the boilers under his care. The object of his plan, however, was not to effect economy in fuel, but rather to obviate the incessant damages to fireboxes from the very bad feed-water with which he had to contend.

A special form of boiler for petroleum firing had been designed by Mr. Paschinin, and might be described as something like a Cornish boiler, having a larger internal firebox, with a flue extending thence along the bottom of the barrel of the smoke box, and with tubes added above the flue. This boiler, however, not only consumed more fuel than the ordinary one, but its structure was very defective, and so far as locomotive work was concerned it was looked upon as a complete failure.

A blower for air supply to the furnaces of his locomotives had been tried, but had been discarded, as no appreciable economy of fuel resulted, while at the same time it was terribly noisy when working.

Experiments had also been made on the use of compressed air instead of steam for the spring injector, but after trying this for two months it was abandoned as useless.

A table of the theoretical evaporative value of petroleum fuel in comparison with that of coal was shown, which we give. At an effective pressure of 8½ atmospheric, or 125lb. on the square inch, the highest evaporative duty on the petroleum refuse used in the author's locomotives on the Grazi and Tsantsin Railway was 14lb. of water per pound of fuel. The actual efficiency was, therefore, nearly 82 per cent.

THEORETICAL EVAPORATIVE VALUE OF PETROLEUM FUEL AND OF COAL.

Fuel.	Specific Gravity at 32° Fahr. Water = 1·000.	Chemical Composition.				Heating Power. British thermal units.	Theoretical Evaporation. Lbs. of Water per lb. of fuel.	
		Carbon.	Hydrogen.	Oxygen.	Sulphur.		From and at 212° Fahr.	At 8½ atm. effective pressure.
	S. G.	Per cent.	Per cent.	Per cent.	Per cent.	Units.	Lbs.	Lbs.
Pennsylvanian Heavy Crude Oil	0·886	84·9	13·7	1·4	...	20,736	21·48	17·8
Caucasian Light Crude Oil	0·884	86·3	13·6	0·1	...	22,027	22·79	18·9
Caucasian Heavy Crude Oil	0·938	86·6	12·3	1·1	...	20,138	20·85	17·3
Petroleum Refuse	0·928	87·1	11·7	1·2	...	19,832	20·53	17·1
Good English Coal, mean of 98 samples	1·380	80·0	5·0	8 0	1·25	14,112	14·61	12·16

Petroleum refuse had been found to make an excellent lubricant, and had been used for some years for the wagons and tenders. It was a very good lubricant, although black in colour, and could easily be obtained pure.

Now that petroluem seemed destined to occupy a prominent place in India, as well as many other parts of the world, the results in regard to its value as a lubricant could hardly fail to be of interest to engineers, irrespective of its use as a fuel.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.*

INTRODUCTION.

In the autumn of 1886 the Council of the Society decided to offer some Society of Arts' medals for prime movers suitable for domestic installations for the electric light and other purposes. The details of the proposed competition were carefully considered by the committee, and in December, 1886, the announcement was made that two gold medals would be offered for prime movers of the class referred to. The classification was intended to include motors of every class—steam, gas, hydraulic, &c. The council proposed to appoint three judges, who would report to the council, and on whose report the awards would be made by the council. The entrance fee was fixed at £2 10s. per horse power, in the hope that the amount derived from fees would suffice to cover a large portion of the cost. The date fixed for sending in entries was the 28th February, 1887. The entries received by that date were not considered sufficient in number to justify the society in incurring the necessary expense, and the council decided to postpone the date for the receipt of entries to the end of December, 1887. Certain alterations were made in the conditions of entry. Four gold and two silver medals were offered. Notice of this was sent to a large number of makers of engines in this country and abroad; but the result, so far as the number of entries went, was very far from satisfactory. Thirteen entries were contemplated, but only seven entries were actually received, and of these three were withdrawn, so that only four engines were actually presented for trial.

In spite of the paucity of entries (fewer even than in the previous year, when there were eleven), the council decided to proceed with their experiments. At their request, Dr. Hopkinson, Professor Kennedy, and Mr. Beauchamp Tower accepted the office of judges, and the trials were successfully carried out in September last, on ground at South Kensington belonging to the Imperial Institute, and kindly lent for the purpose by the council of that body.

The council feel that the society is very greatly indebted to the gentlemen who undertook the office of judges, and who carried out with the utmost care and the most painstaking accuracy the arduous duties of that office. They believe that the report which they have prepared will be found to be of great scientific value, and well worth the cost incurred by the society, and the trouble expended on the matter by the judges and by the committee; indeed, it is not too much to say that, as regards gas engines, the experiments are the only thoroughly independent comparative tests of different engines that have been made with any approach to completeness over such long runs, and with such elaborate measurement of all the principal quantities concerned.

REPORT OF THE JUDGES.

We have made careful tests of the motors which have been offered for the competition for the Society of Arts' medals. Finally, only four motors were presented for test, three gas engines and one steam engine. The gas engines were a Crossley 9 H.P. nominal, a Griffin 8 H.P. nominal, and an Atkinson of 6 H.P. nominal. The steam engine was a Davey-Paxman compound portable engine of 8 H.P. nominal.

The trials were carried out in a building specially erected for the purpose, on a portion of the site of the Imperial Institute at South Kensington, and were made during September last. The tests comprised an efficiency test during a six hours' run for each engine at full power, a three hours' run at half-power, and a test running light. In addition to these, one or two tests were made at the request of the exhibitors themselves, under conditions varied from the conditions of competition. In the case of the gas engine tests, the quantity of gas consumed in the engine itself and in the ignition was separately measured, the readings of the meters being taken every quarter of an hour. The meters were Wright's standard wet meters, one of 100 and the other of 20 light size. They were kindly lent to the society by Mr. Richard Wright, who personally made all the adjustments before the trials, so as to ensure the accuracy of the readings. The pressure and temperature of the gas were measured in the meter, and in each case samples of the gas were taken from time to time, were mixed together for each test, and were analysed by Mr. C. J. Wilson, F.I.C., of University College, London. Indicator diagrams were taken at intervals of a quarter of an hour, the diagrams being taken approximately midway between the times at which the gas was read. The indicator used for the Crossley engine was an improved Richards, made by Elliott and Co., and the same indicator and spring, with another similar one, was used for the Griffin engine. For the Atkinson engine a strengthened Crosby indicator was used. In all cases the indicator springs used have subsequently been tested at University College. The errors being exceedingly small, a correction is not applied in calculating the results given later in respect to each engine. The brake horse power was in all cases ascertained by means of a rope brake upon the flywheel or flywheels of the engine. Two ropes were used for each wheel; they were kept at the proper distances apart and in fixed position upon the flywheel by means of transverse wooden distance pieces. The dead load was applied by means of weights, and the back tension necessary to put the friction on the brake, by means of a spring balance. The spring balance was read every five minutes, and its tension was deducted from the dead load applied. This brake was found to work perfectly satisfactorily, and its results are certainly beyond suspicion. It is important, however, if any metal be used for attaching the wooden cross-pieces to the ropes, it shall not rub against the rim of the flywheel; if this should occur, the metal becomes exceedingly hot and is liable to burn the rope. The quantity of water used for cooling the cylinder of the engine during the run was measured by means of a Schönheyder water meter, and its temperature on emergence from the engine was ascertained by a thermometer. The meter was kindly lent to the society by Messrs. Beck and Co., Limited, and was tested after the trials and found to be without sensible error. The number of revolutions made by the engine was measured by means of a counter continuously geared on to the crank shaft of the engine. The counter was read every quarter of an hour at the exact instant at which the gas meter was read.

The efficiency tests of the steam engine differed slightly from those of the gas engines. Owing to the greater power developed, and to the smaller size of the flywheel of the engine, it would not have been practicable in a continuous run to trust entirely to the cooling of the flywheel by the air. The flywheel was provided, therefore, with two internal return flanges, which formed a groove the full width of the face of the flywheel into which water could be run, which water was continuously evaporated by the heat arising from the friction. This arrangement worked very well, and we are of opinion that considerably greater powers could have been measured upon a flywheel of this size by this method. The indicator diagrams were obtained, the brake power and the number of turns ascertained in a manner exactly the same as in the case of the gas engines (the diagrams being taken, however, only every twenty minutes), but instead of measurements of gas and of cooling water, measurements were made of the quantity of coal burnt and water evaporated. Analyses were made of the coal and also of the furnace gases. In all cases the quantity of lubricant used in the cylinder was measured.

In addition to the efficiency tests of the engines, tests were made to ascertain the regularity of the running and of governing. For this purpose the engines were employed to drive a dynamo machine, and the current from the machine was taken through a metallic resistance controlled by switches; an incandescent lamp was also connected to the machine. The amount of cyclic variation occurring in the driving was ascertained by direct observance of the lamp. For electric light motors this is, of course, a sufficient test, as an engine running so regularly that the variation cannot be detected in a lamp may be taken as being perfectly satisfactory for the production of the electric light. The resistances gave a great facility for speedily varying the load upon the engine. The speed of the engine was ascertained when fully loaded, and when running with the dynamo machine upon open circuit; it was also ascertained when running at half power. Observations were made of the effect of throwing off the load as the engine was running, and the hunting of the governor was judged by the pulsations, if any, which ensued in the incandescent lamp.

Appended to the account of the experiments on each engine will be found what may be appropriately described as a heat table. In the case of the gas engines this gives the heat of combustion of the gas, the quantity of this heat accounted for by the indicator diagrams, and the heat carried off by the cooling water. This leaves a balance which will be mainly accounted for by the loss due to the heated exhaust gas, together with a small amount due to loss by radiation and convection from the surfaces of the engine. If the quantity of the gas and its temperature of exhaust were known, the former and larger of these amounts would be calculable. A very excellent approximation can be made to the quantity of waste gas from the known volume of the cylinder, the only doubtful point being the temperature of the charge when the cylinder is just filled. It is not likely that this temperature will exceed the temperature of the cooling water. Taking this to be the true temperature of the charge immediately before compression begins, the temperature is calculable at which this gas must enter the exhaust to account for the balance. In like manner, in the case of the steam engine, the heat of combustion of the coal is calculated, and this goes partly in heating the furnace gas and partly into the boiler, while in some cases the formation of carbonic dioxide reduces the heat actually developed by the combustion. Allowing for the loss due to radiation and convection from the surface of the boiler, the heat entering the boiler should be wholly accounted for by the water evaporated.

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* Journal of the Society of Arts.

As the temperatures in the gas engines can be estimated by the method just mentioned, and as those in the steam engine are calculable from the pressures, the trials enable us to say what proportion of the heat received would have been turned into work by an engine working as a "perfect" engine between these temperatures, and, therefore, to find the actual efficiency of the engine as compared with this standard. These figures will be found given below, at the end of the details of all the more important trials.

Messrs. Crossley Bros., Limited, of Manchester.—This engine is of the ordinary Crossley type, with exceptions to be mentioned. The cylinder was measured and found to be exactly 9·5in. in diameter and 18in. stroke. The engine has a single cylinder, and is single acting. There are two principal points of divergence from the ordinary type: First, the arrangement for ignition; and secondly, the use of a counter-shaft for driving the dynamo. Instead of igniting by means of a slide valve, which conveys a portion of the igniting flame to the point at which communication is made to the cylinder, there is a closed igniting tube, marked T in the drawing (fig. 1), kept hot by a Bunsen flame. It is possible to effect fairly good and regular ignitions by keeping this tube constantly in connection with the interior of the cylinder, and so arranging the length of the tube that the ignitable gas will be forced into it at the right point in the compression stroke. This, however, would be open to the objection that the time of ignition in the cylinder will vary with the speed of the engine. To render the moment of ignition perfectly definite, Messrs. Crossley have introduced an ignition valve E, which opens connections between the ignition tube and the cylinder at the right moment. This moment varies with the speed of the engine. In order, then, that the ignition may take place at the correct moment when the engine is fully loaded, and that it shall not occur too soon as the engine is being started, a double cam is introduced upon the shaft which actuates the valve. The one cam is used when the engine is running at its proper speed; the other is used when starting. The other special feature of this engine is the use of the counter-shaft with a flywheel upon it, running in bearings attached to the engine bed itself. It is proposed to connect this counter-shaft directly to the dynamo machine to be driven. The intention of this shaft and flywheel is, of course, to obtain regular speed of rotation of the dynamo, notwithstanding the irregularities of the driving force. The results show that this was perfectly effected, but it was so at the expense of a considerable loss from the slipping of the belt. The slip occurs at the moment when there is greatest tension upon the belt, and, consequently, the loss of power is much more than is represented by the deviation in the speed of the counter-shaft from that which it would have calculated on the hypothesis of no slip. The engine had one fly wheel only, 5ft. 5½in. diameter, and 9in. broad on face, weighin 1,652lb.

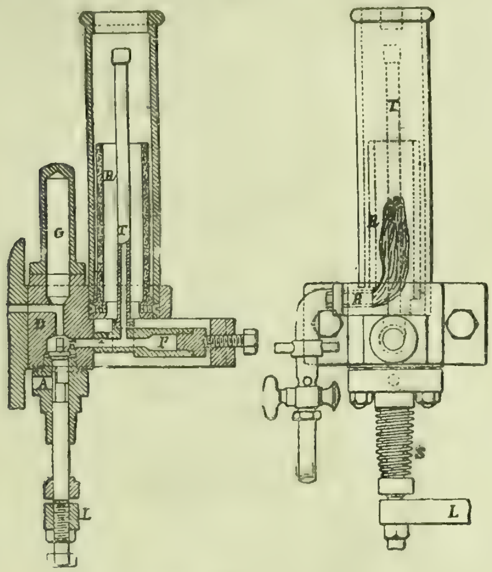

FIG. 1.

DETAILS OF IGNITION VALVE.

C.—Passage to cylinder.

G.—Chamber to receive incombustible contents of passage *C.*

E.—Ignition valve actuated by lever *L.* When *E* is raised by the lever, the peg on *E* enters the hole *D*, and prevents passage of any flame to cylinder, any slight leakage of gas past the peg being then free to pass out at vent-hole *A*, so that there can be no accumulation of pressure in the hot tube until the ignition valve is allowed to descend.

T.—Hot tube.

R.—Asbestos liner of chimney.

B.—Bunsen burner.

F P.—Easily removed holder for tubes.

(To be continued.)

RAISING THE STEAMER FERNDALE.

ON the 4th of February, 1888, the English steamer Ferndale, of 604 tons, loaded with coal and tar refuse, was run down by the English steamer Dowlais, and sunk almost immediately, only giving time to draw it alongside the northern jetty before its bow plunged into the silt. The hinder part was readily unloaded, as it remained afloat for two days; but the front part of the hold was only out of water just at low tide. The rent caused by the bow of the Dowlais was about 13ft. long, and, at 6½ft. below the water-line, it suddenly enlarged from a width of 4¾in. to 2ft. for a height of about 5ft., having been torn open by the anchor of the Dowlais, which hung across its bow. The narrow parts were closed by poplar wedges with packing. A large wrought-iron plate, ½in. thick, lined round its edges with two large tresses of greased cotton, was placed over the large hole, and was fixed in place by being bolted to two very strong T irons put across the opening inside. Rolls of tow were interposed where the plate was not close to the torn plate-iron skin, and the whole was covered with a large felted sheet. Two rotary pumps, capable of discharging 600 tons of water each per hour, were placed upon pontoons alongside the sunken vessel. One of the pumps, discharging water from the front hold, enabled the unloading from it to proceed for two or three hours each tide. On the 13th the two pumps pumped the water out of the holds and engine-room, so that the stern soon rose slightly; and at half-tide the bow was raised from the bottom. The vessel, accompanied by the pontoons, was then taken into the dock; the cargo was further removed from the front hold, and on the 14th the vessel was placed in the graving dock, which was pumped dry the next day.

THE DARNING WEAVER.—Sewing machines there are in plenty, but hitherto no attempt appears to have been made to assist the operation of darning by mechanical means. An apparatus for this purpose, however, has now been invented and is being manufactured by Messrs. Edwards and Barnes, of Birmingham. In using this apparatus the material to be darned is strained over a small wood block, and a couple of multiple hooks are inserted in the work. The worsted is laid as a warp backwards and forwards from one series of hooks to the other, and the woof is put in by hand. At each lay of the woof the weaving hooks are reversed by a touch of the finger, and the woof is made fast at each end to the material under repair. The result is a perfect darn, which is easily accomplished in something like half the time required in ordinary hand work. The invention is both ingenious and simple, and mitigates the tedious but needful operation of darning.

COAL-CUTTING BY ELECTRICITY.—We learn that Mr. Lechner, an American specialist, has recently employed electricity with great success as a motive power, instead of compressed air, in working coal-cutting machinery. The space in which the tools have to work is very limited. The machine tool is separate from the electric motor, which is one of Sprague's dynamos, developing 10 horse power, travelling on rails or remaining stationary, as may be required, and weighing not more than eight cwt. One motor serves to work three machines. As soon as a certain quantity of coal has been cut out by one machine, the motor is transported to another gallery, where it works while the coal first cut is being cleared away, and so the work is uninterrupted. It was found in a preliminary trial that two men could cut out 100 tons of anthracite, which is far harder than ordinary coal, in ten hours, while the cost of working scarcely exceeded one half what it used to be when compressed air was used as the motive power.

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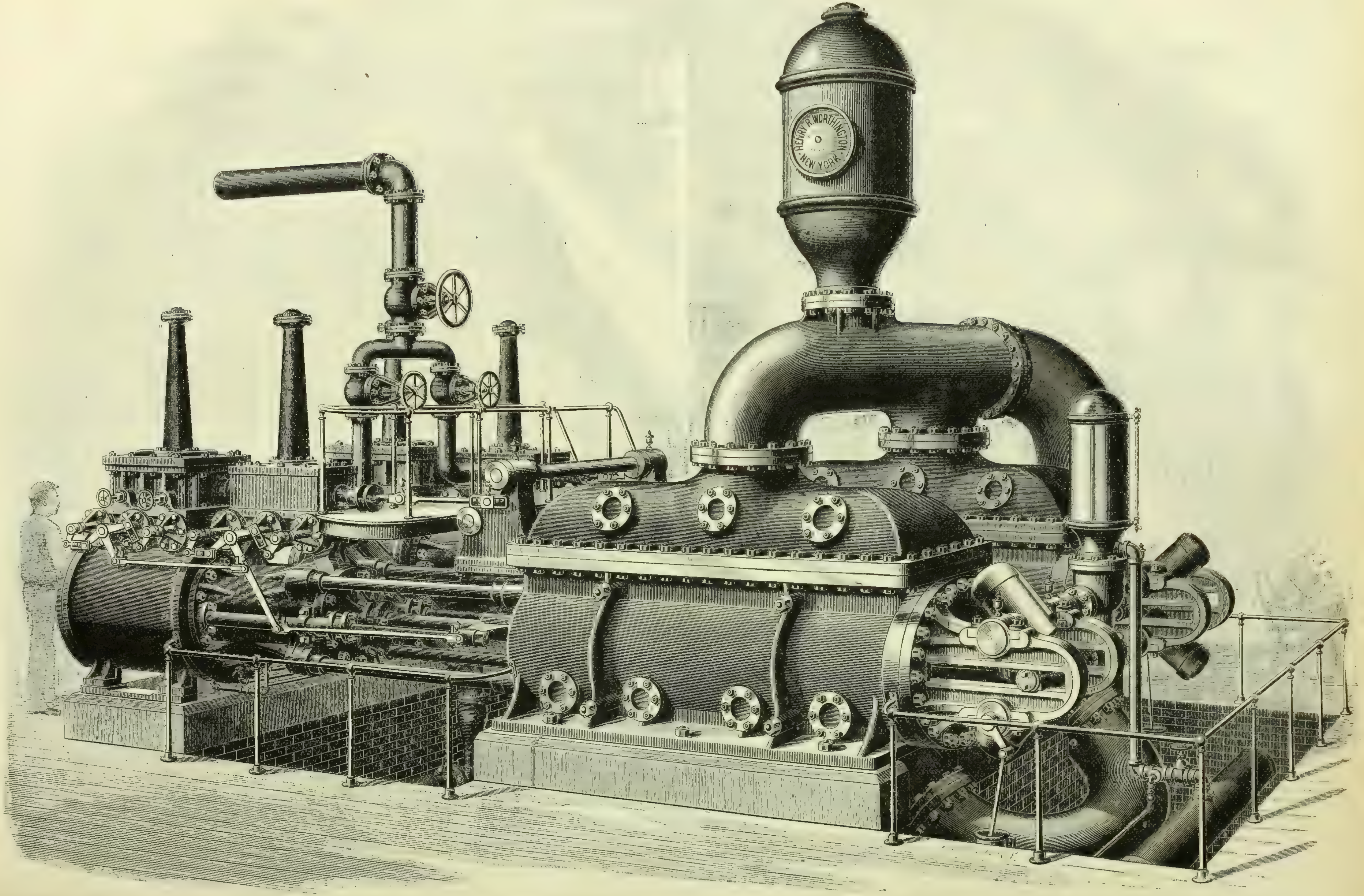
* Foreign Abstracts, Proc. Inst. C.E.

THE WORTHINGTON COMPOUND EXPANSIVE PUMPING ENGINE.



THE WORTHINGTON COMPOUND EXPANSIVE PUMPING ENGINE.

Direct-acting steam pumps, as usually constructed, are somewhat wasteful in their use of steam, and do not give an economy in fuel comparable to the best expansive flywheel engines and pumps. The reason is very obvious. A steam cylinder in direct line with a pump cylinder, and driving the pump piston without the intervention of a flywheel, must always give throughout its stroke a fairly uniform pressure to overcome the resistance of a constant head of water. If at any point the water pressure should exceed the steam pressure, then the piston would stop, and the stroke would not be completed until the resistance became less than the driving pressure. Consequently the full boiler pressure must be carried throughout the entire stroke, or, if the resistance is less than this, the steam must be throttled uniformly throughout the stroke. The mass of the moving parts is so comparatively small, that even when some piston velocity is acquired at middle stroke, but slight variation of pressure, and therefore expansion, is possible. Direct-acting steam pumps are very extensively used, and are convenient for many purposes, but more especially for small powers, where the advantage of low first cost and inexpensive maintenance more than compensates for steam consumption. American engineers have given great attention to the question of direct-acting pumps, and the experience gained in the working of oil pipe lines has developed there a type of pump which till lately has been unfamiliar to us in this country. We allude to the Worthington type of pump. In a former issue we have already illustrated and described the Worthington duplex pump for smaller powers and uses. We now propose to describe and illustrate the modification introduced by Mr. Worthington for large powers and high duty.

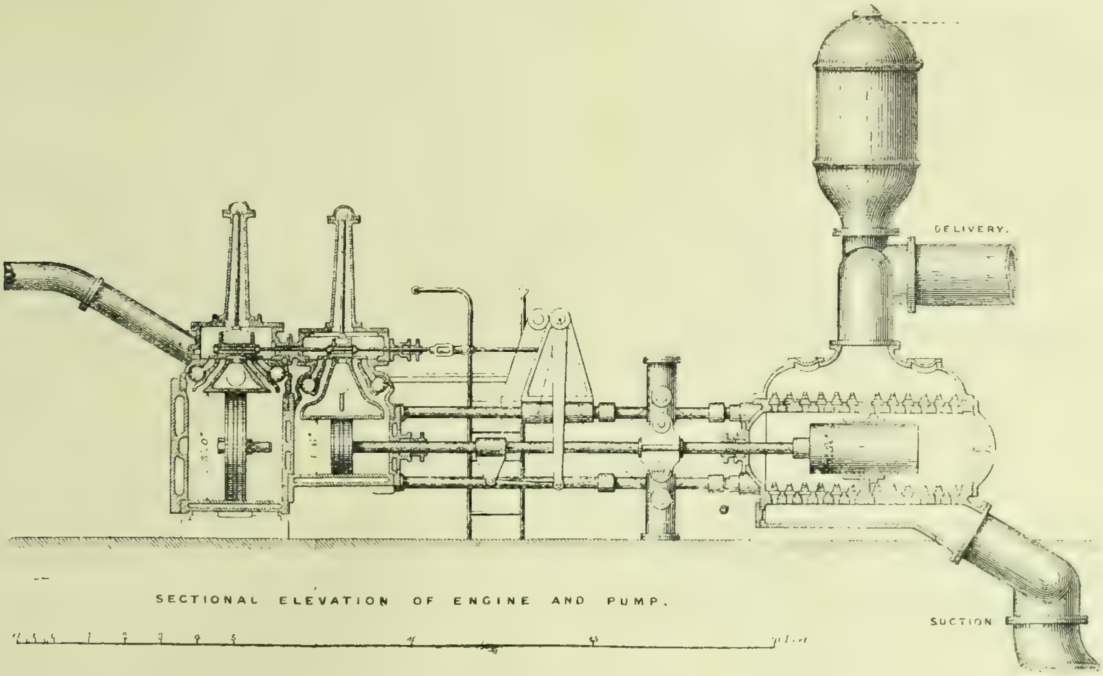


Fig. 1.

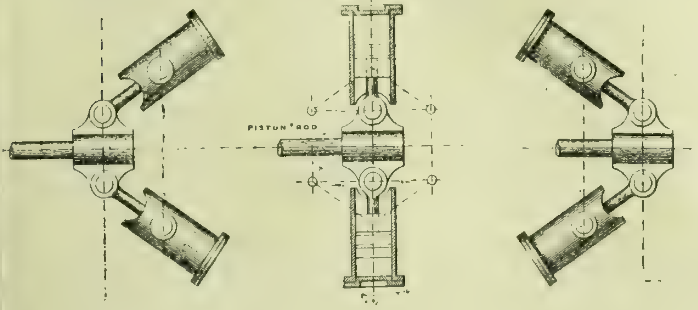


Fig. 2.

On page 130 will be found an illustration of a large high-duty pumping engine, and at figs. 1, 2, 3 we give details of mechanism and diagrams, from which will be seen the methods by which considerable expansion in the steam cylinder is attained without the intervention of flywheels or other heavy moving masses. We may first state the distinctive feature of all these duplex pumps lies in the use of two distinct steam cylinders and pumps placed side by side, and so arranged that the slide valve of the one steam cylinder is actuated from the piston rod of the other. By this contrivance the steam pistons or piston valves common to other direct-acting pumps are dispensed with, and only plain slide valves required. The two pistons act in concert, so that one is always moving while the other is stationary; consequently both valves are never at rest simultaneously, and there is no tendency to stop in any position without starting again, however slowly the pumps work.

The gear designed to equalise the varying pressure in the steam cylinder caused by expansion is shown at fig. 2, and it consists of two oscillating cylinders working on trunnions placed opposite to each other at the centre of the piston stroke. Single-acting pistons work in them, and connect to the piston rod as shown. Air or water pressure from suitable reservoirs press them outwards. When the steam piston commences its stroke at the full boiler pressure the compensating cylinders point in the direction (fig. 2 position 1), and resist the movement of the piston. The resistance diminishes as the middle of the stroke is reached, and at the middle, in position 2, the air cylinders thrust against each other, and have no effect on the steam piston. As the middle stroke is passed the compensating pistons give out more and more power and aid the steam piston, the effort being greatest at the end of the stroke, when the steam pressure is at its lowest. The effort of the steam is resisted at the first part of the stroke, and reinforced at the latter part. In the engine illustrated, shown in section (fig. 1), and in external appearance above, four steam cylinders are used—two to each pump, high and low pressure. The united effect, when combined, is shown at fig. 3, from which will be seen the uniformity of the thrust during the whole stroke. Fig. 3 shows indicator steam diagrams and pump cylinder diagram. By this device the pressure upon the piston rod is made exceedingly uniform, and yet great expansion and variation in the steam cylinder is allowed. Tests have been made of the duty obtainable from these pumping engines by Mr. J. G. Mair, M.Inst.C.E., and others, with exceedingly good results. The stroke of each engine was 26in., and the high-pressure cylinder was 1ft. 6in. diameter, the low-pressure 3ft. diameter. Double steam ports were used, as in all Worthington engines, so as to cushion efficiently.

In one trial the four cylinders indicated between them 130·5 horse power, and showed in the pump diagram 120·4 I.H.P., or an efficiency of 92 per cent. The piston speed per minute per engine was 86·9ft.; boiler pressure, 101lb. per square inch above atmosphere, and the number of expansions 14·1. The consumption of coal per I.H.P. per hour was estimated at 1·70lb.

These results are exceedingly interesting, as showing the high efficiency possible without the use of flywheels for equalising the effort of the varying steam pressures. It would be interesting to compare these performances with those of the best direct-acting pumping engines of English design. Messrs. Simpson and Co., engineers, London, are the makers of these high-duty pumping engines in this country.

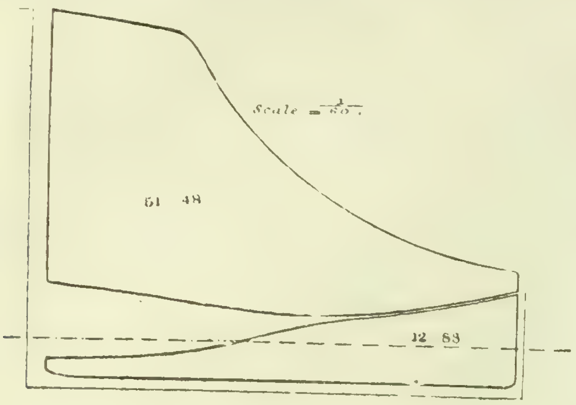
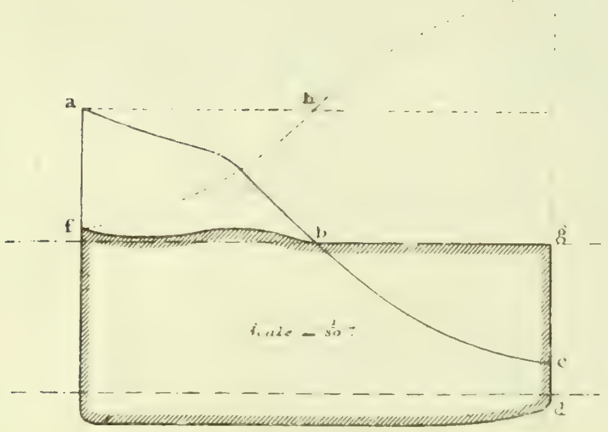


DIAGRAM FROM ENGINE. NEW BEDFORD W. W.

Figs. 1.



COMBINED DIAGRAM. NEW BEDFORD W. W.

a b c d e a *shews Combined Diagram of H. P. and L. P. Cylinder.*
f h k. *shews resultant Pressures from Compensators.*
f b g d e f. *Diagram of effective Pressures on Piston Rod.*

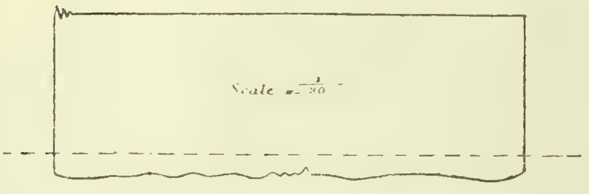


DIAGRAM FROM PUMP. NEW BEDFORD W. W.

Fig. 3.

Great Increase of Steam Machinery in Germany. Nothing can better exemplify the commercial and industrial activity which of late years has characterised Germany than the great increase which has taken place there in the use of steam engines and boilers. It is remarkable also that all such articles in use are of improved pattern—or most of them. The boilers representing over 100 horse power now in use in Germany amount to about 2,600, and those of 100 horse power and under amount to about 2,592.

SILICON IN CAST IRON.—III.

III.—Is the Silicon in the Pig Imparted to other Irons without Loss?

That is, will ferro-silicon hold its silicon until mixed with irons deficient in silicon; and, for making such mixtures, will high or low silicon iron lose most silicon?

To arrive at conclusions regarding these questions, we made four series of melts. Each series was composed of four casts and each cast of six sets of test-bars. We used for these a white-iron base (376), with 0·186 per cent silicon, and a grey-iron base (253), with 1·249 per cent silicon; and for adding silicon we used the first pig of "Pencost" (397), before spoken of, containing 4·36 per cent of silicon, and the fifth pig (401), containing 10·34 per cent silicon.

The first series was white (376) and 4·36 per cent of ferro-silicon (397).

The second series was white (376) and 10·34 per cent of ferro-silicon (401).

The third series was grey "FLM." (253) and 4·36 per cent of ferro-silicon (397).

The fourth series was grey "FLM." (253) and 10·34 per cent of ferro-silicon (401).

The four numbers of each series were to contain respectively 1·5, 2, 2·5, and 3 per cent of silicon. Having been weighed with great care, they were melted so as to avoid oxidation, and were cast into bars and tested, when each set of bars was analysed with the results shown in the following table:—

Table V.

Percentage of Si. calculated to be in Test-bars.	Number of Test.	Silicon found in Bars White (376) and 4·36 per cent Pencost (397).	Number of Test.	Si. found in Bars White (376) and 10·34 per cent Pencost (401).	Number of Test.	Silicon found in Bars Grey FLM (253) and 4·36 per cent Pencost (397).	Number of Test.	Silicon found in Bars Grey FLM (253) and 10·34 per cent Pencost (401).	Losses of Silicon in White (376) and 4·36 per cent Pencost (397).	Losses of Silicon in White (376) and 10·34 per cent Pencost (401).	Losses in Silicon Grey FLM (253) and 4·36 per cent Pencost (397).	Losses of Silicon in Grey FLM (253) and 10·34 per cent Pencost (401).
1·50	340	1·49	344	1·48	348	1·50	352	1·53	—·01	—·02	±·0	+·03
2·00	341	1·97	345	1·92	349	2·01	353	2·11	—·03	—·08	+·01	+·11
2·50	342	2·55	346	2·42	350	2·42	354	2·41	+·05	—·08	—·08	—·09
3·00	343	2·95	347	2·87	351	2·86	355	2·86	—·05	—·13	—·14	—·14
Average deviation from calculated per cent......									·03	·08	·06	·09

A careful examination of this table reveals the following facts:

1. Losses in silicon increase as the percentage of silicon in the mixture increases; that is, an iron deficient in silicon can have its silicon raised to 2 per cent with less loss than if raised to 3 per cent.

2. Losses are slightly higher when using the 10 per cent than with the 4 per cent iron; but the losses are so small in all cases that no commercial discrimination can be drawn in favour of one class over another in the matter of economy of silicon. In the extreme case of melting a white iron and a 10 per cent silicon metal together, to produce a dark soft foundry iron, there was no excessive loss in silicon.

IV. General Conclusions.

We may draw from the results presented the following general conclusions:—

1. Pig irons of any grade may be melted and cast without excessive loss in silicon or excessive change in chemical composition.

2. Ferro-silicons lose in re-melting a little more silicon than do the softeners containing less silicon; but the difference is so small that commercial distinction is not possible.

3. In alloying silicon irons with scrap or pig iron deficient in silicon, the silicon is practically all retained in the mixture, and no economy in silicon results from the use of one class of American silicon iron over another.

4. American ferro-silicon, so far as we have investigated, is more economical than the imported, and probably, in most cases, softens to a greater extent.

We think that we have accomplished what we set out to do. Our discussion is altogether from a chemical standpoint, and we have proved that the founder can produce a desired grade of casting by compounding suitable irons, as cheaply, if not more so, than by purchasing irons in which the combination is already what he desires.

As soon as we can prepare a report upon the physical characteristics of these irons and the mixtures that we have made, we shall publish such results.

A GERMAN SMOKE-CONSUMING FURNACE.*

The progress made in various industries has attracted considerable attention to the question of smoke consumption, and numerous suggestions have been made for its accomplishment by many who have not realised the difficulties which surround the problem. Although generator firing has been extensively applied in gas manufacture, smoke-consuming furnaces are rarely used for steam boilers, on account of the costly nature of the arrangements required, and the difficulty of applying them to existing boiler settings. A simple and cheap smoke-consuming and fuel-economising arrangement is to be found in the furnace of Mr. Wilmsmann (mining director of Hagen, Westphalia), which can be easily applied to all descriptions of boiler and other furnaces. The arrangement consists, mainly, in converting the front part of the furnace into a generator chamber, by forming a fire-brick shield and division wall above the firebars, near to the bridge of the furnace, to keep the gases and smoke from going direct into the flues; the fuel being put into the furnace so that it slopes up against the shield, and the gases and smoke being compelled to pass through a red-hot layer of fuel, thus ensuring their perfect combustion. In starting the furnace, the fuel is at first burnt for three-quarters of an hour in the same manner as with an ordinary furnace, but with the difference that the incandescent layer of fuel is gradually increased in depth until there is sufficient to form an inclined heap against the baffle, and thus close the combustion chamber from the fire space. As the coal burns, carburetted hydrogen is liberated and combines with the air entering through the firebars, while the coal, partly converted into coke, burns off with a further supply of air. The gases formed on the upper surface of the red-hot coals in the combustion chamber are conveyed through channels at the top of the furnace into the back chamber, where they require a secondary air supply for complete combustion, for which heated air is supplied through air channels regulated by dampers.

The formation of smoke, which occurs with ordinary furnaces after supplying fresh fuel, is entirely avoided with the Wilmsmann furnace, if the gas chamber is separated from the fire space and the flues, by the glowing layer of fuel. The principle of this system of firing is similar to generator furnaces for gas retorts, in which the hydro-carbons from the fresh coal have to pass a glowing layer of coke. In both cases carbonic acid is formed at the commencement of the combustion, which, by passing through the glowing coke, takes up a further quantity of carbon, and is reduced to carbonic oxide, and this, if sufficient air is present, is burnt to carbonic acid.

Many unsuccessful attempts have been made to apply generator firing to steam boilers, partly on account of the cost and partly from other difficulties, and also because—although, with intermittent working, the smoke could be consumed—there were other pecuniary disadvantages connected with it, but with the present extremely simple system smoke consumption must succeed; in fact, about 600 Wilmsmann furnaces have been put to work within the last few years for steam boilers, smelting, puddling, and other furnaces in the Rhenish provinces, Westphalia, and the South German States, and most favourable testimonials have been received, not only with regard to the prevention of smoke, but also as to economy of fuel, varying from 15 to 30 and even 40 per cent as compared with ordinary furnaces.

Experiments as to steam-production have been made with a horizontal Cornish boiler, fired with an ordinary and also with a Wilmsmann furnace. With an ordinary furnace a trial of eleven hours was made, during which the consumption of coal was 1,109lb., and the water evaporated 7,045lb., the average feed-water temperature being 104° Fahrenheit, and the average steam pressure 4½ atmospheres. This gives 6·35lb. of water evaporated per lb. of coal.

With the Wilmsmann furnace, fitted to the same boiler, a trial was made for seven days of eleven hours per day. The total coal consumed was 4,916lb., and the water evaporated 46,751lb.; the average temperature of the feed-water was 140° Fahrenheit, and the average pressure of steam 4½ atmospheres, which gives 9·5lb. of water evaporated per lb. of coal. The coal used in both cases was Ruhr nut coal.

Mr. Vogt, chief engineer of the Berg Steam-boiler Examination Society, has also spoken very favourably of the Wilmsmann furnaces as being sound in principle, of great simplicity, and small in cost for fitting.

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* Inst. C.E. Foreign Abstracts.

THE LIMITS OF ANGULAR VELOCITY.

In dealing theoretically with the elements of machines, we find that in the majority of instances the sizes admit of being proportioned to any strain that can occur in practice, but in the case of rotating masses, such as wheels, there is an internal stress which varies directly as the weight of the revolving mass, and it will be shown that in the most favourable cases this stress will vary as the sectional area by which it is resisted; hence there must be a velocity at which rupture will ensue, dependent upon the ultimate tensile resistance of the material used.

Centrifugal force causes the stress to which we allude; it acts radially, but in case of failure of say a plain wheel, the rim will pull asunder and the fragments fly in directions determined by the velocity of rotation at the moment of rupture and the gravitation of the pieces set free. The strain causing their tearing asunder will be tangential in direction; therefore we must in the first place determine the relation existing between radial and tangential forces. This we shall do in the simplest way, avoiding complicated formulæ. In fig. 1 let $a\ b\ c\ d$ represent a section of a pipe subjected to internal liquid pressure, which acts equally in all directions. The tendency of the internal pressures is to tear the ring asunder. Draw any diameter $b\ d$, and draw the diameter $a\ c$ at right angles to it. Now, the force tending to burst the ring at the points b and d will be the sum of the forces acting parallel to $a\ c$, or the pressure per square foot multiplied by the diameter of the pipe in feet; hence the tangential strain on one section will be the force per square foot multiplied by the radius in feet.

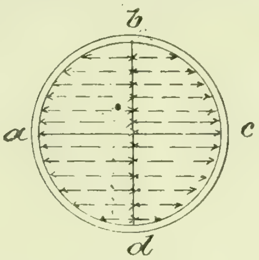


Fig. 1.

The force with which we have to deal as a radial force is centrifugal, and calling that $= C$ in pounds for one foot of periphery of the wheel, and $r =$ radius of the wheel, to the centre of gravity of its rim in feet, the tangential force $T = C \times r$. We will now find an expression for the centrifugal force of a mass revolving in a circular path. In fig. 2 let there be a body at a moving in the direction of the circle $a\ i\ f\ d$, with a velocity per second represented by the line $a\ b$ which is drawn tangential to the circle $a\ i\ f\ h$; were the body free it would pursue its course in the straight line $a\ b$, but not being so it is, while passing towards b, drawn to d, and it is the resistance to this deviation that constitutes the centrifugal force, and it is measured by $b\ d$. Draw $d\ e$ parallel to $a\ b$, and therefore at right angles to the diameter $a\ f$,

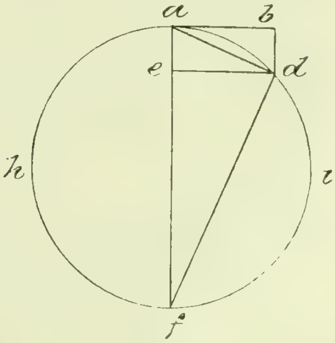


Fig. 2.

and join d; then because $a\,d\,f$ is an angle in a semicircle it is a right angle, and angles $a\,d\,f$ and $a\,e\,d$ are equal. It can be shown, also, that the angles $f\,a\,d$ and $e\,d\,f$ are equal, and the triangles $a\,e\,d$ and $a\,d\,f$ similar—$a\,e = b\,d =$ the measure of the centrifugal force. The force of gravity will cause a body to fall 16·1ft. in one second; hence if $a\,e =$ the distance corresponding to the centrifugal force in one second—

$a\,e : 16{\cdot}1 :: \mathrm{C} : w$, where $w =$ the weight of the body at a.

But from the similarity of the angles $a\,e\,d$ and $a\,d\,f$; $a\,e : a\,d :: a\,d : a\,f$, but $a\,d = v =$ velocity of body per second, for the space passed through being taken as very small, $a\,d$ may be regarded as equal to $a\,b$; and $a\,f = 2\,r$; therefore, $a\,e = \frac{v^2}{2r}$.

Replacing $a\,e$ in the first proportion, we have $\frac{v^2}{2r} : 16{\cdot}1 :: \mathrm{C} : w$,

whence, $\mathrm{C} = \frac{w \times v^2}{32{\cdot}2 \times 7}$.

Let A = the sectional area of the rim of the wheel in square inches, N = the number of revolutions per minute, $w =$ the weight of rim in lbs. per foot of circumference, v being, as before, velocity of rim in feet per second; then

$$v = \frac{\mathrm{N}}{60} \times 2r \times 3\,1416 = 0{\cdot}1047\ \mathrm{N}r\text{; therefore}$$

$$\mathrm{C} = \frac{w}{32{\cdot}2\ r}(0{\cdot}1047 \times \mathrm{N} \times r)^2 = 0{\cdot}00034 \times w \times \mathrm{N}^2 \times r.$$

Cast iron weighs 0·262lb. per cubic inch; therefore a bar 1ft. in length and 1in. square weighs 3·15lb., and the weight of rim per foot $w = \mathrm{A} \times 3{\cdot}15$; hence replacing w, $\mathrm{C} = 0{\cdot}00107 \times \mathrm{A} \times \mathrm{N}^2 \times r$; but as previously shown, $\mathrm{T} = \mathrm{C} \times r = 0\,00107\ \mathrm{A} \times \mathrm{N}^2 \times r^2$. The ultimate tensile resistance of fairly good castiron is 16,000lb. per square inch of sectional area; the ultimate resistance of the rim will be $\mathrm{U} = \mathrm{A} \times 16{,}000$lb. But at the moment of rupture the resistance is equalled by the tangential force derived from the centrifugal force; wherefore, $\mathrm{U} = \mathrm{T} = 16{,}000\ \mathrm{A} = 0{\cdot}00107\ \mathrm{A} \times \mathrm{N}^2 \times r^2$; $\mathrm{N}^2 = \frac{16000}{0{\cdot}00107\ r^2}$; and $\mathrm{N} = \frac{3867}{r}$. N will then be the velocity at which the wheel will be ruptured. Let the factor of safety taken be 4, then 16,000 becomes 4,000, and $\mathrm{N} = \frac{1933}{r}$

This formula applies where the section is uniform, as in fly-wheels, plain pulleys, and the like, but when cast iron is not used another constant must be employed in place of 16,000, and the proper weight per cubic inch also ascertained to give the value for w. The general formula will be

$$\mathrm{N} = \frac{1}{r}\sqrt{\frac{t}{0{\cdot}00034\ w \times f}}$$

where f is the factor of safety.

When the section is not uniform, as in toothed wheels, this formula will not apply. Let A equal the average area of the section, including teeth, and a the net section which runs uniformly round the ring. The centres of the sections will be at different distances from the centre of the wheel, but the difference will not, in comparison to the diameter of the wheel, be of sufficient importance practically to affect the issue; hence the radius of the outside of the running section will be taken as the value of r.

From one of the foregoing equations we have for the centrifugal force, $\mathrm{C} = 0{\cdot}00107\ \mathrm{A} \times \mathrm{N}^2 \times r$; and $\mathrm{T} = \mathrm{C} \times r = 0{\cdot}00107\ \mathrm{A} \times \mathrm{N}^2 \times r^2$; but $\mathrm{V} = a \times 16{,}000$; therefore $16{,}000\ a = 0{\cdot}00107\ \mathrm{A} \times \mathrm{N}^2 \times r^2$. From this,

$$\mathrm{N}^2 = \frac{16{,}000\ a}{0{\cdot}00107\ \mathrm{A} \times r^2}\text{; and } \mathrm{N} = \frac{1}{r}\sqrt{\frac{16{,}000\ a}{0{\cdot}00107\ \mathrm{A}}} = \frac{3867}{r}\sqrt{\frac{a}{\mathrm{A}}}.$$

Taking 4 as a factor,

$$\mathrm{N} = \frac{1933}{r}\sqrt{\frac{a}{\mathrm{A}}};$$

and the general formula will be

$$\mathrm{N} = \frac{1}{r}\sqrt{\frac{t\,a}{0{\cdot}00034\ w \times \mathrm{A} \times f}}.$$

INSTITUTE OF MARINE ENGINEERS.

At a meeting held at Stratford, last week, the formation of an Institute of Marine Engineers was proposed and discussed, and it was stated that sea-going engineers urgently required the advantages which such an institution could furnish in the matter of suitable rooms for meetings and reading the literature of the day while on shore. Young marine engineers especially, whose home was mainly their ship even while in harbour, would greatly benefit by it. The object was chiefly to provide a suitable place where they could spend their evenings, with reading room, library, and such amusements as the council would sanction. Papers would also be read upon interesting engineering matters, and the members would join in discussion upon them. Funds were available for the library from a fund known as the Campbell Memorial Fund, and, besides, Mr. MacFarlane Gray had been good enough to offer several volumes.

Three classes of members were proposed—members, associate members, and associates, as well as a graduate class, to be formed of apprentices who intended making marine engineering their profession.

A motion favourable to the proposition was moved by Mr. Lester, and seconded by Mr. Fish (chief engineer P. and O. Company). The chair was taken by A. Belsam, Esq., supported by Messrs. Lester, W. T. Craig, A. W. Robertson, J. Nelby, J. W. Domoney, and Jas. Adamson. We think there is scope for such an institution, and wish it every possible success.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STEAM ENGINE EFFICIENCY.

To the Editor of "The Practical Engineer."

Sir,—I thank "L. C. D." for his complimentary remarks in your last issue on my letter of the previous week. Now, "L. C. D." asks several queries with reference to my remarks, which I will endeavour to explain. He wishes to know to what extent I would reduce the boiler pressure, and also whether the extra lap on low-pressure valve would not be detrimental to the working of the engine?

Under existing circumstances, and with the light load on the engine, reduce the boiler pressure to 70lb., as per gauge, and slightly regulate your automatic cut-off gear, so as to prolong the duration of admission to about 0·33, one-third of the stroke in the smaller cylinder, which reduces the total number of expansions to about nine-fold. At present, the engine is working with a twenty-fold expansion. Experience has shown that so high a ratio of expansion as 1:20, with a cylinder ratio of 1:3, as in your case, cannot be adopted without loss. By adding a reasonable amount of lap on the slide valve of the low-pressure cylinder you have a better distribution of power, less condensation, and useless expansion of steam between the cylinders. By this means the steam can pass from one cylinder to the other without losing its effect, as every particle of expansion that takes place otherwise than in moving the piston is useless, and so much work lost, and causes increase of back pressure on the smaller piston. Now, I consider a reasonable amount of back pressure necessary in a well-arranged compound engine. The prevailing objection to back pressure is, that it impedes the motion of the high-pressure piston; but at the same time, whatever back pressure retards the smaller piston, the same pressure is propelling the larger piston with a greater force, according to the relative areas of the cylinders.—Yours, &c., A. Evans.

To the Editor of "The Practical Engineer."

Sir,—With the diagrams R. Bramall has sent he has not given the diameters of the respective cylinders to which they belong, and therefore has not shown that the alteration made in the low-pressure valve resulted in more power from the same steam, or that less steam was used to generate the same power than before the alteration. With respect to his remarks about guaranteeing to economise steam when the expansion line gets below the atmospheric line, I beg to say that the laws connecting the absolute pressures, temperatures, and energy of steam have no connection whatever with atmospheric pressure or the position of the atmospheric line on the diagram. We may suppose a condensing engine working on one of the highest mountain tops in the world, while another similar and equal engine in every respect is working in a deep mine, under similar and equal conditions as to absolute pressure, grade of expansion, back pressure, &c., both engines, in fact, doing equal amounts of work with equal quantities of steam. Under the above conditions the diagrams taken from each engine would be exactly similar and equal, with the exception of the atmospheric line of the mine engine being about three times as far from the bottom of its diagram as the atmospheric line of the mountain engine is from the bottom of its diagram. How about economising in the one case more than the other?—Yours, &c., W. A.

ENGINEERING QUERIES

To the Editor of "The Practical Engineer."

Sir,—I wish to draw the attention of the correspondents to the query department of *The Practical Engineer* to the necessity of supplying sufficient particulars in their queries upon which a correct answer may be founded. Queries are constantly appearing asking for definite information on a certain subject, while very indefinite data are given, and it seems that readers do not fully realise that details of the subject upon which they seek information ought to be supplied ; or shall we say it is from want of thought that often some important item is omitted without which it is a mere waste of time to make calculations to advise them, as the assumed quantities may not be sufficiently near the actual for the result to be of any real value to them. Recently we have had ample proof that the readers of this paper are quite willing to render (according to their abilities) assistance to their fellow-readers, but for lack of proper information only approximate results can be given. To my mind this point cannot be too strongly emphasised—that in all existing machinery some special feature must remain constant, such as boiler pressure, stroke, or revolutions where indicated horse power is being considered, or, in questions dealing with valve gear, the travel of valve, stroke of engines, and connecting-rods centres, must be stated before it is possible to make any definite suggestion to alter the same. Trusting these remarks may have the desired effect, yours, &c.,

ORION.

QUERIES AND REPLIES.

12. MOST ECONOMICAL TYPE OF ENGINE.—Will some reader kindly inform me which type of engine is best for factory purposes, as we think of replacing our present engine by one of the most improved and economical type. What dimensions should give 250 I.H.P., and which is best—beam, vertical or horizontal ?—T. H. P.

Answer.—In reply to "T. H. P.," it may be stated that the beam engine is now seldom employed for factory purposes, the vertical or horizontal engine being much preferable, and the choice between them depends upon the ground space at disposal. If the floor space is limited, the vertical would be most suitable to adopt, while, on the other hand, if no such limitation existed, the writer would recommend the horizontal type of engine. The next thing to consider would be the boiler pressure, and this should be from 80lb. to 100lb. per square inch above the atmosphere. In order that the full benefit of this pressure may be advantageously used, the engine should be compound. If it is desired to introduce the most recent improvements, the triple-expansion should be adopted. This type is more economical than the ordinary compound, and although it has not been employed to any great extent for driving mills, &c., yet it will in its turn supplant the ordinary compound engine. Its extra first cost is amply repaid by the reduction in the consumption of fuel. However, whether the compound or triple expansion is adopted by "T. H. P." the engine should be condensing. An economiser ought also to be fitted.—ORION.

13. LEAKAGE IN BOILERS.—I have charge of a 7ft. 6in. Lancashire boiler, recently put down. The shell is made with two plates to a ring, longitudinal seams, butt joints, with covers on both sides. The seams in the lower part of the boiler are just above the seating blocks ; the seams on the left hand of the boiler in the side flue leak at the ends of the cover strips on the outside belts of plating, there being leakage at every joint except the front end angle-irons and the flanged back end. We have had them fullered and made right twice now, and the boiler-maker says they will leak again, and he cannot tell the reason why. Every other part of the boiler is quite tight. Boiler is fed from a well, all the sediment is held in suspension, there being no scale and very little deposit. Economisers are used ; we burn 30 tons per 65 hours ; draught takes under bottom first splits at front and down sides ; bottom flue is 3ft. 6in. by 1ft. 6in. Can any of your readers account for this leakage, which to me is most extraordinary ? Feed valve is at right-hand side, with 10ft. of internal pipes.—ENGINE-MAN.

Answer.—The leakage is certainly of an extraordinary or peculiar nature, which is difficult to advise upon unless the conditions be inquired into more closely, or an examination be made by an expert. The fact that all the butt strip joints at one side are leaky, and all others tight, tends to prove that the trouble is more likely to be due to some peculiar condition of working than to any structural defect. Certainly it cannot be due to hard work, as 25lb. of fuel per square foot of grate is not a very heavy consumption, which, with grates 7ft. by 3ft., is nearly the rate of consumption. Is "Engine-man" sure that the solid matter is carried into the boiler in suspension, as with well water the solids—often carbonate of lime or magnesia—are carried in solution, and such deposit would not be in the form of scale unless sulphates were present in appreciable quantities ; but I would state that a small quantity of carbonate of lime or magnesia is often more troublesome than a much greater quantity of sulphate of lime in the form of scale. However, I do not think the deposit has much to do with the present trouble. Is "Engine-man" sure the flues are properly constructed, and open through ? Are the butt straps of the shell plates jump-jointed, or are they thinned at the ends and tucked under ? For instance : If the inside straps of the outer ring of plates are not thinned at the ends and tucked under the plates forming the inner ring of plates, the joints would be difficult to make good, and if not made good at the first fullering or caulking, they would certainly be most difficult to make tight afterwards. One or two firms make the strap ends to butt up against the edges of the adjoining plates, and make what they are pleased to call an "engine-work fit." This is all very well for new work, but not favourable to hard or severe working. Most boiler-makers know that butt caulking is never reliable. Has "Engine-man" had the boiler examined by an inspector ? What is the working pressure ? What thickness are the plates and butt strips ? If the cause is found out and remedied, it will much interest your readers to know the particulars.—CHALKLINE.

14. CONDENSATION IN RECEIVER OF COMPOUND ENGINE.—Will some reader kindly inform me what is about an average condensation to lose from one cylinder to the other ? I have a pair of compound horizontal engines, side by side, cranks set at quarter centres, high pressure 18in., low pressure 28⅝in., 5ft. stroke, 34 revolutions, driving 223 horse power, cut-off in high pressure cylinder five-tenths of stroke, with 23lb. of back pressure. I only get 15lb. of steam on low-pressure cylinder. I lose 9lb. from one cylinder to the other. I have a receiver betwixt the two cylinders of the same area as the high pressure in cylinder. Is my receiver too large ? What must I do to get a little more steam on low-pressure cylinder ? I shall be much obliged if someone will answer me as soon as possible.—J. P., Chorley.

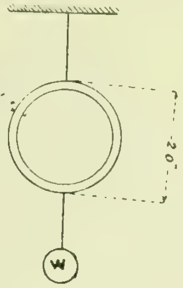
Answer.—In reply to "J. P.," Chorley, he ought to have his cylinders and receiver protected to prevent radiation, and it may be that the steam passages between his cylinder are long, tortuous, and contracted, so as to prevent the steam getting free access to the low-pressure cylinder, which is a very common case, and ought to be examined, as the steam certainly will go if allowed room to do so.—W. A.

Answer.—About 5lb. drop between the high and low pressure cylinders of compound engines, with cranks set at 90 deg., has been the writer's experience, and the excessive drop in the case spoken of by "J. P." may be due to the cut-off in the low-pressure cylinder being too late ; also if the opening for steam be small, the velocity will be too high ; consequently wire drawing of the steam may take place, and the steam line of the indicator card will drop considerably ; or again, if the exhaust edges of the slide valve are late in closing, the compression will be slight, with the result that the clearance space is filled with steam at a pressure much below that of the high-pressure exhaust, and directly the valve opens for steam, the pressure in the clearance space has to be increased, with a consequent drop in the receiver. The receiver is certainly not too large ; the writer advocates a good sized receiver as a decided advantage, as the pressure remains steadier. If "J. P." pins strips on the steam edges of his low-pressure slide valve, and so makes the cut-off in that cylinder earlier, his initial pressure will be augmented, but the velocity of admission must be prevented from rising too high. Does "J. P." combine his indicator cards so as to form a continuous diagram, as it is only by so doing that the real drop between the two cylinders can be accurately measured ; and if the diagrams are not taken simultaneously, care must be taken that the boiler pressure does not fall, as in such a case the low-pressure card would show a drop, although it is really the boiler which has been at fault.—ORION.

2. VARNISH FOR PAPIER-MACHE GOODS.—Would some reader kindly inform me how to make the black varnish that papier-mache goods are coated with ? I want it so that it will not peel off the card. How is the glaze put on after the goods are varnished ?—J. T. L.

7. BLACKLEAD PENCIL MAKING MACHINERY.—Can any reader inform me where to obtain the raw plumbago for making ordinary blacklead pencils, also the mode of manufacturing same, and the name of any makers of pencil machinery ?—B. B.

15. STRENGTH OF RING.—Will some reader show how to find the strength of a ring made of 2in. diameter wrought iron, and 2ft. outside diameter, which has a weight suspended from its lowest point, and is supported by a chain fixed above, as shown in sketch ? I wish to see the calculation, ultimate strength, safe load, &c. How would it resist collapse if the tensions became compressive pressures ?—STYLEX.



16. SETTING CORLISS VALVES.—Would some reader kindly inform me which is the best method of setting Corliss engine valves ?—ENGINEER.

17. CAN anyone inform me where a copy of "The Practical Boiler-maker," by S. Nicholls, published by the author, can be obtained ? I have written to Blackpool, where the author formerly resided, but the letter has been returned.—I. W.

18. VACUUM IN CYLINDER.—Can any reader say what is the cause of bad vacuum in the cylinder of an engine I have ? In the condenser it is 13·75lb. to 14lb., and in the cylinder of the engine only 10lb.—CONDENSER.

19. TRUEING-UP EMERY WHEEL.—Will some reader inform me of the best method of trueing-up emery discs which have become smooth and glazed ?—PRAECEPTUM.

20. LOOM.—What is the best book on the loom and its construction ?—ANXIOUS.

TO CORRESPONDENTS.

INQUIRER, Wakefield.—You can readily get wrought-iron pipes 7in. or 8in. diameter for steam supply purposes. We have seen such pipes screwed, but they are better with screwed or riveted and faced flanges. They cost more than cast iron, but are well worth it. The Credenda Tube Company will no doubt supply you. See our advertising columns.

X. Y.—The area of any circle is obtained by squaring the diameter and multiplying by 0·7854.

LOCO. DRIVER, Ship Canal.—Your question is not clearly put. Please write again and state your meaning more fully and definitely.

AIR.—Please state your question more fully. What is the air to be used for ? Is it to discharge from the four ⅝ pipes into the atmosphere, or are they to supply some machines ?

R. D., Bristol.—We shall describe and illustrate Berry's pulsating pump in our columns shortly.

DRAUGHTSMAN, London.—The weight of steam required for any given engine per horse power per hour depends entirely upon the type, cylinder clearances, dryness of steam, and condensation in the cylinder, compound or non-compound. The indicator diagram never accounts for the whole steam ; that is, steam calculated from it always comes out low. No absolute rule can be given ; tests have been made in which as little as 14lb. of steam has been used per I.H.P. per hour.

T. H. J.—We propose describing shortly in our columns a hydraulic pump as applied for pumping water.

P. R. B., Meersbrook Bank.—We have been unable to find the name of the inventor of the pump you mention. You may find it in the Foreign Abstracts of the Institute of Civil Engineers, last year.

MISCELLANEA.

Bell's Asbestos Co., Limited.—This company has had a most prosperous year, and its business continues to grow rapidly. We observe from the directors report now before us, that the dividend paid during the past year amounts to the very handsome proportion of 22½ per cent.

Ingenious Pipe-iron Machinery.—Probably the most marvellous hydraulic machinery in the world was placed in operation in the Weatland Rolling Mill, at Sharon, Pa., Jan. 15. It is the invention of Mr. Mattocks, of Pittsburg, and is designed for rolling pipe iron. Huge slabs of iron, weighing hundreds of pounds, are pulled from a furnace, glowing at white heat, and placed on a long iron bed, which moves forward, upward, downward, and sideways, pushing the mass through rolls, back again, and stopping only when it has been reduced to the proper size in the shape of pipe iron. The whole operation requires the attendance of only one or two employes, who control the machinery by a few simple levers. The saving in labour is in the proportion of sixteen to one.

The Mineral Resources of Chili.—Among the many valuable minerals found in Chili, the most important are copper, lead, silver, gold, cobalt, nickel, borax, borate of lime, nitrate of soda, magnesia, iron, kaoline, and plastic clay. The kaoline is found in thick beds in the Cordilleras, and is noted for its purity, while plastic clay of excellent quality is found in the neighbourhood of Lotu and Carnel. Nevertheless, owing to the scarcity of labour, there are at present more mines abandoned in Chili than worked; but as the tide of emigration is setting in towards that country, and immigrants receive great support from the Chilian Government, the mines that have been temporarily closed will no doubt shortly be reopened as soon as good roads have been constructed in the Cordilleras. Fresh mines of gold and silver are, however, being constantly discovered, and this of itself also partly accounts for the less productive mines being abandoned. The exportation of saltpetre is carried on on a vast scale, and will certainly increase as soon as the communications in the interior have been opened up.

Engineering Society, King's College, London.—At a general meeting of this society, held in London, on Tuesday, Feb. 12th, the president in the chair, Mr. Dering Beale read a paper on China Clay and Mining. The author divided the subject into three parts. (*a*) The derivation of the clay. (*b*) The refinement from its natural state. (*c*) Its uses. He stated that before granite rock was formed the materials composing it existed in a state of fusion, and that by the subsequent cooling of this solution crystals of quartz, felspar, and mica combined to form the rock called granite. By the decomposition of this rock china clay is formed, its constituents being silica, alumina, and water. In its native state, china clay generally occurs in extensive masses beneath several feet of superstratum, termed overburden. The general aspect presented by clay-bearing ground is that which is locally known in Cornwall as slad, being a hollow depression in the side of a hill, which catches water as it drains from it, the water percolating through the soil assisting the decomposition of the granite beneath. The author gave a detailed description of the apparatus called micas, for getting rid of the impurities, and explained the different parts by means of diagrams. He then described the settling pits and drying houses, concluding with an account of the uses of china clay in the various arts.

The Zalinski Gun.—Further tests of the Zalinski gun were made in the New York harbour recently with successful results. Eight projectiles were fired from the gun used a week earlier. Of these seven contained 175lb. of 75 per cent dynamite, and all were constructed with a hollow tail of the same size as the shell, upon which were a number of small flanges meant to keep the course true. Three chloride of silver batteries were in each shell for exploding, two being already active, while the third was dry, and was made active as soon as the water struck it. The conditions of the trial were that 50 per cent of the shells should strike and explode within a rectangle of 150ft. by 50ft. over a mile from the firing point. The first shell, after a beautiful flight, struck the water 2,048 yards away, but no explosion followed. It was said by observers near the end of its course that the shell broke in two just before striking the water. The second projectile, fired 15 minutes later, seemed to follow exactly the same course, and struck the sea at 2,032 yards distance, and exploded, throwing up a great mass of foaming water into the air. The third shell went in the same direction, producing the same results at a distance of 2,140 yards. The fourth, fifth, and sixth shots quickly followed, all seeming to describe precisely the same curve, and all, like the third, striking the water within the rectangle and causing the usual explosion.

Experimental Steel Ordnance.—The United States Government has been making some interesting experiments with cast-steel breech-loading guns. The present method of constructing large steel guns is to cast a solid cylinder of the requisite length, which is then bored out to the calibre of the intended gun and strengthened by shrinking on successive coils of wrought iron or steel. The American experiments were designed to test the possibility of casting a complete gun which should have sufficient transverse and longitudinal strength to withstand the enormous pressures engendered by the modern brown cocoa and other slow-burning powders. A certain measure of success having attended a small gun of 3in. calibre, a larger casting was made, which when bored, turned, and finished formed a gun 16ft. long by about 6in. calibre. This was tested by a charge of 38lb. of brown Westphalian powder, with a projectile weighing 100lb. The first round was in every respect satisfactory, and the gun appeared to be uninjured. The charge for the second round was increased to 48lb., and the constructors were confident of being able to fire 10 rounds of this before proceeding to larger charges. Unfortunately at the moment of discharge the part of the gun forward on the trunnions accompanied the shot for some feet, and the breech, which should have been the strongest part, was completely shattered. The ordnance officers at Woolwich have been regarding these trials with much interest, for, if successful, the mode of making all large guns would have been altered, but they consider that it has now been proved to be impossible to obtain sufficient strength in a cast gun without chase hooping.

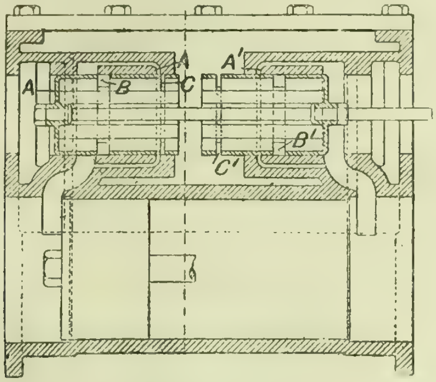
Electrical Stress.—Professor Rücker, at the Royal Institution, delivered a lecture, in which he discussed the effects of the introduction of electrified conductors into non-conducting, or nearly non-conducting, liquids. The subject had been studied by Faraday, Kerr, Quincke, W. Holtz, and others, but various difficulties had prevented some of the more striking phenomena being shown in experimental lectures. The lecturer and Mr. Boys last year devised a set of apparatus which made the exhibition comparatively easy. Faraday's magnetic lines of force could be shown by the aid of iron filings, but the corresponding experiment in the case of electrical lines of force in a liquid was more difficult, because the liquid was thrown into violent agitation, and the solids used tended to cluster about one of the poles. These points were illustrated by experiment, and the lines of force were realised by means of powdered antimony, immersed in ether. The tendency of the lines of force to become shorter and to separate the one from the other was also illustrated, and from this the fact was deduced that a body subject to electrical stress assumed temporarily a kind of crystalline structure. Kerr's and Quincke's experiments on the passage of polarised light through carbon bisulphide were then discussed. Kerr's experiments depended upon the fact that since the electrical stress was a tension along the lines of force and a pressure at right angles to them, a substance in which such a stress was produced assumed a semi-crystalline condition in the sense that its properties along and perpendicular to the lines of force were different. Light was therefore transmitted with different velocities according as the direction of vibrations coincided with or was perpendicular to these lines, and the familiar phenomena of the passage of polarised light through crystals might be imitated by an electrically stressed liquid. These researches were exhibited with various modifications and extensions. Finally the lecturer referred to some outstanding problems which had not yet been completely solved.

The Electric Light in Lighthouses.—In this month's number of the *Fortnightly Review* some remarkable evidence respecting the electric light is given by Professor Tyndall. It appears that the most modern, and by far the most powerful development of the electric light, has been fixed by the Trinity House at St. Catherine's Lighthouse, Isle of Wight. It has been stated, and widely circulated on behalf of the Trinity House, that this light possesses the enormous illuminating power of 7,000,000 candles. This startling statement naturally arrested Professor Tyndall's attention, and he determined to investigate the matter. He sent a "trained" observer to St. Catherine's to watch the performances of the light, and he intercalates in his article passages from the report of his deputy. On January 4, 1889, during three hours' observation, the light was continually varying in power, and actually went out no less than seventeen times. He gives the particulars and duration of these extinctions, some of them being for more than a minute. On 5th January, a fog totally eclipsed the light, nothing was to be seen but a dim, dark mass of fog, and during its continuance a vessel actually went ashore about 2¼ miles west of the lighthouse. The professor invites the Elder Brethren of the Trinity House to consider the really relevant facts of this case. He says that the supreme glory of the electric light in clear weather is uncontested and incontestable, but the 7,000,000 candles have no real meaning for the public. The light is reported by the best authorities to be too "bright and dazzling," and therefore "misleading" as to distance. Professor Tyndall contrasts this unsatisfactory performance of the electric light with the lighthouse gaslights used in Ireland, which never go out, and are absolutely constant in their illuminating power; quotes the testimony of sea captains that when the light of a gas lighthouse is perfectly invisible through fog, the mariner is able to determine his position from the peculiar glow or glare which the gaslight casts on the fog surrounding it, and states that the unvarying testimony of those who have been consulted as to the St. Catherine's Point electric light, including those who describe it as in clear weather magnificent, is that in fog "it is useless." There is surely, he says, a case made out here for examination—whether the gaslight, if applied at its maximum power, would not prove a better friend to the sailor in foggy weather than the splendid electric luminary established at St. Catherine's.

ILLUSTRATED PATENTS.

13,052. Piston Valve for Steam Engines, P. Armington, 12, Franklin Street, Providence, Rhode Island, U.S.A.

The two portions A, A¹ of the valve are made hollow, being closed at one end and open at the other, as shown. They are also of considerable length, to correspond approximately with the length of the cylinders in which they work. They are each furnished with two admission ports B, B¹, and C, C¹, acting in conjunction with corresponding ports in the casing. The exhaust takes place at the outer ends of the valve, or in a modified form at the centre; in the latter the two portions of the valve are reversed on the spindle. The ports C, C¹ are smaller than the others, and act as auxiliary ports to give a rapid opening.—September 27, 1887. [8½d.]



13,089. Locomotive and other Steam Engines, L. Durant and A. Lencauchez, 53, Rue de Chateauden, Paris.

Relates to engines in which the admission valves are separate from the exhaust, and are worked independently by a link motion, whilst the latter are worked by an invariable gear. Valves, distributing: The valves may be either slide valves or of an ordinary oscillating or rotary cylindrical type. In the latter case either two separate admission and two separate exhaust valves may be employed, or only one of each. The steam admission valve J¹ (figs. 1 and 2) is always preferably above the cylinder and the exhaust valve J² below. When slide valves are employed, the admission valve and port face are adapted for admitting steam on both the inner and outer edges of the port at the beginning of the stroke, by the formation of a cavity in the port face communicating with the body of the valve chest. The invention is also illustrated with reference to a valve in which the steam is admitted internally. Valve gear: The steam valves are worked by any ordinary link motion so as to be capable of variable cut-off, but the exhaust valves are worked from a fixed eccentric, or by a reducing lever from the cross head, or again, when a stationary link is employed, from a lever oscillated by the link. Slide valves, balancing: In order to counteract the tendency of the exhaust valve to lift off its face owing to the pressure being only on the underside, the chest containing it is placed in communication with either the boiler or the admission valve chest by an adjustable pressure-reducing valve. The admission valve, when steam is admitted interiorly, may be similarly balanced, the same pressure-reducing valve in this case serving for both chests. Pressure-reducing valve: Consists of a cylinder communicating by a central branch M (fig. 13) with the valve chest, and having at one end an annular space M¹ into which the steam branch opens. In the cylinder slides a plug acted on by a regulable spring R at one end, and at the other by steam at the reduced pressure. The position of the plug is thus entirely dependent on the reduced pressure, and, according to its position, throttles the steam to a greater or less extent. Cylinder relief apparatus: This consists of a casing A (fig. 15) containing a pair of valves H H, which alternately open automatically on the exhaust side at the beginning of each stroke. They communicate with a common outlet C leading to the blast. Their function is to drain the cylinder and to do away with back pressure and cushioning. Cocks are provided for cutting them off from the cylinder. Watery steam, supplying to valve chest: This is effected, for purposes of lubrication, by a supplementary pipe connecting the valve chest with the boiler, from which the steam passes through a suitable pressure-reducing valve. This arrangement is only required when the steam enters through the interior of the valve. Preventing in-draught of furnaces, gases, &c., into cylinders: To prevent this on the reversal of the valves whilst running the exhaust is, by a pressure-reducing valve, constantly kept supplied with steam.– September 27, 1887. [1s. 2d.]

FIG. 1.

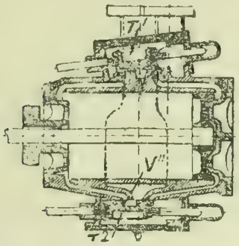


FIG. 2.

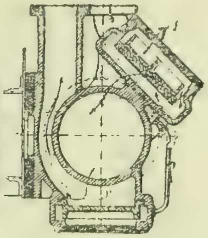


FIG. 13.

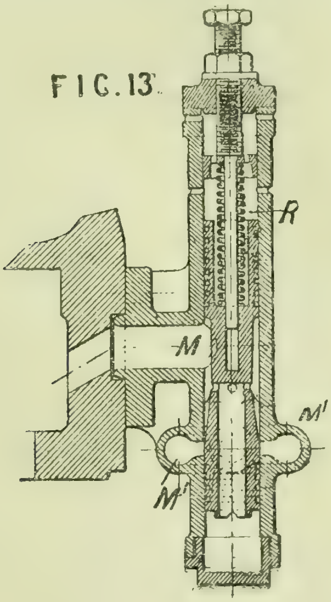
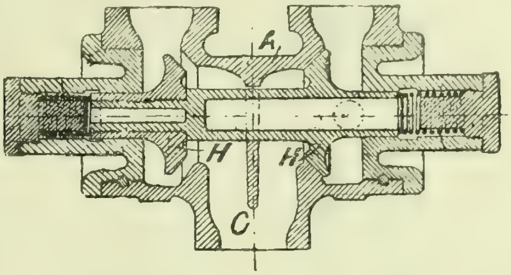
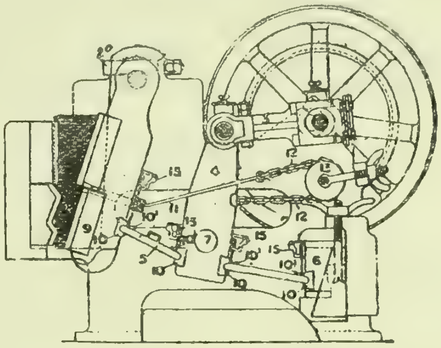


FIG. 15.



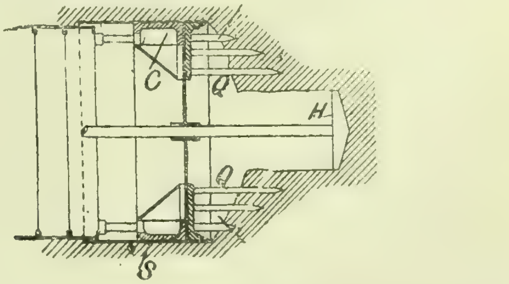
13,116. Stone Crusher, W. H. Baxter, 88, Chapel Town Road, Leeds.

Swing jaw, operating: The vertical lever 4, centred on a pin 7, carried in sliding bearings, is connected at its upper end to the crank shaft 1 by the link 3. At its lower end, below the fulcrum, it carries toggle bearings 10, 10, in which rest toggles 5, 5. The other ends of the toggles engage respectively in bearings carried by the swing jaw 9 and wedge block 6, and the construction is arranged so that the pressure on the block 6 shall be constantly downward. Swing jaw retracting: The jaw is connected with the lever 4 above its fulcrum by means of a link 11 and chain 12 passing over an adjustable pulley 13. Another retracting device consists of a lever and links jointed to the jaw and lever 4 respectively. Swing jaw, mounting: The frame is cast with an eye, in which the suspension pin is secured by a cotter 2c taking into a groove in the pin. Toggles, lubricating: Oil boxes 15, 15 are secured above the toggle bearings on the jaw, lever, and wedge block. The toggles are provided with inclined faces 10¹, by which the oil is directed to the bearings.—September 28, 1887. [8½d.]



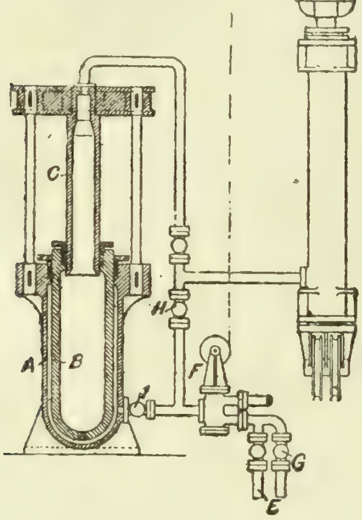
13,215. Shields for Excavating Tunnels or Shafts, J. H. Greathead, 8, Victoria Chambers, Westminster.

The shield S is made buoyant for working in water-bearing strata by air chambers, arranged round the periphery. By this means the sinking and downward deflection of the shield is prevented. A central boring head H is mounted on a shaft passing through the shield, the outer material being disintegrated by spikes or piles. The spikes Q are attached to the shield, and other spikes P are fixed to hydraulic plungers C, which advance the shield. The shield is retracted by the plungers by substituting for the piles P blocks, which butt against the material in front. Other piles, worked hydraulically, may be used, besides those attached to the plungers.—September 29, 1887. [8½d.]



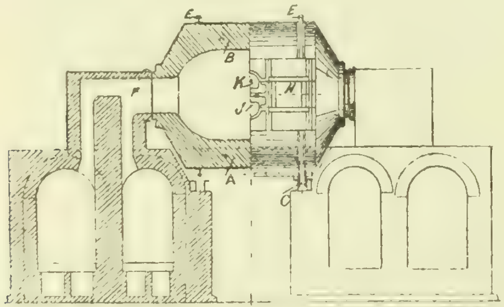
13,136. Hydraulic Cranes and Lifts, W. R. Green and R. Carey, Newington Ironworks, Falmouth Road, London, S.E.

The object is to multiply the pressure in the mains by means of an "intensifier," so as to work high-pressure machines. Such "intensifier" is seen to the left of the drawing, consisting of a cylinder A, into which low-pressure water is admitted, and a ram B, which in advancing slides upon the fixed ram C, thus discharging its contents into the working cylinder D. The pipes E, F are high-pressure connections to supply the working cylinder without using the intensifier, if high-pressure water is available; the cock G upon the low-pressure pipe and the cocks H, I of the intensifier being then closed.—September 28, 1887. [6½d.]



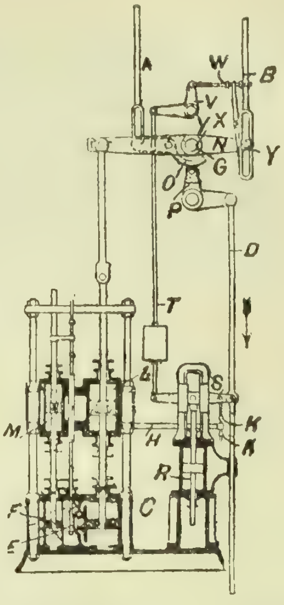
13,242. Iron and Steel, G. Hatton, Hagley, Worcestershire.

In the open-hearth process, a furnace is used having either one or two hearths and mounted to rotate about its centre line. The figure shows an elevation, in part section, of a furnace having two hearths A B. The furnace is cylindrical in form, tapering at the ends, and with the hearths A, B directly opposite, so that when one A occupies the lowest position the other B occupies the highest position and serves temporarily as a roof. The furnace is provided with rails E which run upon rollers or wheels C. The doors H lie between the hearths; J, K are tapping spouts. The hearth A may be acid lined, and hearth B basic lined, the charge being treated in hearth A or B first, according to its composition, and afterwards in hearth B or A. Thus, a too siliceous phosphoric pig is treated in the acid-lined hearth, and, after the slag has been tapped off, the charge is transferred by turning the furnace round to hearth B and treated there. The ports F are practically symmetrical with regard to the centre line of the furnace, and remain fully open during the rotation. Both hearths may be lined with acid or basic material, or the furnaces may have one hearth only, and a roof of ordinary construction.—September 30, 1887. [8½d.]



3,269. Valve Gear for Pumping Engines, H. Davey, 3, Prince's Street, Westminster, Middlesex.

The gear is described as applied to a Cornish engine. A is the steam valve rod and B the equilibrium valve rod. The former is actuated by the combined movements of a piston C and of a rod D, which has the movement of the main piston on a reduced scale. The equilibrium valve is worked by the piston C alone, but means are provided for releasing it if the engine should lose its load, and in a modified form its motion is controlled according to the speed of the engine. Steam is distributed to work the piston C by a valve E, which is operated through tappets by the rod of a second piston F. The valve controlling the supply of steam to act on the piston F is worked by a lever H from tappets K, K, connected directly or indirectly to the rod D. The pistons C and F are connected to cataract cylinders L and M. The piston C operates the equilibrium valve by means of a lever N mounted on a rocking shaft G, and a short arm on this shaft carries a second pivoted lever O connected to the rod A. The lever O has one end curved, and this end rests on a roller on a bell-crank lever P, which is rocked by the rod D. The movement of the rod D thus acts to shift the actual fulcrum on which the lever O is moved to operate the steam valve. R is a cataract cylinder controlling the releasing mechanism for the equilibrium valve. Its piston is connected by the lever S to the rod D, and to a weighted rod T, by which the releasing mechanism is operated. So long as the normal speed is not exceeded the rod T is not moved; but should the engine lose its load this rod is lifted until by means of the bell-crank lever V, tappet W, and lever X, a stop engaging the block Y is withdrawn, and the valve rod B is released, allowing the equilibrium valve to close and stop the engine. In a modified form the equilibrium valve rod is not operated directly by the lever N, but by a lever similar to O carried by a short arm on the rocking shaft G, and having its curved end resting on a lever similar to P, but connected to the rod T. In this arrangement the movement of the equilibrium valve is controlled by the cataract cylinder R. When the gear is applied to other engines the admission valves are worked in the same way as the steam valve above, and the exhaust valves in the same way as the equilibrium valve.—September 30, 1887. [6½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

December 3rd, 1888.

17614a Separation of Metals from their Ores, B. J. B. Mills, Middlesex. (T. A. Edison, United States.)

February 4th, 1889.

1921 Automatic Fog Signal, E. J. Smith, Surrey.
1924 Pivot Hinge, J, Anderson and J. Forsyth, Newcastle-on-Tyne.*
1929 Cramps, B. Akroyd, Keighley.
1933 Lubricators, J. Pickles, London.
1953 Packing Steam Cocks, H. Clayton, Halifax.
1956 Dynamos, J. H. Woodward and E. S. G. Rees, Manchester.
1957 Gas Motors, D. B. Peebles, Glasgow.
1960 Tension Pulleys, P. Bairstow, London.
1962 Nut Locks, N. B. Dennys, London.
1977 Steam and Gases, O. W. Ketchum, London.
1979 Purification of Feed-water, C. Bradbury, London. (Messrs. Grimme Natalis, and Co , Limited, Germany.)*
1986 Rolling Mills, J. Jardine and J. T. Brassington, Glasgow.
1987 Steel and Iron Plates, J. Ward, Glasgow.
1996 Looms, L. Boisseranc, London.
1997 Hot-gas Engines, E. Field, London.
1999 Expansion Engines, H. A. Thorne, London.
2003 Electric-regulating Apparatus, A. L. Shephard, London.
2005 Governors, H. H. Lake, London. (O. Madsen, Denmark.)

February 5th.

2012 Looms, J. Jucker, Manchester.*
2013 Boring Machinery, A. Sugden, Lancashire.
2017 Hydraulic Time Fuse, W. R. Barlow, Woolwich.
2021 Elastic Chain Link, E Ongley, Manchester.*
2031 Metal Alloys, S. McColley Godfrey and J. B. Allen, Middlesex.*
2033 Switch Rails, T. G. Palmer, London.
2036 Pumping Air, W. Sayer, London.*
2037 Steam Boilers, G. G. Picking and W. Hopkins, Middlesex
2049 Cutting Stone, H. Young, London.*
2056 Electric Stop Valves, R. Wellens, London.
2065 Looms, R. Kirkman, London. (J. Kirkman, United States.)*
2075 Hydraulic Hoists, R. Wright, London.
2081 Lock Nuts, A. J. Boult, Middlesex. (J. E. Burns, United States.)*
2087 Steam Boilers, M. Finkelsztein, London.*

February 6th.

2090 Bearings, G. E. Serjent, Newport.
2097 Screws, J. McKay, Ashton-on-Mersey.
2100 Hot-air Motors, W. A. Carlile, Manchester.
2113 Screw Propellers, C. Inwood, Kent.
2114 Screw Keys, T. Archer, jun., Newcastle-on-Tyne.
2119 Vapour Lamps, W. Gordon, Liverpool.
2128 Stop Valves, W. Speight, London.
2138 Steam Boilers, C. L. Bath, London.
2141 Electric Meter, C. Bour, London.
2142 Belt Fasteners, C. W. Dawson, London. (S. M. Johnson, India.)*

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THE
PRACTICAL ENGINEER.
MARCH 1ST, 1889.

BOILER INSURANCE COMPETITION.

In a report issued by the Board of Trade some time ago (see No. 118 Report of Preliminary Inquiry under the Boiler Explosions Act, 1882) some comments were made on what is described as the "unhealthy competition" existing amongst boiler inspecting and insurance companies, which are worthy of the careful consideration of all steam users, and especially of those who believe that by placing their boilers under insurance they are avoiding all risk of accident.

The Engineer Surveyor-in-chief (Mr. Traill), commenting on an explosion referred to, remarks that "the owner of the boiler would doubtless console himself with the money from the insurance company *which they undertook to pay for his premiums*," and he adds that "*so long as such risks pay companies*, so long will there be users who will go on working their boilers without examination." The italics are ours, and we have emphasised these remarks because they present the whole question of boiler insurance and inspection in an aspect in which probably most steam users have never previously considered it.

We believe we are right in assuming that by far the greater number of steam boilers in the United Kingdom are inspected, and the great bulk of them insured by one or other of the voluntary inspection or insurance companies which devote themselves entirely to this work.

The idea of most of those who insure their boilers, we take it, is that by so doing they will get their boilers periodically inspected, and that accidents will be prevented by the timely discovery and repair of defects as they manifest themselves. The more shrewd and observant steam users are aware that if slight defects, such as leakages, fractures, &c., are at once attended to, and the source of deterioration removed immediately they are discovered, not only is the risk of working reduced to a minimum, but a great saving in the annual cost of repairs is effected, and the working "life" of their boilers is almost indefinitely prolonged. It is generally believed also that in this respect their interests and those of the insuring company are identical, and to those who hold this view the idea thrown out by Mr. Traill in the report above referred to, that it *pays* companies to take risks, will come with all the force of an uncomfortable revelation.

Those who insure their boilers mainly for the sake of inspection are usually desirous of giving every facility for thorough examinations, and are naturally dissatisfied if they find the work of examination being performed in a perfunctory manner. There are others, however, who care little for inspection, and who look upon the visits of inspectors rather as a nuisance than otherwise. Such firms will take no trouble to afford opportunities for inspection, and will not prepare their boilers for thorough examination—especially where this means stoppage of works, and consequent loss—except under extreme pressure or threat of withdrawal of insurance. So long as their boilers are insured, many steam users consider they need be under no apprehension, and they thus lull themselves into a fancied security for which there is no real ground.

It is far from being so well understood as it should be that there is a wide difference between boiler inspection and boiler insurance, and that, whilst on the one hand insurance is cheap, competent periodical inspection is very expensive. Abundant evidence can be adduced in proof of this. For instance, the charge for insuring a boiler for a sum of £100 in case of explosion ranges, we are informed, from 22s. 6d. to 25s. with the best companies, whereas a policy for ten times that sum, or £1,000, can be obtained for a premium of about £4—that is, for little more than three times the amount charged for the smaller sum. In other words, whilst a sum of £100 can be insured with a good company for about 25s., an additional £900 of *risk* can be purchased by paying only £2 15s. more, or an average charge of about 6s. only for each additional £100 insured, the service rendered in the way of inspection, advice, &c., being the same in each case.

Many who insure their boilers for the sake of inspection no doubt derive considerable satisfaction from the reflection that the insuring company, in their own interests, will look well to the safety of their boilers; but the idea that the possibility of pecuniary loss on the part of an insurance company is a guarantee of safety to a boiler owner may undoubtedly be carried too far. We have only to consider for a moment the low percentage of accidents, even amongst boilers which are not insured or inspected, and the comparatively small sum which would have to be paid on each annually to provide a fund sufficient to compensate adequately for the few that fail, to see that a boiler insurance company, pure and simple, which never made any inspections, but treated the question as one of risk and insurance only, could pay handsome dividends, and charge very low rates, as compared with one which incurred a heavy annual expenditure in keeping up a costly staff of skilled inspectors and engineers to do the work of inspection.

It is estimated by an eminent authority that it costs on an average not less than £1 per boiler annually to satisfactorily look after and thoroughly inspect a large number of steam boilers; and it has been stated frequently that there are boiler insurance companies who have taken boilers for insurance at from ten to fifteen shillings per boiler. Now, a consideration of what we have already advanced will show that it is quite possible for both of these statements to be correct; but if so, we cannot avoid the conclusion that a boiler insurance company taking such low premiums as those last mentioned must be doing its business on the principle of insurance only, and neglecting the far more important work of inspection. This, we have seen, it will pay an insuring company to do as a matter of risk; but it is not a kind of insurance which it is to the interest of a steam user to adopt, since it does not command that careful periodical inspection and close supervision of his boilers, with other valuable service in the way of competent engineering advice, useful suggestions about working, &c., such as are given by experienced and old-established companies, and which, in our opinion, constitute the principal advantages of boiler insurance. No amount of money, it may be added, can compensate for some of the effects of boiler explosions, and the avoidance of these dreadful occurrences, rather than compen sation for their results, should be the first consideration with all steam users.

That there are boiler inspection and insurance companies who do their work thoroughly and conscientiously cannot be questioned, and we believe it is not an uncommon thing for the best companies to decline business, and allow it to be taken by inferior companies who work more on *insurance* lines, when the rates obtainable are known to be such as will not cover the unavoidable outlay for inspection performed in a reliable and satisfactory manner. Hence, when a boiler owner is offered insurance at an unusually low premium, it behoves him to inquire carefully not only into the financial position and standing of the company soliciting his business, but some information should be obtained as to its reputation for the care with which its inspections are made.

Within the last few years, we believe, not less than four boiler insurance companies have collapsed or been absorbed by others, and those steam users who are disposed to take advantage of the remarkably low rates which we understand are now being offered in some quarters, would do well to bear in mind that such serious reductions in rates as have of late years been made must inevitably tend to the degradation of the service of inspection; and it should not be forgotten that while, as Mr. Traill remarks, it may pay some companies as a matter of profit only to take risk and neglect inspection, it is certainly more to the interest of a boiler owner to have his boilers periodically and regularly inspected by a company who spend the bulk of their income in carefully examining the boilers under their care, and in avoiding risk as far as possible.

MASS AND MOTION.

The columns of our contemporaries have been much occupied lately with somewhat abstract discussions on the nature of mass and the proper units of measurements of mass and energy. Many well-known men have joined in the fray, which to the calm beholder seems to have degenerated from the dignified and impersonal tone suited to the consideration of such weighty and abstruse questions to a somewhat frivolous personal squabble, attended with a considerable loss of temper and a free use of more or less gentlemanly abuse.

Professors Tait, Lodge, Greenhill, and Unwin are the principal combatants, and contrive to entirely disagree upon the essential nature and definition of mass and the equations connecting mass and energy. To our mind it seems clear that, after all, they differ not in ideas or essentials, but merely in words, and that the confusion arises from a too determined attempt on the part of the non-engineering professors to understand the ultimate nature of mass as a property of matter, and to express that understanding in a crisp and clear definition.

It may interest our readers to consider with us briefly the origin of our ideas of mass in matter as distinct from weight, and the use of such ideas in understanding clearly the connection between mass, energy, and work. The idea of work is very easily grasped, and is always forced upon the minds of engineers by their daily contact with resistances which require to be overcome. Work is done when motion is accomplished against a resistance. All machines are examples of resistances to be overcome, and they perform their allotted functions by certain defined and limited motions, or series of motions, caused by the expenditure of energy, and therefore due to the performance of work. It is impossible to estimate the amount of work consumed in driving a machine by a mere casual inspection of its appearance while in motion, and accordingly engineers are obliged to establish some standard of comparison, to which they refer the measurement of the varying expenditures of energy. The most convenient standard is the foot-pound.

The work of raising a weight through a given height is for any fixed spot almost absolutely constant, and even with great variations in position on the earth's surface the intensity of gravity varies but little, and consequently the standard of measurement is fairly constant. The utmost variation is within 0·2 per cent as between the poles and the equator, an amount far within the limits of allowable error in most practical engineering measurements.

Now, it is exceedingly easy to refer measurements of resistance, or work performed to overcome resistance, to foot-pounds; and when we say that a horse power is equivalent to work performed at the rate of 33,000 foot-pounds per minute, we make a statement which is perfectly clear, and free from inaccuracy or vagueness. We are quite well aware that the foot-pound is not an absolutely fixed unit of resistance, and that if the closest possible approximation to the truth is required we shall have to make many minute corrections, but so long as we understand this we are perfectly justified in using it as a standard.

The question of mass, as apart from weight, is not so easily comprehended, but a little care will show exactly what we understand by it, and how that understanding originates. We are well aware from experience that matter when in motion possesses energy apart altogether from its attraction to the earth's surface; that is, that any particle of matter in motion requires a certain expenditure of energy to bring it to rest. Thus: suppose a heavy flywheel in rapid rotation on a shaft, running in comparatively frictionless bearings. We all know that before this wheel can be stopped a very considerable resistance will require to be interposed, and accordingly, when we have such a wheel, as in some forms of hoisting engines, which we require to stop at once, we supply a very powerful brake. This power of performing work is not dependent in any way upon the attraction of the earth for the wheel, because it may be perfectly balanced in all positions, but is dependent in some way on the matter constituting the wheel. We also know that to start this wheel from a state of rest to a state of rapid motion requires the expenditure of energy entirely apart from losses by friction; and if we could construct such a frictionless arrangement, we would be able to regain from the wheel in stopping all the energy we put into it to give it motion.

In the same way, if we suppose a block of metal to rest upon a perfectly frictionless and horizontal surface, along which it could slide, we know that we must do work to bring that block from a state of rest to a state of motion, and that the block will do work in passing to rest from motion. Now, it is found that the amount of energy required to move this block while free from any resistance caused by the attraction of gravity, neglecting friction, and to cause it to acquire any given velocity, is dependent upon the weight of the block; that is, a block of double weight under these circumstances would require double the expenditure of energy to give it a certain velocity, and would perform double the amount of work on passing from that velocity to a state of rest. The capacity of any given portion of matter for containing energy at any given velocity is proportional to its weight. A portion of matter weighed at the earth, and then taken entirely away from its attraction to far-off space, would not lose by this its capacity for containing energy at a given velocity, but we could predict from its weight the energy which it would contain at any given velocity.

We therefore measure the amount of energy by its capability of performing work, and say that energy is equal to so many foot-pounds, or so many absolute units. An absolute unit is the amount of energy required to give unit weight of matter a velocity of one foot per second. Now, the velocity given to matter by the attraction of gravitation acting for one second at the earth's surface is roughly 32·2ft. per second; that is, a particle of matter acted on by gravity for one second will have acquired at the end of that time a velocity of 32·2ft. per second, and it will have fallen through a distance of 16·1ft. The fundamental equation connecting energy, mass, and motion is $E = \frac{M\,v^2}{2}$, when E = energy in absolute units, M = units of mass and v = velocity in feet per second, and one foot-pound is equal to 32·2 absolute units; so that if unit of mass be taken as measured by one pound weight, one foot-pound would give, if applied to one pound weight of matter, a velocity equivalent to the presence of 32·2 absolute units at the end of one second.

Now, the conception of the idea of mass apart from weight is merely a means of expressing to ourselves the fact that matter in motion contains energy apart from any due to a pull from neighbouring bodies, and that the amount of this energy varies with different bodies moving at identical velocities, with the variation of what we agree to call the mass as measured by the weight of the body; or, in other words, the idea of mass is the idea by which we figure to ourselves the quality of matter which enables it to store up energy while in motion, and therefore to do work while coming to rest. The term *inertia* is used to express the resistance of any body to be put into motion, and it has caused much discussion and metaphysical inquiry into its nature; but after all it must be evident that if matter in motion contains energy due to the motion, and gives out energy or performs work in coming to rest, there must be a resistance to motion, or rather work must be done to put it in motion from a state of rest.

It is idle, we think, to attempt to frame universally satisfactory definitions of mass, as all such definitions must involve the previous understanding of its nature; thus, the *quantity of matter* in a body does not help us in giving an idea of mass, because it assumes a means of measuring such quantity. If we had bodies in such positions in space that the relative weight could not be determined, then the relative masses could still be ascertained by measuring the energy (by means of a spring) necessary to give them equal velocities, or by measuring the work done by them in passing from equal velocities to a state of rest. In this case the mass would be proportional to the work done by the bodies in coming to rest, or to the energy required to set them moving at equal velocities. Under such circumstances, we should have no difficulty in clearly understanding the distinction between mass and weight.

In conclusion, it seems to us that the professors seek to understand too much. We, as practical men, have very clear ideas of the effects of mass, and what we mean by it, but admit our ignorance of its ultimate nature in common with our ignorance of the ultimate nature of all other phenomena. The human mind cannot really understand the essence of things, or the relations between phenomena; it can only grasp sequences and arrange occurrences in similar series. Gravitation, elasticity, and cohesion are all equally mysterious and unexplainable; we accept them as facts, but as facts which we can never understand.

LORD BRASSEY ON DOCKYARDS ADMINISTRATION.

Admiral Lord Clanwilliam presided over a very crowded meeting, held at the Royal United Service Institution, on the occasion of Lord Brassey's speaking on the subject of "Naval Shipbuilding and the Efficiency of Royal Dockyard Administration." There were present in the large audience Field-Marshal Lord Napier of Magdala, Admiral Sir John Hay, Admiral Sir E. Fanshawe, General Sir Beauchamp Walker, General Sir H. Havelock-Allan, M.P., General Erskine, and Admiral Colomb.

Lord Brassey said he proposed on this occasion to treat of shipbuilding with reference to types, and to close with some remarks on the efficiency of dockyard administration. He began with a review of recent shipbuilding at home and abroad, and with reference to foreign Powers he showed that the French had mainly adhered to a type much admired in our own navy—the continuous belted ship with a high freeboard. In our ships we had established a decided superiority in speed, and the heavy guns were better protected. The Italians, while building ships of the largest dimensions, had thrown off the belts, preferring other methods of protection for the vitals of ships. The Germans were rather imitators than pioneers in construction. America was adding several ships in which were combined the best features of modern construction. The Russians were throwing their main efforts into turret ships, heavily armoured and armed. Neither at home nor abroad were the constructors allowed to pursue their way unchallenged by criticism, and Lord Brassey, after passing in review some of the criticisms of late, strongly deprecated the unqualified criticism upon ships built, and declared that there had been distinct progress of late years in British naval shipbuilding—a fact which ought fairly to be recognised. He held that the Admiral class would be more satisfactory if they had more protection by armour. As to the belted cruisers, he said that in the important element of speed these ships more than fulfilled the conditions of their original design. He considered that these ships, as at present manned, were overcrowded. He questioned the action of the Admiralty in refitting the Minotaur in regard to retaining the old-fashioned engines and boilers, and he considered the £50,000 was wasted in this way on a policy of half measures. He considered that we should require more vessels of the Blake and Blenheim class—high-speed cruisers of a large type; and then, passing on to line-of-battle ships, he said the great cost of these vessels—£800,000 each—rendered it impossible to multiply such vessels beyond a certain limit; but all laid down should not be mere repetitions, but, if possible, improvements upon their predecessors. He showed that American views were in favour of the ram, and that the French, too, had copied our Polyphemus. He held that this type of vessel should be added to in our programme of construction, which should have each year a line-of-battle ship of the first class, three armoured rams, two Blenheims, three Medusas, and eight sharp-shooters. Turning then to the Royal dockyard administration, he said he had no wish to shield maladministration, but in the main the public was well served in our dockyards, and he objected to the class of criticism which held up the administrators as incapables. This country was making steady progress in construction, and he referred to the Trafalgar, which would be ready in six months from the time of her keel being laid. Certain it was that the British dockyards compared most favourably with those under foreign administration. In Italy the Duilio and the Dandolo, laid down in January, 1873, were ready for commission in January, 1880, and March, 1882, respectively. The Italia and Lepanto, laid down in January and September, 1876, were ready for commission—the former in October, 1885, the latter in May, 1888. Turning to the French navy, he said the ironclads now in construction—the Neptune, laid down at Brest, and the Magenta, at Toulon, in October, 1880—would not be ready for their trial before 1890. The Formidable, laid down at Lorient, and the Admiral Baudin, at Brest, in December, 1878, would be ready for their trials in the present year. The Hoche and Marceau—the one building in the dockyard and the other by contract—were both laid down in 1880. The Marceau would be ready this year. The Hoche was 23-100ths short of completion. And the delay in completing in France was more striking still in the case of smaller vessels. The four armoured gunboats laid down in 1882, one of 1,640 tons and one of 1,050 tons, would be ready this year; another pair, one of larger and the other of smaller size, would be advanced to 49-100ths and 41-100ths respectively. The crowning instance was that of the torpedo cruiser, the Vautour, of 1,280 tons; commenced in 1882, it was only in 1888 that she was completed for sea. In a comparison of cost, he showed that shipbuilding was relatively at the same rate in French and English dockyards. He made suggestions for reform in the constitution of our foreign squadrons, and, in conclusion, thanked the audience for the interest shown in the subject.

The discussion was opened by Admiral Colomb, and Admiral Sir John Hay insisted that our line-of-battle ships, now of 34 effectives, should be brought up to 69, the number of other nations combined.

Thanks to Lord Brassey ended the proceedings.

A New Alloy.—We learn that Messrs. H. Ostermann and C. Lacroix, of Geneva, have taken out a patent for a new alloy, to be used as a substitute for steel in the manufacture of certain parts of watches such as spiral springs and escapement wheels, which are at present liable to become magnetised. This alloy is composed of from 30 to 40 parts of gold, the same number of parts of palladium, 10 to 20 of copper, and small quantities of rhodium, silver, platina, and manganese. The copper and the manganese are first melted, and the other metals are subsequently added; or all the metals may be placed in a crucible at the same time, the manganese being at the bottom.

THE FORTH BRIDGE.*

Rather more than six years ago I read, at the request of our ever-to-be-remembered friend, the late Sir William Siemens, my first paper on the Forth Bridge. I did it under protest, as the designs were not then matured nor the contract let; and I prefaced my paper by saying that I "would have preferred to postpone any communication on the subject until the works were well in hand, and the many points of interest and difficulties inseparable from so gigantic an undertaking had manifested themselves." That time has now arrived, for we look for the completion of the bridge in the autumn of the present year, and although very probably new points of interest and difficulty will arise between now and then, I have sufficient material in the work already accomplished for more than a hundred lectures. I can indeed attempt nothing more in the time at my disposal than to convey to you some general idea of the magnitude of the design, and the mode of executing the Forth Bridge; in short, I promise no more than to give, with the aid of the photographs which I shall throw on the screen, what may be regarded as an illustrated table of contents of a descriptive treatise on the bridge, which no doubt will have to be written in the future by some one.

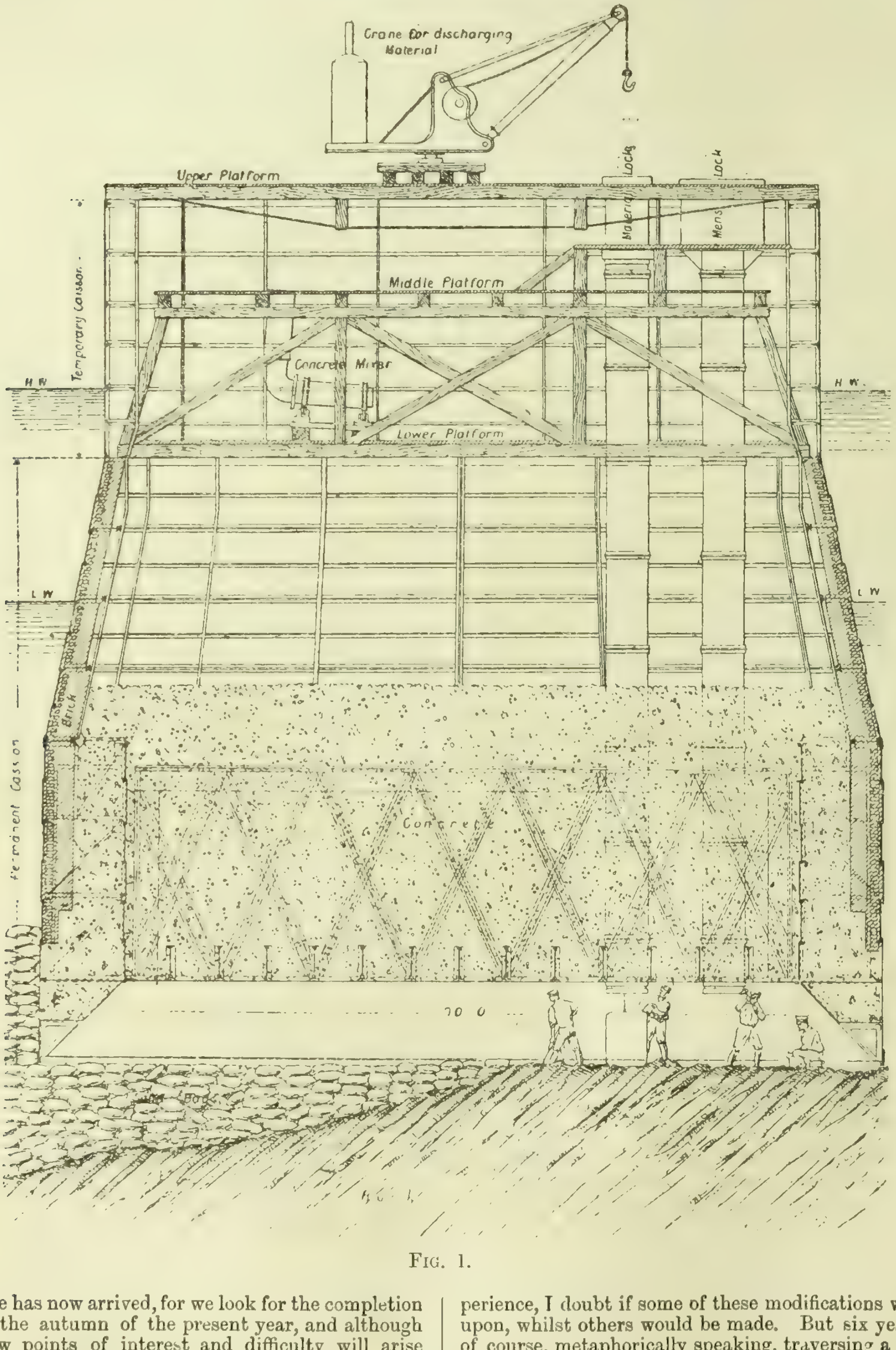

Fig. 1.

I may begin by saying that the design of the Forth Bridge is a compromise. Sir John Fowler and myself prepared the original design, and Mr. Barlow, on the part of the Midland Railway, and Mr. Harrison, on the part of the North-Eastern Railway, asked for certain modifications in detail which in the end we had to accept. If we had to do the work again, with our present experience, I doubt if some of these modifications would be insisted upon, whilst others would be made. But six years ago we were, of course, metaphorically speaking, traversing a trackless jungle, and not following a beaten path.

In preparing what I have termed the illustrated table of contents which I propose to present to you to-night, I thought it would be most convenient to give first of all a general notion of the situation, the size, and the principle of design of the Forth Bridge, and then to describe briefly the mode of executing the piers, and manufacturing and erecting the superstructure of the

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Paper read at the Society of Arts by Benjamin Baker, Esq., M.Inst.C.E.

work, depending in all cases more upon the photographs than upon my own words for conveying to you some idea of the operations.

SITUATION.

The Firth of Forth, as everyone who has glanced at a map knows, cuts Scotland almost half in two, and its broad and deep channel has always offered a great impediment to traffic between north and south. It is no matter for surprise therefore that suggestions for facilitating communication across the Firth have been numerous during the past 100 years. In 1804 an enterprising and fearless Edinburgh surveyor published designs for a bridge across the Forth, at the same spot and with spans of the same size as the present structure. He proposed a suspension bridge, and from experiments made with a short piece of chain, hung from posts like a clothesline, he came to the conclusion that about 200 tons of iron would do the job, and the cost of the work was to be something less than six months' interest on the cost of the present Forth Bridge. To come to recent times and modern requirements, it is needless to remind you of the "race to the north" last autumn between the east and west railway companies. Fourteen years ago it was seen by the directors of the several companies forming the East Coast route that the Firth of Forth was the weak link in their chain of communication from north to south, and it was to that point therefore that they wisely addressed themselves with a view to improvement. At first, the enormous spans required for a crossing at Queensferry, though cheerfully faced a century ago by the Edinburgh surveyor already referred to, daunted the modern engineer, so an Act of Parliament was first obtained for a bridge higher up the Forth than Queensferry. Subsequently, however, it turned out that, although we have changed in our views not a little since 1804 as to the design of the bridge, the Firth of Forth itself has not changed. Now, as then, the best site for a bridge is at Queensferry, where the estuary narrows, and the island of Inchgarvie stands like a giant stepping-stone in the middle of the stream to help the way across. On each side of the island the

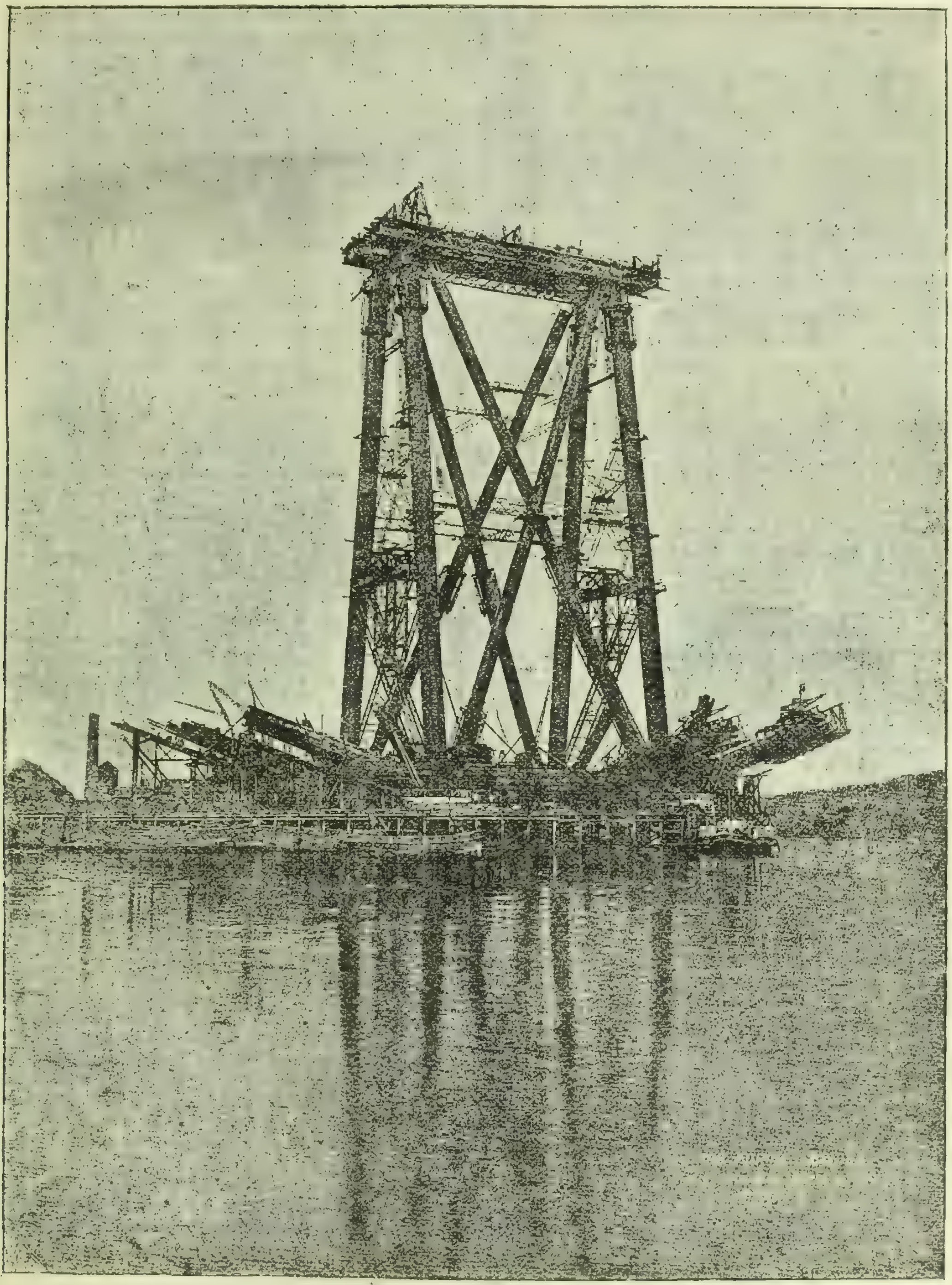


FIG. 2.

channels are over 200 feet deep, and so the necessity arose for building a bridge having two spans of the unprecedented magnitude of 1,710 feet each, to clear the deep channels at one jump.

Size.

It is not easy to realise how vast is the difference in scale between a 1,700-feet bridge and all other railway bridges hitherto constructed. The largest bridge in this country—the Britannia tubular bridge across the Menai Straits—has a span of 465 feet; therefore the Forth Bridge spans are 3⅔rd times as great. This arithmetical comparison will probably not help you much in itself, but I may assist your imagination by mentioning the fact that a 16½-hand high hunter is just 3⅔rd times the height of a well-bred harrier, which, as you are aware, is a much smaller dog than a foxhound. Each of the Forth Bridge spans would take you at one bound from the Strand, over the hall we are in, across John Street, Adelphi Terrace, the Thames Embankment, and the river itself, to the Surrey side. The height of the steelwork is also exceptionally great, being equal to that of the golden cross at St. Paul's; but this may be best shown by a diagram of the comparative heights of different buildings.

Principle of Design.

When I was a student, a girder bridge which had the top member in tension, and the bottom member in compression over the piers, was called a "continuous girder bridge." The Forth Bridge is of that type, and I used to call it a continuous girder bridge; but the Americans persisted in calling all the bridges they were building on the same plan "cantilever bridges," so I yielded the point, and the system will be so designated in Dr. Murray's new English dictionary. "Cantilever" is a 200-year-old term for a bracket, and the Forth Bridge spans are made up of two brackets and a connecting girder. Imagine two men trying to shake hands across a stream a little too wide for their hands to meet. One man extends his walking stick, and the other one grasps it, and so the stream is bridged. There we have the two arms, or brackets, and a connecting girder. In the Forth Bridge the arms are supported by great struts, as in a living model which I showed at the Royal Institution a couple of years ago, where raking struts extended from the men's wrists to the points of support. The principle of bracket and girder construction is as old as the hills, for it lends itself peculiarly to timber construction, which we know in primitive times preceded masonry.

Piers.

Each of the three main piers includes four columns of masonry and concrete from 50 feet to 70 feet in diameter, founded on rock or boulder clay, at depths ranging up to 90 feet below high water. I must content myself with describing briefly one of the twelve piers, which all differed somewhat in detail, and I will select one of the Inchgarvie piers, founded on a sloping fissured rock bottom, at a depth of 72ft. below sea level, in a very exposed and stormy estuary. The method adopted was as follows: A huge wrought-iron bucket, or caisson as it is technically called, 70ft. in diameter, and between 50ft. and 60ft. high, was built on launching ways like a ship. The bottom of the caisson was set up 7ft. above the cutting edge, and so constituted a chamber 70ft. diameter and 7ft. high, capable of being pumped full of compressed air, so that the men could work in it below the water, as in the case of a diving bell (fig. 1). The ironwork weighed about 500 tons, and when towed out to position the added concrete and brickwork brought the total weight up to 2,700 tons. Additional concrete was then filled in, and when the weight reached 3,300 tons the caisson grounded on the sea bottom, where a bed had been prepared for it with sand bags. The workmen entered through air-locks, and the rock excavation proceeded in this electrically-lighted chamber as safely as on dry land. The air pressure in the working chamber was at times as high as 35lb. per square inch. We say the barometer is high if it stands at 31in., but in the working chamber it often stood at 72in. When Coxwell made his high ascent the barometer fell to 7½in., or about one-tenth of the preceding height, which illustrates how marvellously the human mechanism is adapted to sustain wide variations of atmospheric pressure.

Manufacture of Superstructure.

The superstructure of the Forth Bridge has required the manufacture on the spot of about 50,000 tons of steelwork. As a rule, the compression members consist of tubes, and the tension members of lattice girders. This arrangement, as was anticipated, is, from an architectural point of view, most effective, for, seen against the sky background, all columns and struts show up in strong, dark lines, whilst the ties look like delicate tracery. In making the tubes, the plates were bent hot, the edges planed, and the plates built up temporarily into long tubes, to be drilled by traversing machines through the whole thickness of plates. In practice, I may mention that our steel plates, having an average tensile strength of 34 tons per square inch, drill more readily than iron plates of 22 tons. We have at times turned out as much as 1,800 tons of steelwork per month at the Forth Bridge works. As regards trustworthiness of steel, in no single instance have we had a failure, or even cause for anxiety, out of the hundreds of thousands of steel plates, bars, and rivets which go to make up the superstructure of the Forth Bridge.

(To be continued.)

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

(Continued from page 129.)

The Griffin Gas Engine (sent by Messrs. Dick, Kerr, and Co., of 101, Leadenhall Street, and Kilmarnock).—The Griffin engine is a double-acting engine, which, when working at its full power, ignites the charge at every third stroke at each end of the cylinder. The cycle of the engine at each end of the cylinder is—drawing in gas and air, compressing gas and air, igniting and expanding the charge, ejecting the products of combustion, drawing in scavenger charge of air. The ignition is a flame ignition by a slide valve. The general arrangement of the engine and the details of the valve gear are shown in fig. 2, p. 145. The cylinder was 9·02in. diameter and 14·00in. stroke, with a piston rod 1·75in. diameter at one end. The governing is effected by omitting the admission of gas whenever the engine is over speed. The engine has two flywheels, and an inspection of the speed results show that the governing is effective, and the engine quite free from cyclical variation of speed. The flywheels were each 60·1in. diameter by 7·5in. broad on face, and each weighed 1,144lb.

Atkinson (or "Cycle") Gas Engine (sent by the British Gas Engine and Engineering Company Limited, Gospel Oak Works).—The Atkinson engine, so far as the connection between the piston and the crank is concerned, differs entirely from either of the other two. During one revolution of the crank shaft the piston performs the following evolutions: Starting from the extreme back end of the cylinder, it advances, drawing in gas and air; it then retires compressing the mixture, but only to a point some distance from the end of the cylinder; the charge is then ignited and the working stroke performed; and lastly, the piston retires to the end of the cylinder, ejecting the whole of the products of combustion.

(As we described the general arrangement of this engine in our last issue, it will doubtless be familiar to our readers. We may state, however, that in the engine used the cylinder was 9·50in. diameter, the suction stroke 6·33in., the compression stroke 5·03in., the working stroke 11·13in., and the exhaust stroke 12·43in. The radius of the crank of the engine was 12⅞in. There were two flywheels, one on each end of the crank shaft. Each wheel was 69·3in. diameter, 4·5in. broad on face, and weighed 1,462lb.)

Paxman Portable Engine (sent by Messrs. Davey, Paxman, and Co., of Colchester).—The general arrangement is as follows: The boiler is of the locomotive type, and the engine is a compound horizontal, the general arrangement being that well known as adopted by Mr. Paxman. The cylinders are fitted with steam jackets, which were, however, not used in these experiments. The feed water is heated, first, by the exhaust steam in a tubular heater placed upon the top of the boiler, and secondly, by passing through a coil in the smoke-box. The governor acts upon a cut-off valve, through the medium of a link-motion worked by two eccentrics (see figs. 3 and 4). The diameter of the cylinders is 5·24in. and 8·98in., and their stroke 14·00in. The engine was fitted with one flywheel only, 62in. diameter and 7⅜in. wide, with rim of trough section, as already described. Its weight was 910lb. In what follows we have given full particulars of the trials of each engine separately, taking first the full-power trial or trials (lettered A in all cases), then the half-power trial (lettered B), next the trial running empty (lettered C), and, lastly, any extra trials that were made by the wish of the exhibitor, or to determine any special points which we thought to require investigation. Each engine has the principal results of all its trials summed up in one table, and the tables are arranged so as to be, as far as possible, comparative.

The order in which it has been found most convenient to describe the trials is not exactly that in which the experiments were made, but is—

I. Atkinson.
II. Crossley.
III. Griffin.
IV. Paxman.

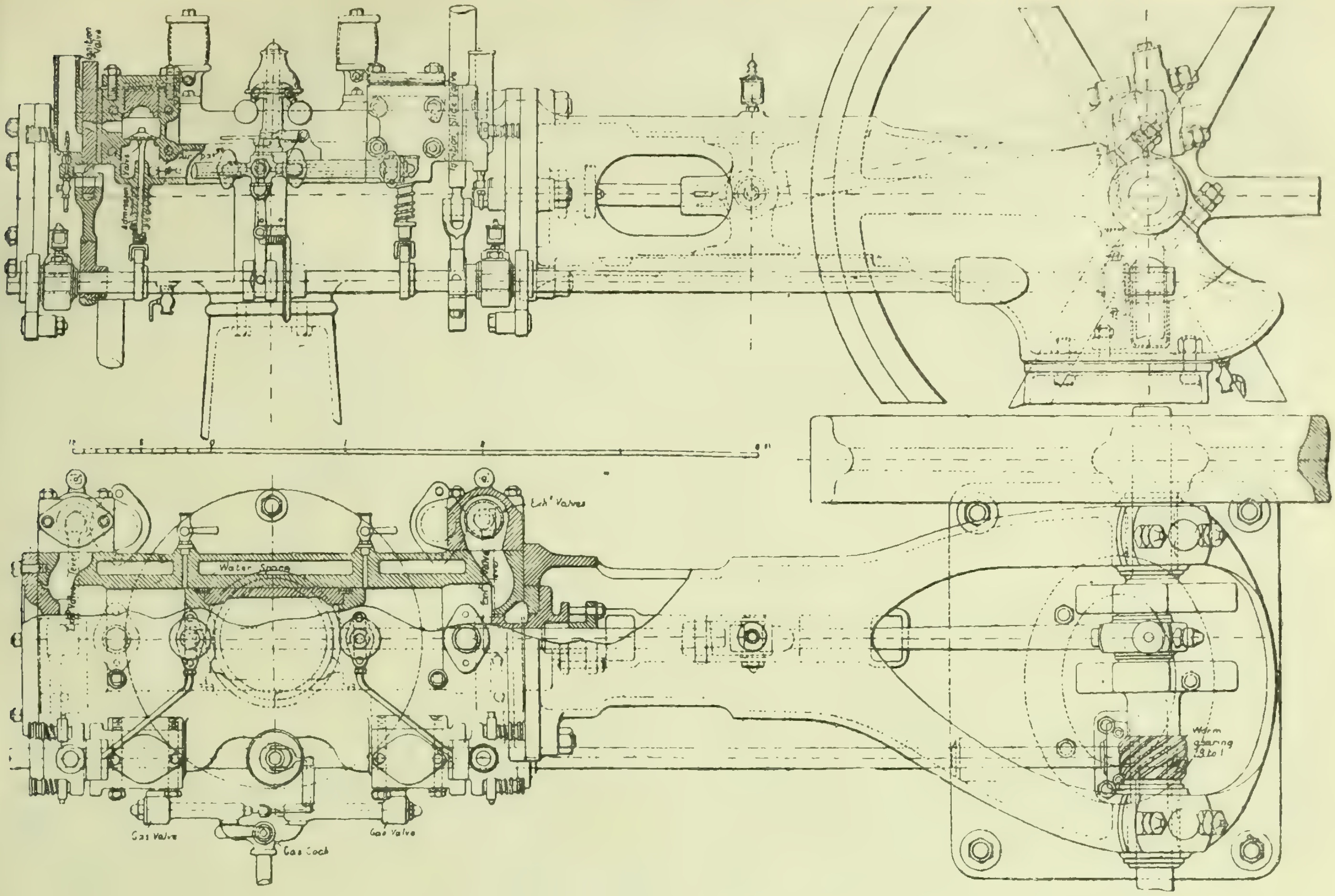


Fig. 2.—Trials of Motors for Electric Lighting.

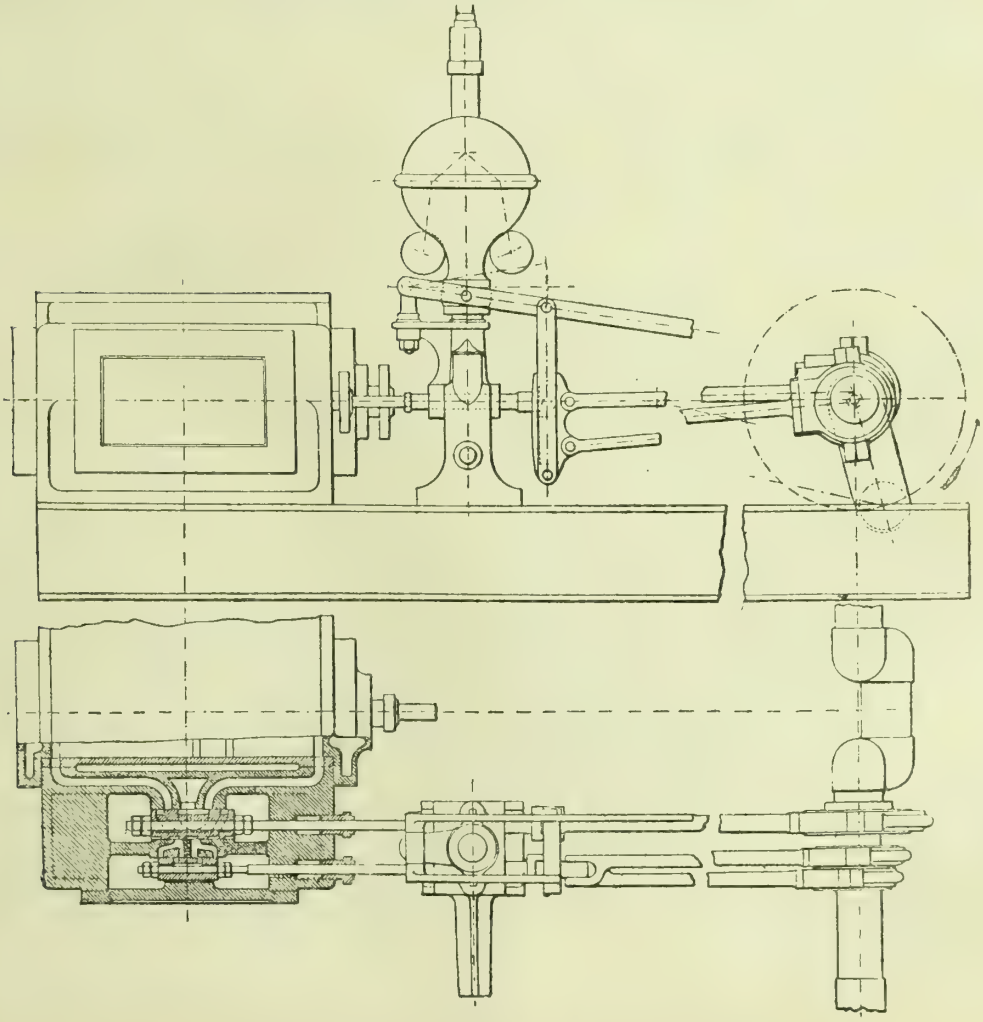


Fig. 3.—Trials of Motors for Electric Lighting.

Atkinson's Gas Engine.—Five experiments, in all, were made with this engine, and they will be distinguished by the letters A, B, C, D, and E. Trial A was a full power trial of six hours duration, and trial B, a half power trial of three hours. In trial C, the engine ran without load for half an hour. Trials D and E were special short trials with full brake load, but at speeds below the normal. The principal results of these trials are given in Table I.

Table I.—Atkinson Gas Engine.

1	Date	Sept. 21	Sept. 22	Sept. 22	Sept. 24	Sept. 24
2	Trial	A	B	C	D	E
3	Duration	6 hours	3 hours	½ hour	½ hour	½ hour
4	Power	full	half	empty	full	full
5	Revolutions per minute	131·1	129·6	131·9	110·5	100·5
6	Explosions	121·6	69·1	23·8	....	....
7	Mean initial pressure	166·0	166·5	145·5	....	....
8	Mean effective pressure	46·07	47·60	48·59	....	....
9	Indicated H.P.	11·15	6·59	2·3	....	....
10	Brake load, net	130·5	66·0	....	135·4	127·1
11	Brake H.P.	9·48	4·74	....	8·29	7·08
12	Mechanical efficiency	0·850	0·719	....	....	....
13	Gas per hour, main	209·8	127·1	47·2	188·60	157·8
14	,, ,, ignition	4·5	5·9	....	5·42	5·1
15	,, ,, total	214·3	133·0	....	194·02	162·9
16	Gas per indicated H.P. per hour main	18·82	19·29	20·50	....	....
17	Gas per indicated H P. per hour, total	19·22	20·18	....	....	....
18	Gas per brake H.P. per hour, main	22·14	26·80	....	22·75	22·29
19	Gas per brake H.P. per hour, total	22·61	28·10	....	23·40	23·01
20	Water per hour	680lb.	260lb.	....	....	....
21	Rise of temperature	52·20	67·80	....	....	....
22	H.P. in driving engine	1·67	1·85	2·3	....	....
23	Mean pressure during working stroke, equivalent to work done in pumping strokes, about	1·0	....	....	....	....
24	Corresponding indicated H.P.	0·26	....	....	....	....

This trial took place on 21st September, and lasted six hours continuously. Mr. Atkinson elected to run at about 9½ H.P. and 130 revolutions per minute. Indicator diagrams were taken every quarter of an hour, and worked out with the number of revolutions made in that interval as read on the counter.

The two meters were read every quarter of an hour, and the gas pressure and temperature noted at the same time. The water-meter was also read every quarter of an hour. The spring balances on the brakes were read every five minutes. The work taken up by each of the two flywheels was kept as nearly equal as possible. The rope brakes were worked perfectly dry, without any lubricant whatever. The mean speed of the engine was 131·1 revolutions per minute. The maximum speed for any quarter-hour was 132·7 revolutions per minute, the minimum for any similiar period 129·2 revolutions per minute. The number of explosions per minute was 121·6; so that 7·2 per cent of the explosions were cut off by the governor. The mean initial pressure was 166lb. per square inch above the atmosphere, but the mean effective pressure, owing to the great ratio of expansion employed was only 46·1, the indicated H.P. was thus 11·15. This power is calculated from the revolutions per quarter-hour after deducting the actual number of misses during that time. A record of the actual misses was kept throughout the whole of this and all the other trials by two observers, who relieved one another at hourly (or shorter) intervals.

The brake horse power was 9·48, so that the mechanical efficiency of the engine reached 85 per cent. The horse power expended in driving the engine (difference between indicated H.P. and brake H.P.) was 1·67.

The gas per hour through the main meter was 209·8 cubic feet, which is at the rate of 18·8 cubic feet per indicated h.p. per hour, and 22·1 per brake H.P. per hour. The addition of the gas used for ignition, 4·5 cubic feet per hour, raises these figures to 19·2 and 22·6 cubic feet respectively.

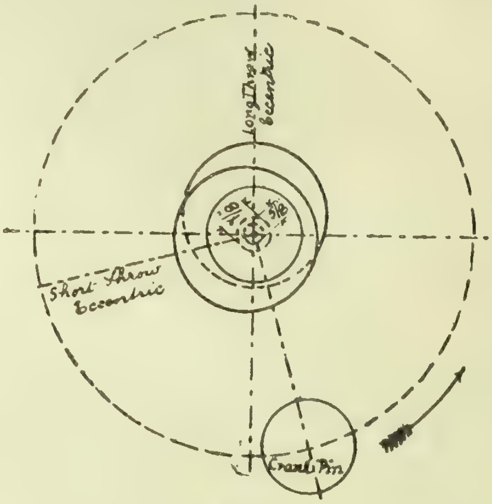


Fig. 4.

Diagrams were taken with a light spring to enable some estimate to be made of the power expended by the engine in what have been called the "pumping strokes." Copies of two of these diagrams are given in fig. 5. The work done during the pumping strokes was equivalent to a mean pressure during the working stroke of about 1·0lb. per square inch, and this corresponds to an indicted H.P. of 0·26.

The weight of oil used for cylinder lubrication during the six hours was 1·18lb. It was a gas-engine oil supplied by the makers of the engine, and costing about 2s. per gallon, or say 2·7d. per lb. At this rate, and taking the cost of gas as 2s. 6d. per 1,000 cubic feet, the cost of the cylinder lubrication was equal to that of 1·59 cubic feet of gas per indicated H.P. per hour. The bearings were lubricated with grease, and worked perfectly cool throughout the whole trial.

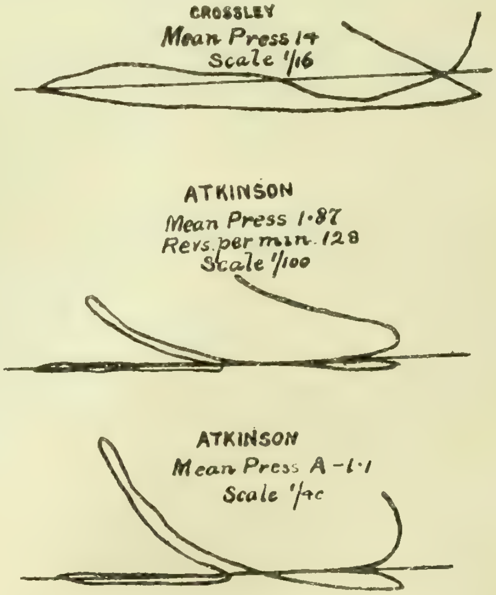


Fig. 5.

Analysis of Results.

The measurements made upon this trial, together with the gas analyses of Mr. Wilson, given later on, allow a tolerably complete examination of the working of the engine to be made. In Table II. is given Mr. Wilson's analysis of the gas, which is by volume, with the corresponding analysis by weight worked out. In the same table the calorific value of the gas is also worked out.

TABLE II.—Atkinson Trial, Sept. 21, 1888.

Constituents.	Proportion by volume.	Weight of one cubic foot.	Weight in one cubic foot of gas.	Proportion by weight.	Calorific value per lb. down to 100° C.	Calorific value per lb. of gas down to 100° C.	Proportional weight of O required for complete combustion of 1lb. gas.	Weight of O required for complete combustion of 1lb. gas.	Weight of products of combustion for 1lb. gas.	
		At standard pressure and temperature.							Steam.	Carbonic acid.
	Per cent.	lbs.	lbs.		Thermal units.	Thermal units.		lbs.	lbs.	lbs.
CH_4	37·73	0·0447	0·01686	0·511	21510	10991	4	2·044	1·150	1·405
C_2H_4, &c.	4·07	0·1410	0 00574	0·174	20100	3497	$2\frac{4}{7}$	0·597	0·224	0·547
H	48·56	0·00559	0·00271	0·082	52200	4280	8	0·656	0 738	
CO	4·19	0 0783	0 00328	0·099	4350	431	$\frac{4}{7}$	0·057	—	0·156
N	4·93	0·0783	0 00386	0·117	—	—	—		—	—
CO_2 and O	0·52	0·1060	0·00055	0·017	—	—	—		—	—
	100·00		0·03300	1·000		19199		3·354	2·112	2·108

Calorific value of one cubic foot = 19,199 × 0 0330 = 633 thermal units.

It will be seen that this comes to 19,200 thermal units per lb., or 633 thermal units per cubic foot at standard pressure and temperature.

In order to work out a heat balance for a gas engine, it is necessary to assume that the various operations have gone on in a certain fashion, to some extent idealised from the actual operations. For this purpose it has been assumed that the indicator diagram of the engine has the form shown in fig. 6. The points B, C, D, and F have been determined by measurements of the actual pressures in the whole of the indicator cards, and represent the mean of those measurements. The point E has been found by marking a line on each of the indicator diagrams at the mean height of D, and then taking the average distances D E on all the cards. How nearly this ideal diagram corresponds with the actual one is shown well by the figure, where one of the actual diagrams nearest to the mean is drawn within it. The pressures and volumes at the cardinal points of the ideal mean diagram are as follow:—

Table III.

	Pressure in pounds per square inch, absolute.	Volume in cubic feet.
A	14·87	0·064
B	14·87	0·324
C	50·30	0·118
D	180·90	0·118
E	180·90	0·135
F	29·00	0·575
G	14·87	0·575

The atmospheric pressure was 14·87lb., and the light spring cards showed that the points A, B, and G lay sensibly on the atmospheric line. The meter pressure was 1·48in. of water, and the temperature of the gas inside the meter 68·8 deg. F. Under these conditions, the weight of gas used per explosion was 0 000,896lb. The temperature of the gas after admission is unknown, but it is not improbable that it was about equal to that of the jacket water when discharged, namely, 116 deg. F. On this assumption, the volume of the gas per explosion would be 0·0314 cubic feet in the cylinder. This assumption as to the temperature of the charge (which has been already alluded to in the introduction) is one which cannot pretend to accuracy, but it is believed to be very near the mark. It should be pointed out that an error of even 20 deg. in this temperature would have a comparatively small effect on any of the following figures, and it is not likely that the error of the assumption made is at all so much as this. The volume of the air under the same conditions would be 0·293 cubic feet, and this corresponds to a ratio of air to gas of 9·33 by volume and 22·8 by weight.

For the purposes of the ideal indicator card it has been assumed that the compression and expansion curves can be represented by equations of the form pv^n = constant. The figure shows that this is a very justifiable assumption. The value of the index n (which in this case, and in all the others given below, has been found by actual measurement of and calculation from the pressures on the whole of the diagrams taken in each trial) for the compression curve is 1·205. The curve, therefore, lies below the adiabatic (which will be sensibly the same as for air, with $n = 1·408$), so that heat must have been rejected to the jacket water during compression. The temperature at the point C would be 719 degrees absolute, and the amount of heat rejected during the compression would be equivalent to 412 foot-pounds.

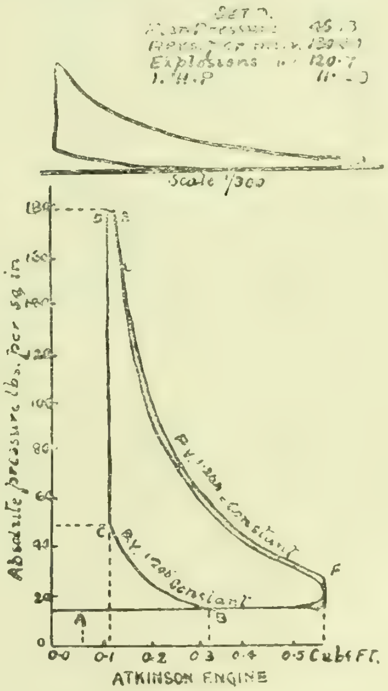


Fig 6.

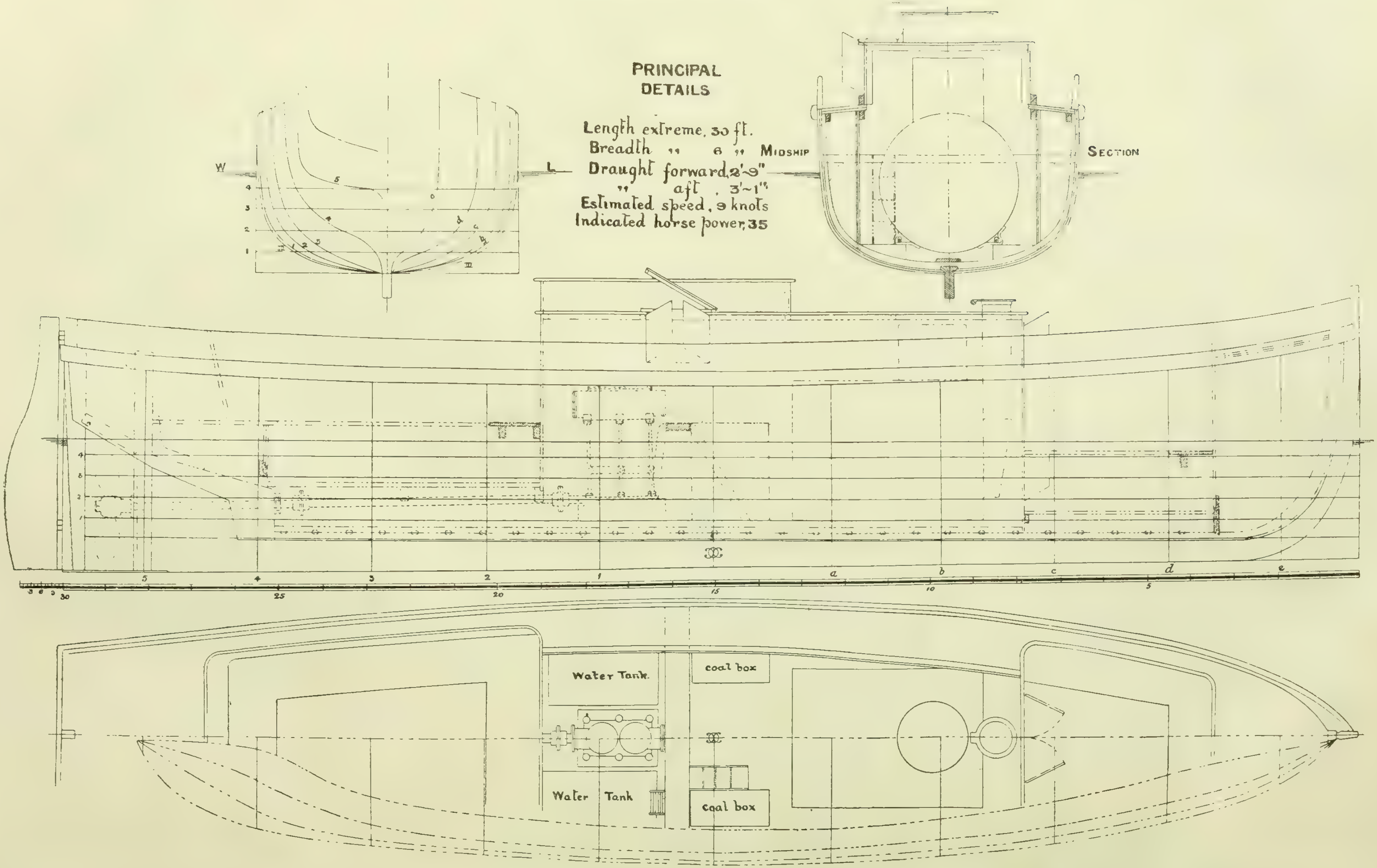
In the ideal card the main part of the reception of heat is supposed to take place first at constant volume CD, and then at constant pressure DE. In most cases the combustion is still incomplete when the expansion begins, and continues as the gas expands. The charge, therefore, goes on receiving heat even during the expansion. The temperature at D works out to 2,620 deg. absolute, and at E, where it reaches its highest value, to 2,990 deg. absolute, or 2,530 deg. F. No work is done, of course, during CD. The work done during DE amounts to 435 foot-pounds.

(To be continued.)

WORKING DRAWINGS.

STEAM LAUNCH SUITABLE FOR RIVER NAVIGATION.

(For specification see page 150.)

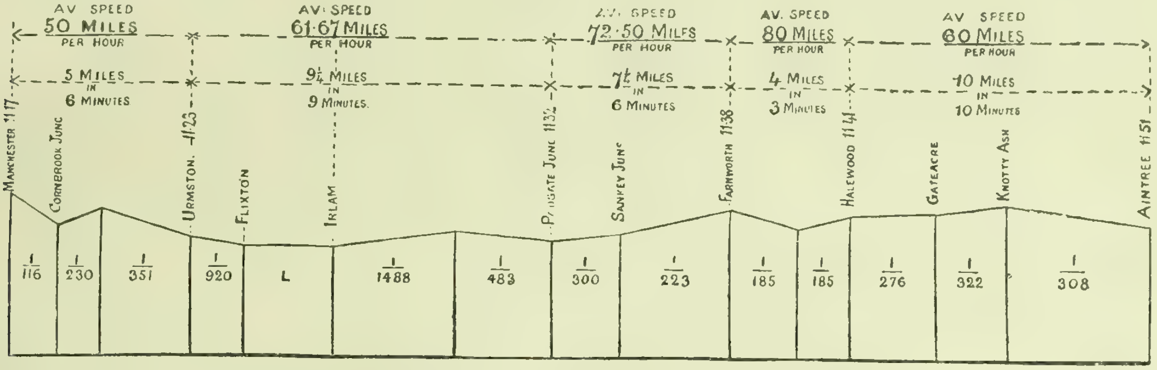


PRINCIPAL DETAILS

Length extreme, 30 ft.
Breadth ,, 6 ,, Midship
Draught forward, 2'-9"
,, aft , 3'-1"
Estimated speed, 9 knots
Indicated horse power, 35

THE RUNNING OF A LOCOMOTIVE.

A paper was read before the Owens College Engineering Society by Mr. H. Pollitt, in which were described the duties of the driver and fireman, and the attention engines required before being hooked on to their trains. It was stated that it was necessary to examine the motion, for which purpose the engine must be placed over a pit, and cranks put in such a position that the big ends of the connecting rods were both below the centre of the driving axle, so that they could be easily seen and oiled. The slide bar must be well oiled, and the trimming of the glands looked after to see that they were tight. The fire should be made hollow, and the coals thrown in well to the side of the fire-box, as the oscillation of the engine brings it down; the firing should be done often, and small quantities put on, so as to keep up a constant heat, and coaling should not be done at stations. Firing while the steam was on should be managed so as to keep the fire door always open. To maintain steam, the water should be put into the boiler gradually, the regulator opened slowly, and the reversing gear notched up slowly while the regulator was open; for economy of steam and fuel the steam should be used as expansively as possible. When the rails were slippery, the sand valves were opened, and especially in tunnels, where they were nearly always damp. The steam sand blast was a great improvement on the old style; the sand should be placed under both tires at the same time, otherwise a very severe twisting action came upon the driving axle. The same precaution ought to be taken with the brakes, so that they may act simultaneously on both wheels. The reader described a sight-feed lubricator which saved 10 cwt. of coal in a 200 miles run, and the advantages derived from it. The driver had to regulate his time to working time tables, and several were mentioned for their forethought and skill in emergencies. There was one case in which a driver in starting out of a station left his train behind him, until he over-shot the platform at the next station. Other cases were mentioned in which drivers had taken out disabled engines. Then followed descriptions, illustrated by diagrams of various types of engines, proving relative advantages of inside and outside cylinder and coupled and uncoupled engines. For fast, light work the single engine was undoubtedly the best, as the coupling rods were a great disadvantage at high speeds. It was considered that a high centre of gravity in an engine caused it to run more steadily and diminished the amount of side thrust on the rails. Bogies were an advantage, especially for curved lines, and preferable to a radial axle-box, as the latter adjusted itself by a jerky motion. Several fast runs were mentioned, especially one from Manchester to Aintree, a distance of 36 miles, performed in 34 minutes, or an average of 62·6 miles per hour. A diagram was given, which we illustrate above, showing particulars of the run, and from which it will be seen that a very high rate of speed was attained on certain parts of the road. The profile shows the various gradients, and the names of the stations are marked upon it. The highest speed attained was 80 miles per hour, and this was kept up for four miles, partly down a gradient of 1 in 185, and partly up a similar gradient. The run was an interesting one.



Ballast or Cargo?—For a long period the sailing vessels that trade to the Tyne from the Thames and the south have brought chalk as ballast. That material is used in the cement manufactories; but the lessening number of ships makes the supply inadequate. It is now said that steamships have had to be put into the trade, to carry as cargo the chalk which was long ballast. And thus another if a small outlet for the employment of the dominant steamer is to be found.

AN ENGINEER'S LIFE AT SEA.—XXIV.

Quarantine, &c.

Sometimes it is not easy to get rid of ashes when a steamer is anchored in a tidal river, or is quarantined. In the latter case, discharge of ashes into the bay may be prohibited, as well as communication with the shore. If, as is frequent, an officer should be aboard, the case is more complicated; but one engineer, whose work was much hindered by the ashes piled up on the stokehold plates, took advantage of a friendly game of cards between the official and a mate, and had the ashes lowered in bags to the water's edge, and there quietly emptied. Such a proceeding is, however, very risky, as penalties are frequently heavy.

In an English port, unless actual sickness is aboard, quarantine is not imposed; but in many foreign ports the regulations would seem to be needlessly vexatious, causing injury to shipowners as well as loss of commerce to the nation enforcing them, for the country with the strictest quarantine is avoided if possible. An English steamer once loaded at a cholera port. On arrival at home, all being well, she was allowed to discharge and reload, but on arrival at her next foreign port she was quarantined for several days, because of her visit on the preceding voyage. The crew of one vessel had to pay daily visits to the quarantine hospital ashore. In this hospital there was a case of cholera, and in consequence cholera broke out on board the English steamer the day after her quarantine had expired, leading to further delay and loss. Such regulations, which have been tried and found unnecessary in the case of maritime England, can hardly have the value attached to them by some other countries. Sometimes officialdom would seem to be at the bottom of it. In one case a steamer was quarantined on account of a passenger whose illness was said to have been chronic from childhood. Then, owing to the unhealthy station, with its surrounding swamps, officers and men began to be struck down daily by fever, and for every fresh case several days were added to the quarantine, though the fever was not infectious. On board there was a strong belief that the officials made a profit out of each day's detention, and at last, as their only chance, the sick rallied to the daily muster, put on their best looks, and walked as steadily as they could past the doctor, though when out of sight they had to be carried to their bunks again. With strong representations from the captain, who felt himself getting ill, and with a judicious use of "palm oil," the vessel was allowed to proceed, after which sickness rapidly disappeared. At the same port, another steamer, though free from sickness, was made to discharge all her cargo because she had called at an infected port. The cargo and the empty holds were then well fumigated, and she reloaded, but fever appeared on board immediately after. One rash captain defied the law, and proceeded to his discharging berth. Forced to return by the guns of a man-of-war, a heavy fine was imposed, which not being paid, both ship and cargo were seized and sold. While the yellow flag flies the steamer is as one accursed. A letter, if allowed to pass, has to be cautiously passed out at the end of a long pole, perhaps to unhealthy-looking foreigners, who fumigate and subject it to various mysteries before it is considered safe. In an English port, if sickness is on board, the pilot has to report it, and once a lively scene might have been witnessed on deck, the pilot having just discovered that a sick passenger had been safely smuggled ashore.

Many are the incidents of illness and death related by African traders, of ships short-handed where fever was busy, of feeble workers, and of silent, covered forms, waiting for burial in the morning. For this the engineer is applied to for firebars, but in one case, where a round shot was also attached, the engineer, to his amazement, found it on deck again next morning. On making inquiry, he found that the mate, thinking the use of the shot superfluous, had attached a cord to it in such a way as to disengage it and bring it on board again. Further than this economy could hardly go.

Unhealthy routes, such as these, are always better paid than others—a kind of insurance against risk—and as some men pass untouched through half a lifetime in these regions, they naturally draw the prizes and receive the reward of having fever-proof constitutions, though few escape slight attacks, African negroes themselves included.

Besides fever, whether "yellow" or "malarial," another enemy of the engineer is heat. In the northern regions, while the mates battle with cold on the bridge, the engineer is snug below; but in the tropics, he looks longingly up to the cool awning above the lounging figure of the mate on his airy perch. For the engineer's comfort, a windsail is usually rigged up, and a considerable part of his watch is spent on the fascinating spot just beneath its open mouth, and many a critical observation is made of the direction of the smokedrift from the funnel, so as to be sure that the full benefit of the wind is being utilised. The engineer will also find that the parts of the engine nearest to the charmed circle require an unusual amount of attention, and little is likely to go wrong there for want of watching. Clothing also is freely cast aside, though it will be found by trial that it is coolest to keep something on, as a protection from the heat of the engines, or from the solitary scalding drop which is sure to alight on the engineer's back when he stoops over to feel the crank pin.

Of all hot places the Red Sea is perhaps the worst. The wind itself is hot, yet the faintest breath of it is sought at the wide open port holes, while one man who regarded his comfort more than his dignity, was found lying on deck with his mouth near the scupper hole, so that he might enjoy the cooler air which came up and down the pipe as the ship rolled. When the air is travelling in the same direction and at the same speed as the steamer, wind-ripples will be seen on the waters while no air is stirring on board. Even in this case the draught of the fires will sometimes keep the stokehold cool, this place being often the coolest part of the ship.

One engineer, who scorned to seek coolness in the stokehold, divested himself of all his clothing and perambulated the engine-room platform, in the simple dignity of primeval man. A temporary darkness roused him from meditation, and, looking up, he saw a row of smiling faces along the skylight line, like the heads of cherubs on the ceilings of churches, though, unlike them, these were of different ages and sexes. This he saw in a flash; the next instant he had vanished, but had to make several strategic movements to recover his clothes, which were in full view of the enemy.

It might be thought at first that the hotter the climate the more readily steam could be maintained, but the reverse is the case. Not only does the work of the fireman become more laborious, and therefore less efficient, but excessive heat is usually associated with bad draught, and this means low steam. Thus, though radiation is slightly checked, loss of steam follows the increase of external heat. But, in addition, the sea-water being warmer, more of it has to be put through the condenser, thus increasing the load on the circulating pump without proportional advantage. The efficiency of an engine being measured by the difference in temperature between the initial and exhaust steam, we find that external heat tends to loss at each end. While in cold weather engines go best, yet excessive external cold also tends to loss, for boilers and cylinders cannot be kept at their full heat. In reference to condenser temperature, a sudden alteration in the vacuum during one watch has been known to occur during the crossing of a cold current in the Atlantic, its position being verified on the chart next morning.

SPECIFICATION OF STEAM LAUNCH.

On page 148 we give working drawings for a steam launch, of which we have already given the working drawings of the engines in several issues of our last volume. The details are fully shown, and in order to make them more valuable we append specification.

PRINCIPAL DIMENSIONS.

Length (extreme)		30ft.
Breadth ,,		6ft.
Breadth (moulded)		5ft. $10\frac{1}{2}$in.
Draught of water	forward	1ft. 9in.
	aft	2ft. 1in.
Indicated horse power		35
Speed of vessel (estimated)		9 knots

The details of construction of hull, &c, are as follow:—

Stem.—To be of English oak, grown to shape, to scarf on and secure to keel with inch copper nails, having a rove or ring of copper under the head, and the points clenched on another rove of the same material. To be sided 3in. at scarf, tapering to $2\frac{1}{2}$in. at head, and tapered in a longitudinal direction from the bearding to front, finishing in a round of 1in. radius. To be moulded 6in. at head, and 7in. at scarf, where it unites to keel.

Body Post.—To be of English oak, sided as form of body may require, owing to swell for engine's tube for propeller shaft to pass through, sided at head and heel 3in., moulded 6in., and of form as shown on profile. To scarf to keel and be secured to it with copper clench nails, as described for stem.

Stern Post.—To be of English oak, sided $2\frac{1}{2}$in. and moulded $5\frac{1}{2}$in., to be connected to the body post by means of a casting of brass or phosphor bronze of the form shown on profile; copper bolts, 1in. in diameter, passing through, and clenching on cheeks of casting, form the means of securing both this and the body post.

Keel.—Of Canada elm in one length, one end scarfing to stem, the other to the body post, as before described. To be sided 3in. throughout, and moulded 7in.

Hogging Piece.—Of English elm, in one length, from scarf of apron to after deadwood, of a sufficient width to take one or more through fastenings from the lower garboard strake. To be 4in. in thickness, and secured to the keel with $\frac{1}{4}$in. copper bolts, clenched up on rings at the heads and points. The bolts to be spaced about 15in. apart, before and abaft engines and boilers, where they are to be 12in. apart.

Keelson.—Of English elm, in one length, 6in. wide and 2in. thick, to extend as far forward and aft as possible over the floors, to be secured to them with brass screws of suitable dimensions, being of sufficient length to secure the whole to hogging piece.

Apron.—Of English elm, sided as per requirements due to form of bow, moulded 4in. at part scarfing to hogging piece, and tapering to $3\frac{1}{2}$in. at upper part, secured to stem with $\frac{3}{8}$in. copper through bolts, clenched on rings as described for keel, &c.; these bolts to be spaced 15in. apart.

Breasthooks.—Of wrought iron, of suitable dimensions, fitted where shown on drawings, through-bolted at stem and topside planking, &c.

Deadwood.—To be of English oak, of the form shown on profile, and of sufficient siding to house the ends of the bottom planking, this being a fair surface. To be tabled to keel and body post, and secured with copper through bolts of $\frac{1}{2}$in. diameter, clenched on rings let into the keel. A knee is to be fitted on top of above, of English oak, grown to shape, and secured to deadwood with copper spikes, and to body post with $\frac{1}{2}$in. copper through bolts, clenched on rings.

Fashion Pieces.—Of English oak, moulded depth 4in., and sided 2in., to be secured to the posts with through copper bolts, $\frac{5}{16}$in. diameter, clenched on rings.

Cartings.—Of English oak, sided 3in., moulded 4in., rabbeted on lower edge to house bottom planking, secured to body and stern posts by knees, and fastened with $\frac{5}{16}$in. through bolts, clenched on rings.

Transom.—Of English oak, to score into the post, moulded as form of body requires, sided 2in. A rabbet to be taken out of lower edge to house the bottom plank. A cross piece to be fitted to this, and fastened to it with copper nails, clenched on roves. The cross pieces and gunwale to be secured together with grown knees of English oak, 2in. thick, or iron knees, as may be considered most suitable, but in either case they are to be secured with through fastenings, clenched on rings.

Gunwales.—To be of mahogany, moulded 9in. and sided 2in., rounded on the upper edge, and secured to the shelf (the top side planking being stopped short for this purpose) with $\frac{1}{4}$in. copper through bolts, clenched up on rings. To have watercourses cut at intervals to clear deck of any water that may get there through wash of sea, &c.

Coamings.—Those around the wells, forward and aft, for passenger accommodation, to be moulded 6in. and sided $1\frac{1}{2}$in. To be of mahogany, the upper edge being rounded. To be polished on the inside surface, and varnished on the outside.

Rubbing Piece.—Of mahogany, 4in. wide and 2in. thick, worked so as to break joint with the gunwale and top side planking, secured with brass screws of suitable dimensions. To be of segmental form, having a hollow taken out of centre on outside, 1in. broad, $\frac{1}{2}$in. deep; this is to be gilded.

Shelf.—Of Canada elm, moulded 3in., sided $2\frac{1}{2}$in., rabbeted to receive the gunwale; to be in one length.

Beams.—To deck, of English oak, 2ft. apart, to round 3in. in breadth of vessel amidships, moulded 3in. and sided 2in., to connect to shelf with tail or stop, having knees or brackets of suitable dimensions to connect to side planking, &c. Over engine and boiler as above, but the knees to be stronger, and, in addition, four iron plates, $1\frac{1}{2}$in. wide and $\frac{1}{4}$in. thick, to extend along beam under crown 1ft. and down to side of vessel, connecting thereto, and to beams with $\frac{3}{8}$in. screws; these plates to be one at each end, and the other two being of equal spacing—*i.e.*, one-fourth the length of engine and boiler room apart.

Frames or Floors.—To be of two descriptions, viz, those amidships, of Canada elm, steamed to form, moulded 1in. and sided $1\frac{1}{2}$in., spaced about 12in. apart, and extending in one length from turn of bilge on one side to a corresponding height on the other, secured to bottom planking with copper nails $\frac{3}{16}$in. diameter, clenched up on roves of the same material; also to hogging piece, with ragged-pointed copper nails of a similar dimension. The other kinds of floors are those which cross the fore deadwood. These are to be of English oak, grown to form, and moulded $1\frac{1}{4}$in., sided $1\frac{1}{2}$in., secured similar to the above.

Planking.—To be worked in two thicknesses—the inner in a diagonal direction, making an angle of 45 degrees with the keel, to be 6in. wide and $\frac{3}{8}$in. thick throughout, to be of Honduras or any other free-grained tough mahogany; the outer thickness of the same material, the lower or garboard strakes being $\frac{5}{8}$in. thick, tapering to $\frac{3}{8}$in. at the upper edge of the third strake out from keel on either side. This thickness is to be maintained to top sides, to be $4\frac{1}{2}$in. in width, and worked in a longitudinal direction. The two thicknesses to be fastened together with copper nails $\frac{3}{16}$in. diameter, clenched on roves of the same material; from four to six nails to be in every space formed by the planks crossing. The garboard to be through-bolted with $\frac{1}{4}$in. copper bolts, clenched on rings, in vicinity of hogging piece, floors, &c.; also the lower edge of first garboard out from keel to be fastened to hogging piece, with ragged-pointed bolts of the same dimensions required for the through fastenings. In shifting the butts of the outer plank three strakes should intervene between consecutive butts, the inner planks to be in one length.

Carlings, in vicinity of engine and boiler rooms, wells, &c., to be of a similar material to the beams, and sided 2in., moulded 3in.; the beams to tail or tenon into them, a small knee being used to connect them together if thought desirable.

Hood to Engine-room.—To be in form as shown on midship section, having a means of access to engine-room cut in side, also sliding sashes fitted in sides for ventilating purposes. The portion forming seats and back to them to be of mahogany $1\frac{1}{2}$in. thick; the crown to be of fir $1\frac{1}{4}$in., tongued together.

Bulkheads.—Transverse where shown on plans, of fir $1\frac{1}{4}$in. thick, tongued together, and connected to side, beams, &c., with screws of suitable dimensions. A longitudinal bulkhead to be fitted on each side of engine and boiler room, where shown on midship section, of steel $\frac{1}{8}$in. thick, connected to hood over engine and boiler room with angles $1\frac{1}{4}$in. by $1\frac{1}{4}$in. by $\frac{1}{8}$in., riveted to bulkhead with $\frac{1}{4}$in. rivets, and fastened to hull, hood, &c., with $\frac{1}{4}$in. iron screws. To be stiffened with angles $1\frac{1}{4}$in. by $1\frac{1}{4}$in. by $\frac{3}{16}$in., worked vertically about 2ft. 6in. apart.

Deck Planking.—Of fir (Dantzic preferable), $1\frac{1}{2}$in. thick, secured to beams with copper nails.

Seats in Fore and After Wells.—To be in the form of lockers, sides of fir $1\frac{1}{4}$in. thick, tops mahogany 1in. thick, hinged with brass hinges. The back boards to seats forming sides to well to be of mahogany 1in. thick, fitted in shutters in order to facilitate easy access to the side of vessel. These boards to be polished.

Skylight.—To be fitted in crown of engine-room, 4ft. long and 2ft. 6in. wide, for the purpose of ventilating, &c. The coaming to be of mahogany, 2in. thick and 6in. wide, the top to hinge; also fitted with appliance to keep open, &c.

Rudder.—Of English elm, of the form shown on profile, thickness at head $2\frac{1}{2}$in; to be hung on two wrought-iron pintles and braces (galvanised) of suitable dimensions.

Tiller.—Of wrought iron, of suitable dimensions, with a sheave or block fitted to end for steering purposes. A wheel to be fitted in after well for steering vessel; suitable chains and sheaves for this purpose to be provided, the wheel to be of mahogany (polished), with a metal cap on one spoke to indicate when vertical, the rudder being in a fore and aft line. All sheaves to be either of cast-steel metal bushed, or phosphor bronze. The standing part of steering chain to be secured at side of vessel, passing around sheave on tiller, then around sheave at side, and over wheel, to be in one length, one end of which will be secured to either side forming the standing part.

Awning Stanchions.—To be fitted for the purpose of sheltering the sitting accommodation, to be of wrought iron galvanised, of suitable dimensions and length.

Bollards.—To be fitted in bow, for securing boat, of English oak, 5in. by 5in., metal capped, a transverse bulkhead, 2in. thick, to be fitted for the purpose of securing to, the deck to be suitably strengthened in vicinity. One to be fitted on either quarter for towing purposes, &c., of similar form, material, and dimensions to above, to be well and efficiently connected to vessel.

Anchor.—Of suitable dimensions and pattern, to be supplied with the vessel, together with a sufficient quantity of cable chain for mooring.

Funnel and Side Lights.—To be supplied and fitted on suitable stands, in accordance with the requirements of the Board of Trade regulations.

Materials.—All materials to be well seasoned and otherwise free from defects; all wooden connections, such as scarfs, tenons, &c., to be coated with thick whitelead paint before being united. In the bottom planking the inner stem to be painted with some waterproof composition before working the outer thickness, which should have its inner surface well coated with thick whitelead paint. To be caulked, &c., in order to render the hull perfectly water-tight.

Iron Work.—All weather work to be galvanised.

Metal Work.—To be of good brass or phosphor bronze.

Painting, &c.—The inside to have three coats of good oil paint, of an approved colour; the outside surface to be varnished. Top of engine-room hood, &c., to be painted with three coats, white paint being the final colour. The mahogany fittings, &c., to be French-polished.

SIR GUILFORD MOLESWORTH, who has retired from the service in India, travels to England by way of China, Japan, and California.

LAUNCHES AND TRIAL TRIPS.

There was launched recently from the shipbuilding yard of Messrs. David and William Henderson and Co., Partick, a steel twin-screw tug, which has been built to the order of Mr. G. T. Davie, Quebec, and is intended for plying on the St. Lawrence. Her dimensions are 140ft. by 24ft. by 12ft., with a gross tonnage of about 280 tons. She will be fitted with two sets of powerful triple-expansion engines, and all the latest improvements for a vessel of this type.

On Thursday, 31st January, at the yard of the Tyne Iron Shipbuilding Company Limited, a handsome steel screw steamer, of the improved well-deck type, was launched. She has been built to the order of Messrs. Hunting and Pattison, of Newcastle and London. Her dimensions are: Length, 300ft.; breadth, $38\frac{1}{2}$ft.; depth, 23ft. 3in. She will be fitted with powerful triple-expansion engines, by the North-Eastern Marine Engineering Co. Limited, of Wallsend. She is fitted with all the modern improvements for the rapid loading and discharging of cargo.

Recently, at the yard of the Blyth Shipbuilding Co. Limited, a steel screw steamer was launched. She has been built to the order of Messrs. Lilly, Wilson, and Co., West Hartlepool, the managers for the Petunia Steamship Co. Limited. The dimensions of the vessel are: Length between perpendiculars, 250ft.; breadth, 36ft. 6in.; depth, 18ft. She is built to class 100 A1 at Lloyd's, and guaranteed to carry 2,500 tons d.w. cargo and bunkers. She is fitted with water ballast fore and aft on cellular principle, and has web frames, thus dispensing with all hold beams and broken stowage. The vessel is built on the improved well-deck type, with long raised quarter-deck, and bridge to foremast, is schooner-rigged, and has steam-steering apparatus on the pilot bridge, and screw purchase aft. The vessel will be fitted with triple-expansion engines by Messrs. Black, Hawthorn, and Co., of Gateshead, with cylinders 20in., 33in., and 54in., by 36in. stroke, and has two boilers 12ft. 6in. by 10ft., working at a pressure of 160lb. There are also a donkey boiler, four steam winches, patent steam windlass, and other gear to ensure rapid loading and discharging.

On Saturday morning, 26th January, the steamship Hindoo, built and engined by Messrs. Robert Stephenson and Co. Limited, of Newcastle-on-Tyne, to the order of Messrs. Thomas Wilson, Sons, and Co., of Hull, left the Tyne for her official trial, consisting of a run over the measured mile, and a trip to Hull. The Hindoo is of the following dimensions: Length, 369ft.; breadth, 42ft. 10in.; depth, 30ft. 4in. The engines are of the triple-expansion, direct-acting type, with cylinders 27in., 43in., and 70in. diameter respectively, and 48in. stroke. There are two double-ended steel boilers, 14ft. 2in. in diameter, and 16ft. 6in. long, fitted with Fox's corrugated furnaces and Henderson's patent firebars. The engines are fitted with a feed heater and evaporator, for supplying the boilers with fresh water, both by Messrs. John Gilmour and Co., of Glasgow. The ship is lighted throughout by electricity, and has powerful electric lights for discharging cargo, and for use when passing through the Suez Canal by night. The vessel was loaded with 4,000 tons, and attained a speed of $11\frac{3}{4}$ knots over the measured mile. The voyage to Hull was accomplished at full speed to the satisfaction of the owners' representatives. The steamer has been built to Lloyd's and the Board of Trade passenger certificate.

The new steel screw-steamer Blakemoor, built by Messrs. John Readhead and Sons to the order of Messrs. Walter Runciman and Co., South Shields, had a successful trial trip off the Tyne the other day. The steamer is of the following dimensions: Length, 259ft.; breadth, 36ft.; depth of hold, 19ft. She is of the improved well-deck type, and classed 100 A1 at Lloyd's. She is fitted with triple-expansion engines, also built by Messrs. Readhead and Sons, while two large steel boilers supply the propelling power. The vessel made several runs over the measured mile and along the coast, and the mean speed obtained was 11 knots per hour, a result highly satisfactory, the vessel having steamed continuously after leaving the harbour without the slightest stoppage or adjustment being necessary. After the trial the Blakemoor proceeded to Hebburn spouts, where she will load a cargo of coals for Naples. She wiil be commanded by Captain Sanders.

On Saturday, 26th January, a steel twin-screw steamer was launched from the Caledon Shipyard, Dundee, by Messrs. W. B. Thompson and Co. Limited, for the Shropshire Union Railway and Canals Company of Chester. The vessel, built of steel, has been called the Arrow, and is intended for towing and passenger trade on the Mersey. Her dimensions are: Length over all, 108ft.; beam, 21ft.; depth, 7ft. 8in. The Arrow has been built beyond the requirements of Lloyd's highest class, and is fitted up with towing arrangements aft and large cabin forward, a spacious promenade deck, from which she will be steered, having been constructed above the house enclosing the machinery. Her engines are of the triple-expansion type, fitted with hydraulic controlling gear, the cylinders being 9in., 13in., and 24in. respectively, with a piston stroke of 14in. A large steel boiler supplies the steam at a pressure of 150lb. per square inch. The deck space for a vessel of this class is unusually clear, the steering gear connections being carried under the deck to avoid all possible obstructions. By means of the recently erected travelling crane the vessel was launched complete, with steam up and in sailing trim, with the exception of the compass adjustments.

The Fairfield Shipbuilding and Engineering Company, Limited, launched from their yard recently a steel screw steamer of about 5,000 tons for the Norddeutscher Lloyd of Bremen. As the vessel left the ways she was named the "Munchen" by Miss Maclean. Her principal dimensions are: Length over all, 405ft.; breadth, 46ft. 6in.; depth, 33ft. The Munchen, like her sister ship the Dresden, launched some six weeks ago, has been constructed in accordance with the newest regulations of the Germanischer Lloyd under their special survey, and will be classed in the highest grade of that society. She also conforms in every respect to the Board of Trade regulations, and to the latest requirements of the United States. She is built throughout of the best tough ductile Martin steel, and has two watertight steel decks, all fore and aft, poop bridgehouse, and topgallant forecastle. The weather and upper decks are of teak, and the deckhouses are of steel and teak. When complete, the vessel will have accommodation for about 40 first-class, 16 second-class, and 2,000 third-class passengers, besides ample accommodation for the officers and crew. The Munchen is lighted throughout by electricity, for which purpose she has two distinct engines and duplicate dynamos, each furnishing power for about 300 incandescent lights. Provision against fire has been made by suitable sub-division of the ship, and by the use of steam injectors and independent water service from powerful hand and steam pumps. In the unlikely event of disaster she is amply provided with 10 large steel lifeboats, besides collapsible boats. The Munchen is schooner-rigged, having two pole masts of steel, with yards on the foremast. She will be fitted with steam capstan windlass, warping capstan, steam winches, and all the latest improvements for working cargo and safety of passengers. The engines for the Munchen are of the inverted triple-expansion type, with cylinders of 30in., 50in., and 80in. diameter, the stroke of piston being 4ft. 6in. The crank shaft is built, and, like the propeller shaft, is made of Vickers, Sons, and Co.'s steel. The tunnel shafts are of Siemens-Martin steel, and were supplied by Messrs. John Brown and Co., Sheffield. The engines are fitted with all the latest improvements for economising fuel, including a feed-water heater, a fresh-water producer for the boilers, &c. The propeller boss and blades are of cast steel, the latter being coated at the back by Johnston's process. Steam is supplied from two double-ended boilers and one single-ended auxiliary boiler, made of steel plates throughout. The furnaces, 15 in number, are also of steel, and corrugated. The boilers have been constructed in accordance with the British Board of Trade and Germanischer Lloyd rules for a working pressure of 150lb. per square inch.

THE INSTITUTION OF CIVIL ENGINEERS.

THE thirteenth ordinary meeting of the session 1888-89 was held on Tuesday, the 19th of February, under the presidency of Sir George B. Bruce. The paper read was on "Alternate-current Machinery," by Mr. Gisbert Kapp, Assoc.M.Inst.C.E.

The theory of alternate-current machines, as given in modern text books, was based upon the assumption that the currents were generated in wire coils, the magnetic induction through which underwent periodical changes according to a simple sine function. A machine of this character would be represented, in its most elementary form, by a coil of insulated wire revolving round an axis in its own plane, with uniform velocity, in a uniform magnetic field, the axis of rotation being at right angles to the lines of the field. The electromotive force at any moment was

$$e = 2\pi n z \frac{\tau}{2} \sin a,$$

where n was the frequency (number of complete periods per second), τ was the number of wires in both branches A and B of the coil collectively, z was the total induction through the coil when the latter stood at right angles to the lines of force, and a was the angle between this position and the position at which the electromotive force e was generated. The mean electromotive force was

$$e = \frac{\pi}{\sqrt{2}} n z \tau.$$

It was convenient to compare this value with that representing the electromotive force of a direct-current machine having the same field and external number of wires τ (but equally distributed) on the armature. The electromotive force of such a machine was given by the product $z \tau \frac{N}{60}$, where N, the number of revolutions per minute, might obviously be replaced by $60n$ when the machine had two poles; because in this case frequency and number of revolutions per second were identical. The ratio between the electromotive forces of the two machines remained the same, namely, $\frac{\pi}{\sqrt{2}}$. Alternators as now constructed had more than one pair of poles, which were set in a circle, and were so arranged that the coils of the armature swept past them. As the interpolar space was always very small, the density of lines, emerging from or entering the polar surfaces, might be taken as fairly uniform over the extent of these surfaces, and it became thus possible to determine for every shape of coil the configuration of polar surface which would produce that variation in the induction which corresponded to the simple sine function. Poles of this shape were, however, not used in practice—the poles were either trapezoidal, circular, or rectangular. In the Mordey alternator the poles had a trapezoidal face, and those succeeding each other on the same side of the armature were of the same sign, and were placed in line with those of opposite sign on the other side of the armature. Thus, along the mean pitch line, uniform fields alternated with spaces in which there was no induction. The electromotive force of this arrangement was

$$e = 2 n z \tau.$$

The type of field most commonly used in modern alternators was, however, one in which N and S poles succeeded each other around the armature, and the portion of the armature not embraced by the poles might be taken as equal to that embraced. The electromotive force of this arrangement was

$$e = \frac{4}{\sqrt{2}} n z \tau.$$

These results referred to machines in which the active wires on the armature were concentrated into single lines. This was of course impossible in practice; the wire coils on the armature, whether this contained iron or not, must occupy a considerable space, and this circumstance would, generally speaking, cause the electromotive force obtainable, with the different forms of fields considered, to be lower than the values given. The reason for this reduction was that, with a wide coil, all the coils were not equally and simultaneously influenced by the field, and in certain positions the action was differential. The calculation of the effective mean electromotive force for any configuration of field and armature coils presented no special difficulty, though for certain complicated forms the operation was somewhat laborious.

The electromotive force of an alternator could be expressed as the product of the electromotive force of a direct-current machine, having the same dimensions and weight, and a certain coefficient depending on the configuration of the field magnets and armature coils. The winding and other constructive data of an alternator being known, it was only necessary to find this coefficient in order to determine the electromotive force, by reference to the electromotive force which would be produced by the same machine if the armature coils were connected in such a way as to give a continuous current. The electromotive force in volts of an ordinary dynamo was given by the formula—

$$e = z \tau \mathrm{N}\, 10^{-6},$$

where z represented the total induction in English lines of force (each equal to 6,000 C. G. S. lines), τ the total number of active wires counted all round the armature, and N the speed in revolutions per minute. If the machine was multipolar, and if the different armature circuits were arranged in series, the expression for e must be multiplied by p, the number of pairs of poles in the field. Let k be the coefficient which expressed the ratio between the electromotive forces of the alternate and continuous current machines, then the formula for the former was

$$e = k p z \tau \mathrm{N}\, 10^{-6}.$$

(To be continued.)

ELECTRIC LIGHTING IN THE HOUSES OF PARLIAMENT.—A small steam engine and dynamo capable of working about 120 extra electric lights have been erected at the Houses of Parliament, thus increasing the total number in the building to 620. Seventeen of the additional lights have been placed in one of the reporters' writing-rooms, and the remainder are supplied to the members' entrance lobby, staircase, and corridor. After Easter the light will probably be extended to the Commons' Lobby, St. Stephen's Hall, the offices immediately adjoining the House, and several of the Ministers' and reporters' rooms.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

ERROR IN "MODERNISED TEMPLETON."

To the Editor of "The Practical Engineer."

SIR,—I should like to point out through the medium of your paper an error that exists in the "Modernised Templeton." On page 123 there is a table, giving the length of angle iron for making different sized hoops. On page 127 I find the following directions: Add the width to the diameter, and look in table No. 20, which gives the length of bar required to make the given hoop. Let me take an example: Required a hoop, 12in. diameter, 2½in. by 2½in. by ⅜in. section. By the above method I get 12in. + 2½in. = 14½in. ; and on looking in the table we find 14½in. gives 3ft. 6½in., which is about the correct length. Now let me take a larger hoop, say 4ft. diameter inside, by 2½in. by 2½in. by ⅜in. section, and, proceeding as in previous example, I get 4ft. + 2½in. = 4ft. 2½in. ; against this diameter in the table is 12ft. 4in. Now, I find by actually bending a hoop 4ft. diameter inside, by 2½in. by 2½in. by ⅜in. section, that the length required is 12ft. 10¾in., or 6¾in. longer than given in table. To this length must be added 1in. for welding, making the total length 12ft. 11¾in.

By the method given in the book the *thickness* of the angle iron is neglected entirely, and I think this is where the mistake is made. The following is the rule that I adopt for getting out hoops of all diameters and sections :—

Inside diameter × 3⅐ (thickness of heel of angle iron × 6) + 1in. = total length of bar.

Required the length of a bar of angle iron, 2½in. by 2½in. by ⅜in. section, to form a hoop 4ft. diameter ; 4ft. × 3⅐ = 12ft. 7in.

Thickness of heel of a ⅜in. angle iron is about ⅝in. ; ⅝ × 6 = 3¾.

Welding, 1in.

12ft. 7in. + 3¾ + 1in. = 12ft. 11¾in. length of bar.

From this we see that the table is correct for small diameters, but for large ones it cannot be relied upon by yours, &c., BOILER-MAKER.

STEAM-ENGINE EFFICIENCY.

To the Editor of "The Practical Engineer."

SIR,—In reply to "W. A." in your issue of the 15th instant, I surely misread his letter as to the equalising of the work done in the cylinders of a compound engine, because I maintain that with the present cylinders of "L. C. D.'s" engine the work done by the two can be equalised, and that a slight gain would be the result. Anyone practically acquainted with the indicating of steam engines can see from "L. C. D.'s" diagrams that there is something wrong, and a very serious loss to the pocket of those who pay for the coal is the consequence. Unless the load is increased, or the cylinder capacity reduced, the loss cannot be effectually prevented. The diagrams of your correspondent, R. Bramall, showed a slight gain by the alteration, but the engine is too large for the load. It would be interesting to know if there is a back-slide cut-off on the high-pressure cylinder, and how much coal was saved after the alteration ; no doubt it is small, but it is a step in the right direction. I should advise "L. C. D." to dispense with the key of his low-pressure eccentric and to use two set-pins and dies. He need not be afraid to lap the low-pressure valve or give it lead without altering the high-pressure exhaust rods, as it would only give a little earlier release and a little more compression, which will be of advantage. But the engine requires something more than lap or lead, and if the alteration suggested in my previous letter was carried out it would pay capital interest for the money expended.

The letter of your correspondent, "Piston," has several questions our modern engine builders would do well to study. The reason of a discrepancy of 8lb. to 10lb., and in some cases 15lb., between boiler and high-pressure initial, is a matter our Corliss engine builders would do well to study. I have known engines made by the same firm which varied from 1½lb. to 10lb. This, in my opinion, was due to the same valve box being used for too great a range of cylinder diameters. If ports, passages, and receiver capacity be large enough, there need not be more than 1½lb. to 2lb. loss between high-pressure cylinder initial, also high-pressure, back-pressure, and low-pressure initial.—Trusting the suggestion of "Piston" may be carried out, I remain, yours, &c.,

BOLTON.

To the Editor of "The Practical Engineer."

SIR,—In reference to "W. A.'s" last letter, I admit that his remarks regarding the laws of absolute pressure and power of steam are scientifically correct, but in practice he will find that by increasing lap on valves of low-pressure cylinder any augmentation of back pressure in the high-pressure cylinders will be more than compensated for by the greater power of low-pressure cylinders, and also the smaller amount of condensation which occurs, owing to lessening useless expansion of steam between the cylinders. Of course the amount of lap will have to be varied according to the ratio of cylinders, so as to diminish as far as possible any loss of power from back pressure in high-pressure cylinder, as I find in practice that a reasonable amount conduces to the efficient and economical working of a well-arranged compound engine. A. Evans seems also of this opinion. If "W. A." will examine my diagrams, he will find, after adding 1in. of lap to low-pressure valves, that it has diminished power in high-pressure cylinder, and increased power in low-pressure, therefore lessening condensation considerably. Scale 30th H.P., 20th L.P.—Yours &c., R. BRAMALL.

QUERIES AND REPLIES.

18. VACUUM IN CYLINDER.—Can any reader say what is the cause of bad vacuum in the cylinder of an engine I have? In the condenser it is 13·75lb. to 14lb., and in the cylinder of the engine only 10lb.—CONDENSER.

Answer.—It is impossible to say what is the cause of the bad vacuum in the cylinder of which "Condenser" complains from any information given of the attendant circumstances. I would suggest that perhaps his exhaust valve does not open sufficiently to allow the steam to escape from the cylinder ; or the steam passages between the cylinder and condenser may be too small, contracted, or obstructed at some point, or too long and tortuous, to allow free vent to the steam.—W. A.

19. TRUEING-UP EMERY WHEEL.—Will some reader inform me of the best method of trueing-up emery discs which have become smooth and glazed?—PRAECEPTUM.

Answer.—The best method to true up emery discs which have become glazed is by the aid of a diamond.—H. G. S.

The diamonds used for trueing up emery wheels are black, and are set in steel tools in a kind of pitch. A fairly good one costs about 50s.—ED. *P. E.*

20. LOOM.—What is the best book on the loom and its construction?—ANXIOUS.

Answer.—You will find "Cotton Manufacture," by C. P. Brooks, M.S.A., a very good work on the subject.—S. B.

21. MARKING OFF CRANK.—Will some practical reader inform me the best way to mark off a two-throw crank shaft for "turning," after the webs have been "slotted" out ; also how to get the position of the arms to turn the "throws?"—CRANK.

22. ANTIMONY.—Will any reader kindly inform me of the best way to melt ground antimony? The only means at my disposal for doing so are in a ladle over gas or over a large stove, and this is not effectual, as the powder simply cakes.—H. P. S.

TO CORRESPONDENTS.

STRENGTH, Washwood Heath.—You will find your query on strength of pipe for resisting hydraulic pressure very fully treated in our article on Hydraulic Machinery, &c., now appearing.

B. C., Engine Constant.—The area of the piston rod should, of course, be deducted from the area of the cylinder in calculating constant for that end.

W. H. B., Victoria Park.—If you cannot discharge the steam elsewhere, your only course is to use a condenser. The jet condenser is the form most commonly used on land, and if you have a sufficient supply of water there can be no difficulty in applying it.

E. P. R., Mirfield.—The usual method of enlarging an indicated diagram is by dividing the surface into a number of equal squares, and then copying the various points on a larger sheet similarly ruled, but with larger squares. Colour is washed on, as in any other mechanical drawing.

PRO AFRICA.—There are many valuable works upon the branches of mechanical and civil engineering to which you refer, but we fear none which give the range of information you desire within single volumes. A. Rigg's work on the steam engine is perhaps nearly what you require on that subject. D. K. Clark's rules and tables for engineers may also be useful to you. They are to be obtained through all booksellers.

W., Birmingham.—"Practical Electric Lighting," by A. B. Holmes, published by Messrs. E. and F. N. Spon, London, will suit your purpose. Messrs. Longmans and Co. also publish a good work upon the subject of electric lighting, by J. C. Swinton.

ENGINEER.—There is no book as yet on triple-expansion engines, although several good papers have been published, which you will find in the transactions of engineering societies, including the Institution of Civil Engineers and the Institution of Mechanical Engineers, now to be found in all the reference libraries. The proportions of the three cylinders vary with the pressures used. We hope shortly to give articles on compound and triple-expansion engines.

G. R., Chesterfield.—The energy of a flywheel 21ft. in diameter with its rim, weighing 5 tons, at 30 revolutions per minute, depends to some extent on the section, as the velocity varies from point to point as it nears the centre. If, however, it be supposed that the rim is very thin on the edge, and broad on the face, the energy is easily calculated. Taking the circumference of the circle as 66ft., 66 × 30 = 1980ft. per minute is the velocity of the moving mass, which is equal to 33ft. per second. Now, the equation connection energy and mass is $E = \frac{M v^2}{2g}$ When E is energy in foot-pounds, M mass in pounds, v is velocity in feet per second, and g intensity of gravity = 32·2. This becomes $E = \frac{11{,}200 \times 33^2}{64 \cdot 4} = 189{,}391$ foot-pounds. This would nearly give about six horse power for one minute. The weights required to balance at the opposite sides of the shafts are inversely proportional to the diameters of the drums ; you can easily calculate the amount for yourself.

STEAMSHIP.—"Shipbuilding," by Pollack, published by Messrs. Spon, may suit your purpose. The functions of the Board of Trade and Lloyd's are far too wide-reaching to be described in a short answer. Engineers must conform to the rules of the Board of Trade, and also to Lloyd's, if they wish to register there.

MISCELLANEA.

Another Large Bridge.—A project is talked of for bridging the Ganges at Sara Ghat. The least waterway required will be ¾ mile.

Oil Wells in Central Asia.—Mr. Ouspensky, a Russian engineer sent to Central Asia on a special scientific mission, reports that the oil wells at Penjakend, near Samarcand, in the Zerafshan Valley, contain at least 9,000,000,000lb. of perfectly pure oil.

New Cruisers.—Two new fast cruisers of 2,500 tons displacement and 7,500 horse power, to be called the Phœbe and Philomel, have been ordered to be built at Devonport Dockyard. They will have a speed of 16 knots, and carry an armament of 6in. breech-loaders and 32-pounder quick-firing guns.

Tin.—A Paris syndicate has purchased the tin mines of Villeder, which, it was feared, were about to fall into the hands of an English company. These mines are being erroneously represented as the only source of tin in France. But tin has been found in Bretagne from remote times. The tin mine at Montebras (Creuse) is still being worked.

Eiffel Tower.—The Eiffel Tower has now attained the height of 281 metres, or 927 feet; so that very little is now wanted to complete the thousand feet of this modern Babel. It is expected that the work will be finished, as far as height goes, in about a fortnight. The lifts are not to be in operation till about April 1. There is every appearance that all will be ready for the opening on the 1st of May.

Shipbuilding Contracts.—The Naval Construction and Armaments Company at Barrow has, it is stated, received an order from the British and African Steam Navigation Company for the construction of two steamers, 3,000 tons each, 312ft. in length, and fitted with triple-expansion engines. The company has also received a contract for three large steamers for the French Transatlantic Company.

Electric Lighting in Bulgaria.—Her Majesty's Agent and Consul-General at Sofia reports that the municipality of that capital has decided to light the streets of the town, and the ministries, consisting of ten houses, with about 20 rooms in each, with electric light. Tenders for that purpose will be received by the Municipality of Sofia up to the 13th of April, and it is desirable that communications should be made in French or German, if possible.

Metric System.—The metric system of weights and measures is destined to become universal. According to a statement now made public by M. de Malarce the system is now legally recognised in the civilised world among 794,817,796 people. That is 60·6 per cent of the world's population. But to be legally recognised is very far indeed from being generally practised. The metric system is legally recognised in the United Kingdom, for example. But how many of the population understand it?

Fleeing from Panama.—A great number of workmen have already been discharged from the canal works, and most of them have gone to Chili and the West Indies. All having the means to get away from the region are doing so as quickly as possible. For it is believed that within a few weeks there will be a total suspension of the work; and those having anything to preserve, to say nothing of their lives, have in view what may happen when the thousands of semi-savage navvies, gathered up from all quarters, will be thrown into idleness.

The Railway Race.—The meeting of the Great Northern Railway has disposed of one of the rumours which have of late been so plentiful as to the building of great locomotives and the laying down of water troughs. It was stated by Lord Colville, the chairman of the company, that there is no truth in these rumours. The Great Northern is building no larger engines, and is putting down no troughs. It is content with the present speed to Edinburgh; so that, unless the minds of the companies change, there will be no railway race next year.

Brake Instruction Car.—An instruction car has been built at Altoona for Geo. Westinghouse, jun., which is designed to exhibit to railroad men the practical workings of all the Westinghouse appliances, consisting of working models of the latest improved air brake for passenger and freight cars, the new friction buffer air signal, steam-heating apparatus, electric lighting, and in fact everything pertaining to the mechanical equipment. A 15 H.P. boiler will supply steam to a Westinghouse engine, which will operate a dynamo, while a tank with a capacity of 6,000lb. will carry a supply of water under the car.

Bangkok Rice Mill Industry.—The first steam rice mill at Bangkok was established by an American firm, but not finding it profitable they disposed of their plant. Now the preparation of rice for market has grown into a prosperous business. The large crop this year and the increased demand has induced several firms to put electric lights into their mills, so that they can run night and day. There are now 15 steam rice mills in Bangkok, one in course of construction, and two at Patriew, a city thirty miles west of the capital. Most of the mills are in charge of foreign engineers. The only fuel used in these mills is the husk of the rice. Notwithstanding the country is full of rice—the last year's crop being an unusual one—the drought which has prevailed has dried up the water in the canals to such an extent that only a small portion has so far reached market.

The Sunbeam.—In the age in which we live science and mechanical invention are rapidly sweeping away many picturesque traditions. Nowhere is the change more marked than in the pleasure fleet. In the larger yachts the canvas which supplied much of the romance of a sea life is more and more rarely seen. The Sunbeam is a notable exception. In this well-known vessel the use of steam has been discontinued, and the screw aperture has been filled up. Her latest performance is a remarkable instance of rapid sailing. From the Isle Wight to Naples, in constantly varying conditions of weather, an average speed has been maintained of 9½ knots.

Mechanical Scavengers.—The man with his barrow and his broom is to be brushed aside for ever. He is being crushed out of existence by machinery. There has just been successfully tried in London a new machine which does all at once which the scavenger and his besom and his shovel and his scraper and his barrow do, one after the other. It is a street-cleansing machine. Its horizontal brushes, fixed on a pair of endless chains revolving around spindles, sweep the mud into a receiver. From that receiver a series of buckets, fixed on endless chains, lifts the mud into a shoot, which delivers it into the mud cart. The travelling wheels on which the apparatus is mounted set the mechanism going.

The New Gatling Gun Manufactory.—The Gatling Gun Company, Limited, took possession of the Holdford Mills at Whitton in October, since when they have carried out extensive alterations, and have laid down gunmaking plant of the value of about £15,000, a large portion having been brought from the United States. When in full swing it is calculated that the company can produce nearly 1,000 machine guns a year, and 3,000,000 cartridges a week. At present about 130 workpeople are employed, but ultimately nearly ten times that number will be required. There is a complete cartridge-making plant, ample shedding for the manufacture of the new guns, with the requisite shooting ranges, and water and steam power.

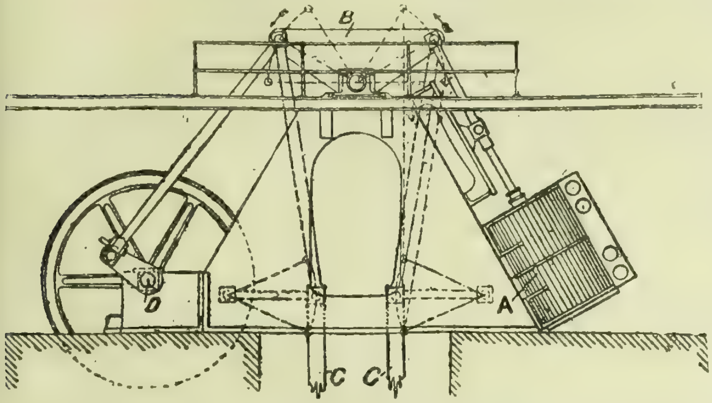
The Purchase of a Shipyard.—We understand that Messrs. Scott and Co. will fit up the yard just purchased at Greenock, and which was formerly occupied by Messrs. Steele and Co., with new machinery and other appliances for the construction of the largest vessels, both for purposes of commerce and warfare. They have also resolved upon the extension of their engine works. All this, no doubt, points to the certainty of a large tonnage on hand, and the probability of additional contracts to follow soon. It is well enough known that Messrs. Scott are in treaty for one or two steamers for the Brighton and South-Coast Railway, to run between the Isle of Wight and Southampton, and it is stated also that negotiations are going on with regard to a contract for several Government gunboats. The two gunboats now on the stocks are proceeding towards completion, but as the time allowed for their construction extends to three years, Messrs. Scott and Co. are determined to make no particular hurry, so that the work may be brought to as high a state of perfection as possible.

E. Blakey and Sons v. Latham and Company.—Without calling upon counsel for the respondents, Lord Justices Cotton, Lindley, and Lopes gave judgment upon the appeal of the plaintiffs in this action from the decision of Mr. Justice Kay on the question of the validity of the patent for boot-protectors cast with the fastening nail or spikes fixed to the metal plates. Lord Justice Cotton said the action was brought by the transferee of a patent granted to one Fessey in 1876 for improvements in heel-plates for the protection of boots and shoes. It was not alleged that there was any novelty in the plates themselves, but what was claimed as the invention of the patentee was the casting of the plates with the pins or nails used to fasten them to the leather connected with the inside of the plate, so that it could be readily attached to the boot or shoe. A thing was not to be called new in a patent sense simply because it had never before been applied in that particular way; the novelty must show invention. He assumed that heel-plates made with the fixed pins were unknown before the date of the patent; but they were analagous to the clinker nail previously in use for attaching protectors to the toes of boots. In his opinion, therefore, the appeal failed. Lord Justice Lindley was of the same opinion. It was difficult to draw the line between good patents and bad; but, unless care was taken, trade would be paralysed in every direction. In these days a patent could be got for almost anything; but if a patent was to be upheld because it varied slightly from something that had gone before, a stop could be put to all improvements. A patent was a serious matter, and for the protection it gave there must be a *quid pro quo*. What was there in this particular patent? The old fashion was to drive a nail through the heel-plate, and the plaintiffs cast their plates with the nails in them. The clinker nail was the same thing. It was a rubbishing and mischievous patent, and the Court ought to say so. Lord Justice Lopes said if patents like this were held good, and a very slight difference of applying and using a well-known thing was held to constitute a patent, there would be no end of patents and very little freedom of trade. The appeal was accordingly dismissed, with costs.

ILLUSTRATED PATENTS.

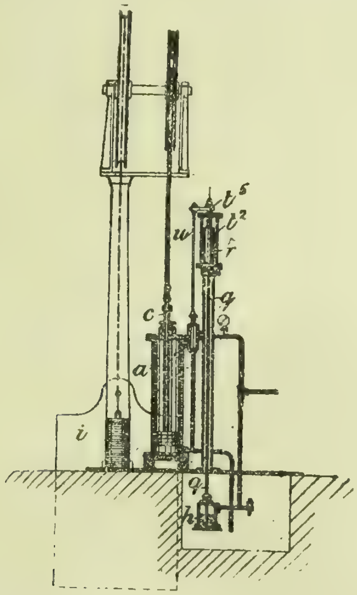
13,270. **Pumping Engines**, H Davey, 3, Prince's Street, Westminster.

An inclined cylinder A is arranged to work on one arm of a rocking frame B, to which the rods C, C, of lift pumps are connected. The other arm of the frame is connected to a crank on a flywheel shaft D, or it may be connected to a second cylinder similar to A, in which case the flywheel shaft is dispensed with. Owing to the angular arrangement of the rocking frame the lifting stroke of each pump is effected with an increasing leverage, and by reason of this the cylinders may be worked with expansion.—September 30, 1887. [6½d.]



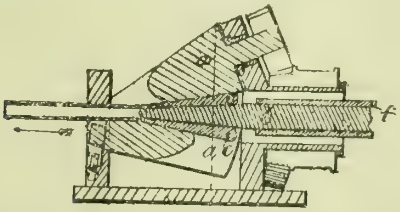
13,289. **Dampers for Steam-boiler Furnaces**, D., D. J., J. H., and S. J. Parsons, all of Corbyns Hall Ironworks, Pensnett, near Dudley, Staffordshire.

Arrangements are provided for the automatic actuation of dampers by variations of the steam pressure within the boilers. For this purpose a single or double acting cylinder *a* is employed to which steam is supplied by means of a balanced valve, preferably of the piston type. The valve is operated by means of the rise and fall of a mercurial column *q* correspondingly moving a float t^2, which by suitable connections t^5, *u*, moves the steam distributing valve in a similar manner. The mercury is operated by the pressure of boiler steam acting upon its surface within the trough *h*. The piston rod *c* is connected to the damper *i* by any suitable arrangement. Several dampers corresponding to a battery of boilers may be actuated by one apparatus, while in the place of steam from the boilers the compressed air supplied to the furnaces may be utilised. A mercury overflow pipe from the float cylinder *r* is also provided. In addition, spring cushions of convenient form and material are fitted to the steam cylinder.—October 1, 1887. [8½d.]



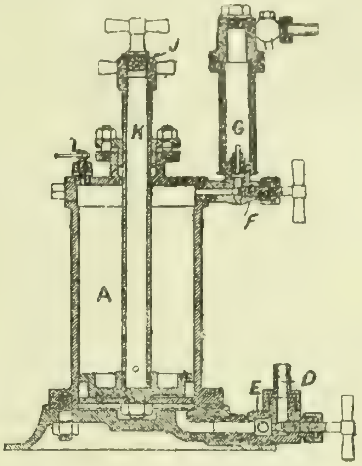
13,760. **Tubes**, C. White, 6, Prince's Terrace, Darlington.

This figure is a vertical section of a tube rolling mill with three conical rolls *a*, which are set obliquely round the tapered mandrel *b*. A cylindrical blank *c* is placed on the mandrel, which is driven forward to the rolls by a sleeve *f*. The rolls, which are all driven in the same direction by bevil gearing, compress and reduce the blank, forcing it along the mandrel and out of the mill in the direction of the arrow.—October 11, 1887. [6½d.]



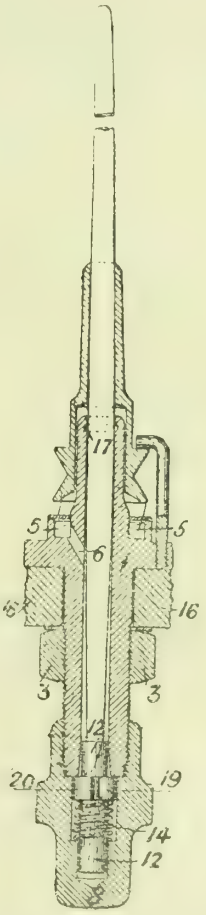
13,292. **Lubricators**, J. L. Grandison, 269, Moss Lane East, Manchester.

The lubricator consists of a cylinder A, containing a piston, above which the lubricant is stored. Steam is admitted below, and the lubricant is driven out owing to the difference in pressure on the sides of the piston depending on the area of the piston rod, the end of which passes out of the cover. The oil is introduced by means of a valve J, at the end of the piston rod K, which is hollow, and is in communication with the cylinder; the air is allowed to escape through the valve L. The apparatus may be provided with one or more sight-tubes G, with regulating valves F. The admission of steam from the pipe D is controlled by a valve, and a drain cock E is provided.—October 1, 1887. [8½d.]



13,478. **Bearings for Ring Spindles**, W. Bodden, Hargreaves Works, Oldham, Lancashire. *(J. H. McMullan, Biddeford, Main, U.S.A.)*

The bolster 1, supported by the rail 16, and secured by the nut 3, carries at its lower end the footstep case 8, which is preferably of the form shown. The bolster is preferably cylindrical throughout its length, and is provided with an oil well 5, and duct 6, and with a groove 17, to prevent the oil from passing in considerable quantities over the top. The footstep 12, which fits loosely in the case, and may be prevented from rotating by screws passing through the side thereof, is supported by a spiral spring 14, the upper end of which takes against a collar 19, upon the footstep, in which are grooves 20, to allow sediment to pass from the bolster into the case 8. The spindle is provided with a sleeve whirl, and at its lower part is preferably made tapering, as shown, terminating in a sharp point.—October 5, 1887. [8½d.]



13,436. Starting Gas Engines, H. Lea, 38, Bennett's Hill, Birmingham.

The invention consists (1st) in arrangements for turning the engine, and (2nd) in arrangement for opening the exhaust valve during the compression stroke. (1st) Three sorts of turning gear are described in figs. 1 and 2. A ratchet wheel *a*, with an odd number of teeth, is keyed to the crank shaft between two discs *b* fastened together by bolts b^2; two pawls *c*, on opposite sides of the ratchet wheel, are carried on gudgeons, turning in holes in the discs, and a handspike *e* is inserted in holes *f*, f^1 in the latter to turn it. When the engine is started and the handspike is withdrawn the discs rotate with the ratchet wheel. The ratchet wheel may be replaced by a friction wheel, and the pawl by an eccentric *c*, held against the wheel by a spring c^3 (fig. 7), or by a friction pawl (fig. 13), in a hole, in which the handspike is inserted. (2nd) The roller *h* on the exhaust valve lever h^1 runs between two pins k^3 on the lever *k*, which is shown in fig. 19 in its normal position. When starting the engine the lever is moved to the left, which causes it to bring the roller *h* in the path of a projection g^2 on the cam *g* for opening the exhaust valve during the compression stroke of the engine. The lever *k* is retained in its two positions by a weight *m* on its free end.—October 4, 1887. [8½d.]

FIG. 1.

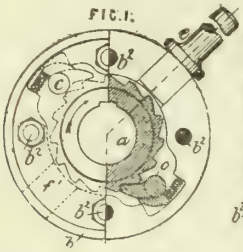


FIG. 2.

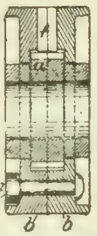


FIG. 7

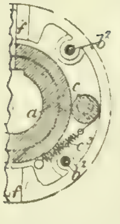


FIG. 13.

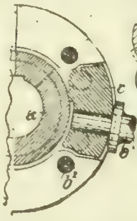
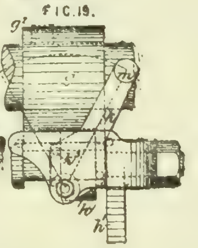
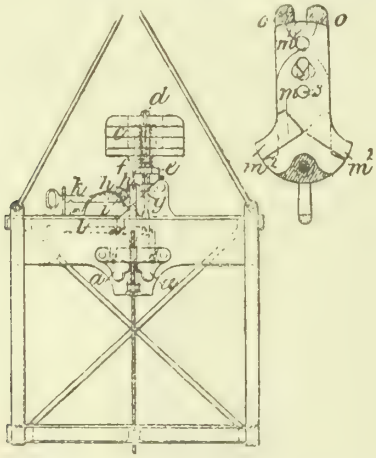


FIG. 19.



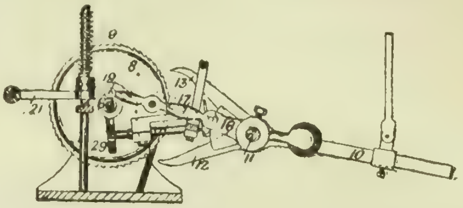
13,863. Mine and Hoist Cage Safety Gear, E. Ormerod, Atherton, Lancashire.

Suspension gear: The grippers *a* normally hang free of the guide ropes, but if the lifting rope breaks they are raised into gripping contact by the action of the spring *f*. This rests upon the bridge-piece *e* and surrounds the spindle *d*, which carries a weight *c*. Ordinarily this weight compresses the spring, but should the cage fall through the breaking of the rope, the spring raises the weight and its spindle, and thereby lifts the lever *h* connected by links to the grippers, by means of the snug *g*. The spring catch *i* sustains the lever *h* in its raised position. It can, however, be released by the rod *k*. By means of the lever *l* the grippers may be worked by hand from the cage. Preventing overwinding: The ordinary scissors-like hooks *m* are used. These are pivoted at *s* and are separated to open the claws m^1 by the inclines m^2 meeting a fixed ring. The improvement consists in joining the side-plates above the hooks by blocks *o*, which take part of the strain. In a modification, in which a single slotted hook works between two plates having hooked ends, the centre piece is continued upwards and carries a cross pin passing over said hooks, so bringing part of the strain upon it.—October 13, 1887. [8½d.]



13,871. Steam Engines, R. Wilby, Britannia Terrace, Mirfield, Yorkshire.

Relates to ratchet transmitting mechanism for governors, whereby every deviation of the governor from the normal position produces a permanent alteration in the valve; the transmitting mechanism operating by rotating the spindle of an ordinary variable expansion valve. The drawing is a vertical section. On a spindle 6, connected with the expansion valve spindle by bevel gearing, are mounted a pair of right-hand and left-hand ratchet wheels 8, 9. About the axis of the spindle rocks a frame 10, operated from any moving part of the engine, carrying a pair of pawls 12, 13, normally out of engagement with the ratchets. These pawls are on a spindle 11, with an arm 16, by which either may be brought into gear when the governors shift by the following arrangement. The arm is pivoted to a lever 17, mounted on the rocking frames, and having a pin 19 transversely projecting parallel to and vertically over the spindle 6. On this pin rests the curved end of an arm 21, pivoted at the opposite end to a fixed point, and at an intermediate point connected resiliently through various rods, &c., with the governor sleeve. The curvature of the lever end, and position of transverse pin, are such as normally to allow the rocking frame to reciprocate without change. A movement of the governor, however, depresses or raises the curved lever end, resulting in a change in position of the arm 16, and bringing one or other pawl into gear. The next few succeeding oscillations of the rocking frame then act to alter the valve, during which time the governor and pawl apparatus return to their initial positions. A worm on the spindle gears with a worm wheel 29 mounted in the rocking frames, by which a finger putting the pawls out of gear is operated before the apparatus can overrun itself.—October 13, 1887. [11½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq. *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

February 6th.

2144 Petroleum Engines, Sir E. F. Piers, Bart., Manchester.
2148 Steam Engines, W. Wilson, London.
2149 Rotary Fans, E. G. N. Salenius, London.
2158 Drill Chucks, J. Hayes, Middlesex.

February 7th.

2173 Nails, H. H. Lake, London. (M. Chase and M. H. Foster, United States.)*
2174 Steel Ordnance, J. Hill, Greenwich.
2210 Gas Engines, J. F. Shaw and R. H. Shaw, Manchester.
2233 Ships, A. C. A. Holzapfel, London.
2234 Riveting Machinery, A. C. A. Holzapfel, London.
2242 Motors, A. J. Boult, Middlesex. (J. R. Valentine and A. T. Grigg, United States.)*

February 8th.

2246 Producing Water Gas, G. H. Lloyd, A. L. Lloyd, H. Bewlay, and W. S. Sutherland, Liverpool.
2253 Stop-valve, W. Park, Salford.
2259 Economising Coal, J. Simpson and S. Read, London.
2264 Raising Water, J. E. Rogers, Staffordshire.
2266 Low-water Alarm, J. H. Dewhurst, Sheffield.
2286 Files, G. J. Davis, London.
2288 Valves, C. Downs, London.

February 9th.

2323 Hydraulic Rams, J. Blake, Manchester.
2326 Fans, R. Pye, Halifax.
2329 Joining Pipes, B. Shaw and B. Shaw, jun., Huddersfield.
2336 Mules, J. Whitehead, London.
2339 Blow-pipes, R. Renwick, London.
2345 Pumps, E. B. Ellington, London.
2354 Spanner, C. W. Titterington, London.
2363 Elastic-tyred Wheels, W. Blakely, London.*
2364 Tube Stopper, W. H. Gales, London.

February 11th.

2369 Steel and Open-hearth Furnaces, L. Roberts, J. Jones, and the Moor Steel and Iron Co. (Limited), Stockton-on-Tees.
2370 Compressing Air, C. Barnett, Surrey.
2376 Telescopic Steam Joint, H. Skelton and B. Sutcliffe, London.
2377 Flanging Steel and Iron Plates, A. C. A. Holzapfel, London.
2378 Paraffin Oil Gas, M. Murphy and S. J. Cluff, Dublin.
2379 Clay-cutting Machines, H. Potter and E. Assmann, Berlin.*
2384 Gaseous Fuel, B. D. Healey, Lancashire.
2393 Ventilating, W. E. Heath, Islington.
2404 Duplex Steam Engines, S. G. Browne and W. Roby, London.
2410 Piston Rod Packing, I. B. Harris, London.
2412 Excavating and Removing Soil, R. H. Fowler and S. McCaughey, London.

February 12th.

2454 Riveting Machinery, G. H. Lloyd and H. Bewlay, Birmingham.
2478 Propelling Ships, J. Rettie, London.
2490 Transmitting Power, T. W. Lemieux, London.
2501 Indicators, B. Donkin, jun., and E. Collins, London.
2508 Carburetting Gas, H. S. Maxim, London.
2513 Fittings for Drilling Machines, &c., J. Houston, Glasgow.
2515 Coiling Pipes, H. E. Fowler, London.*
2518 Firing Guns, J. A. C. Adelsköld, London.

February 13th.

2521 Ships' Boats, H. Day and S. F. Read, Kent.
2528 Centrifugal Separator, W. Hucks, Camden Town.
2542 Pistons, T. W. Scott and F. A. Durnford, Lewisham.
2543 Cartridge Cases, C. S. Bailey, London.
2544 Secondary Battery Plates, A. Douglass and F. Smith, London.
2546 Drilling Machines, A. Knüpfer, London.*
2548 Lock Nuts, T. Cloke, London.
2549 Gravity Railway, H. M. Barron, London.
2567 Electrically-driven Vehicles, P. B. Elwell and J. K. Starley, London.
2572 Water Meter, W. G. Kent, London.
2578 Governors, T. A. Green and C. M. Walker, London.*
2581 Screw Conveyors, L. Hopcraft, London.
2583 Explosive Compound, H. C. Williams, London.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

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THE

PRACTICAL ENGINEER,

MARCH 8TH, 1889.

BRAKES AND BRAKE TRIALS.

THE necessity of using the friction brake as well as the indicator is now very generally admitted by our leading engineers and engineering firms, and engine trials are made with a completeness and care which leave little to be desired, and which furnish us with very full and accurate information. In the early days of steam, when pumping was its principal task, and accuracy in mechanical construction was still unattainable, the indicator in Watt's hands, crude as it was, did good work, and gave perhaps as much information as was needful. Now, however, engineers require to know much more. Steam pressures are high, and moving parts are very differently constructed to withstand comparatively great pressure variations. Mechanical efficiency, therefore, as well as indicated efficiency, requires to be very carefully considered, so that the story told by the indicator diagram must be supplemented by that of the brake dynamometer. Accordingly we propose to shortly discuss the question of brakes, and more particularly to give a succinct account of our personal experiences with them.

The fundamental form of brake dynamometer is due essentially to Prony, and at its simplest consists of two wooden blocks clamping a wheel by suitable bolts, and carrying a long lever from which a weight is suspended. The power required to rotate the wheel varies with the friction of the blocks on the wheel surface, and is measured by the speed of rotation, the distance of the point of weight suspension from the centre, and the weight which hangs freely upon the end of the lever. The lever is arranged so that the extent of its motion is limited by a couple of stops, and the tension of the brake screws is regulated to keep the lever floating between the upper and lower stops, and as nearly as possible in a horizontal position. Under these circumstances, while working smoothly and without jerking, the effect upon the driving power is the same as if it were occupied in winding up a weight equal to that suspended, and upon a drum of radius equal to the radius of the point of suspension. The surface velocity of such a drum in feet per minute, multiplied by the weight suspended in pounds, gives the work performed in foot-pounds.

The idea is exceedingly simple and easily understood, but the practical carrying into effect is a very different matter. Accordingly, many forms of brake have been proposed and advocated by engineers, some simple, some complex, and all intended to overcome one difficulty, namely, variation in the brake grip or friction, and consequent continual adjustment of the tension screws. Methods have been devised for varying this tension automatically, for varying the frictional surfaces in contact both of brake blocks and ropes or belts, for varying lubrication, temperature, and so on, but all with indifferent success. After all, the real point should be to secure constancy of effort and pull, not to adjust when variation has occurred.

Our personal experience with the measurement of power by brake dynamometer is somewhat extensive, extending over many hundreds of brake trials, some of them for days together, and as a result we unhesitatingly advise engineers to have none of the equilibrating contrivances, but rather to arrange for constancy of conditions, and measure carefully any range of variation while carefully limiting it, and thus discover the limits of possible error. Large and unknown errors have been, with little doubt, introduced into such tests by the use of what are known as the Appold compensating levers, and results obtained by engineers so well known as those of the Royal Agricultural Society have quite recently been discredited from this cause.

The very simplest form of brake is, in our opinion, the best, and with that simple form exceedingly accurate results can be readily obtained with powers varying from half-horse to one hundred. It consists of a flexible iron hoop, to which are screwed wood blocks fitting the surface of a smoothly-turned flywheel. The blocks are shaped to fit the wheel as closely as possible, and the ends of the hoop are brought together by an adjusting screw and nut. The blocks thus encircle the wheel, and press upon it more or less as the screw is tightened or loosened. Under the thumb nut, which serves to tighten up, a strong spring is placed, whose compression determines the brake grip, and on the opposite side of the strap to the screw is riveted a jaw, carrying an eyebolt, from which weights are suspended. A chain or rope secures the eyebolt to the floor, in order to prevent the weights being moved too far and thrown over the wheel, if from any cause the brake should grip suddenly. To a point on the strap opposite to the eyebolt is attached a spring balance held from above, and a small siphon lubricator surmounts the upper part of the strap. When the blocks are new the friction is somewhat irregular, but if kept running for a week, well lubricated, they come to a good bearing, and in subsequent tests give no trouble whatever. Mineral oil should always be used as a lubricant, as animal or vegetable oil, when highly heated, is liable to gum and cause unsatisfactory work.

With such a brake applied to a flywheel weighing about 18 cwt., and of 6ft. 6in. diameter by 4in. across the face, running at 140 revolutions per minute, we have easily measured 30 horse power, and kept the load on continuously for ten hours' trial, without using water or any other form of artificial cooling. The wheel becomes very hot after about an hour's work, but the temperature does not then rise further; the radiation and cooling by air currents take away the heat as fast as it is generated.

The pull is exceedingly steady after the first half-hour, and the spring balance keeps the point of weight suspension approximately in the horizontal line passing through the shaft centre. As the spring balance also resists the turning of the shaft, its reading must be added to the weights hanging upon the eyebolt; once adjusted, and the small lubricator at work, the friction varies but slightly. We have watched a brake registering 30 horse power for many hours in succession without touching the adjusting screw, and a maximum variation on the spring balance reading of only five pounds. We have always found it advisable in adjusting to use weights for the main portion of the brake load, leaving not more than ten pounds to be taken by the spring balance; by so doing the weights remain suspended with very slight variation in position all day.

It is a curious fact that if the speed of the engine be increased, the tension upon the strap remaining the same and the adjusting screw being left untouched, the weights very soon fall to the ground. The co-efficient of friction between the brake blocks and the wheel changes considerably with change of speed. On the other hand, a fall in speed causes increase in friction and a rise of the weights.

In brake tests, therefore, it is necessary to run at a uniform speed if uniformity and accuracy be desired. Variation in speed, however, is most undesirable in any engine trial, and therefore we much prefer to arrange the engine to run steadily rather than adopt any compensating system whatever. In this matter there is no real difficulty.

It is a great mistake to use thin, light wheels for brake trials, as with them the heating is irregular, and there is considerable danger of cracking the arms. With a smoothly-turned and heavy flywheel, on the other hand, there is no necessity for artificial cooling, provided the power to be absorbed does not exceed 30 H.P. for the dimensions and speed we have given. At lower speeds for that power larger wheels, or a greater number, are necessary, as it is unadvisable to increase the pressure upon the blocks unduly. They then act capriciously, and are liable to seize without warning.

Such a brake in careful hands gives measurement of power far within the limits of error usual in indicators, and such trials are absolutely essential to a correct understanding of the real efficiency of an engine, which is, after all, measured by the power given off for external work.

Rope brakes have been lately used in the interesting motor trials conducted by the Society of Arts, but although valuable for occasional testing, we cannot, from our own experience, recommend them for the continuous tests which should be made in all first-class engineering works.

Many interesting facts come under observation in brake trials, and it is astonishing, for one thing, how much power may be absorbed by a piston which is slightly too good a fit—a hot eccentric or crank pin. Much is still to be learned, and we hope such trials may become even more numerous, as no doubt great and important advances will be the result.

MR. RICHARD PEACOCK, M.I.C.E., M.P.

Mr. R. Peacock, M.P., the well-known engineer, of the firm of Beyer, Peacock, and Co., Manchester, died at his residence, at Gorton Hall, on Sunday evening last. Few engineers now remain among us who took a leading part in the introduction of railways, and their number becomes less year by year. Mr. Peacock was born in 1820, in the North Riding. At the age of fourteen he was apprenticed to the firm of Fenton, Murray, and Jackson, of Leeds, who were then busily engaged in the construction of locomotives for the Liverpool and Manchester and the Leeds and Selby Railways. He remained with the firm for four years, and in 1838 left them for London. The excellent introductions with which he was provided obtained for him an interview with Mr. (afterwards Sir) Daniel Gooch, who was chief engineer of the Great Western, under the direction of Mr. Brunel. An immediate engagement was secured, and young Peacock's duties were as varied as they were laborious. Sometimes he superintended a gang of navvies; occasionally he took charge of an engine used by the great engineer for running up and down the line, and in this way established with him a friendly relation which was interrupted only by Mr. Brunel's death. In 1841 the Manchester and Sheffield line was approaching completion, and Mr. Peacock applied for the post of locomotive superintendent, which he obtained, without an interview even with the board, on the strength of his testimonials. He arrived in Manchester just one week before the first engine was received; and for fourteen years, every one of which brought increasing responsibilities, he held this important position with distinguished ability and success. He chose Gorton for the site of the locomotive depot, which was afterwards erected from his designs. This led to the rapid development of Gorton and of the adjoining township of Openshaw, and of the great engineering establishment with which his name will always be identified. It was at his suggestion that Mr. Ashbury built his extensive carriage and wagon works at Openshaw, of which Mr. Peacock laid the foundation stone. He also recommended the late Sir Joseph Whitworth to transfer to the same neighbourhood his manufactory of guns and mechanical tools, and he purchased the land for the Midland Railway on which that company placed its locomotive sheds. Not inappropriately has he been designated as the founder of the trade and prosperity of these two townships. But in 1854 Mr. Peacock determined to take a step in a new direction. He formed a partnership with his friend Mr. Charles Beyer, who for some years had been the manager of the extensive works of Messrs. Sharp Brothers, but was himself casting about for some new channel for his capital and skill. They chose as the site of their future works about fourteen acres at Gorton, and at once began to build. It is a striking proof of their energy that, although cattle were grazing on the ground on the 1st of May, 1854, they built and sent out within twelve months of that date their first locomotive engine, which was ordered by the Great Western Railway. The various sections of these works are almost exact counterparts of each other, and are so arranged as to admit of further enlargement without disturbing or altering the portions previously erected. Some idea of the recent operations of the firm may be formed from the facts that they employ from 2,000 to 3,000 people, that they annually turn out about 200 engines, and pay £120,000 in wages. In 1883 the firm was converted into a limited liability company, Mr. Peacock continuing as its manager, and also holding the office of chairman of the board.

HYDRAULIC MACHINERY EMPLOYED IN THE TRANSMISSION AND CONCENTRATION OF POWER.—III.

In our last article we disposed of the pretension of the so-called "elastic limit" to be considered an indication of the safe working load of a bar of wrought iron or steel. We have now to point out another fallacy, which has a deep root in the minds of many. It is a common belief that if a piece of metal or a machine pass its "test" without giving signs of undue strain by taking permanent set—for instance, in the case of a bar stressed in tension, or as in the case of a hook or a punching machine, by a permanent springing open of the jaw—that it is quite safe for any number of repetitions of the test load. Some early experiments of Sir Wm. Fairbairn went to show the fallacy of this error in the case of riveted girders, but were too crudely conducted to be conclusive. More recently, however, the researches of Herren Wöhler and Spangenberg have thrown a flood of light on the subject. It appears from their experiments that the breaking weight of a piece of metal depends not merely on the absolute magnitude of the stress per square inch, but also on the number of repetitions and the range of variation of the stress. The experiments, though very extensive and amply conclusive as to the general results, are not sufficiently so to enable us to state an exact formula, but the general nature of the results will be readily understood by considering the breaking weights, as determined from them, of a bar of wrought iron loaded either by (1) a steady load applied constantly; (2) a steady load applied and removed alternately an indefinite number of times; (3) a steady load applied alternately in opposite directions—that is, alternately compressing and extending the fibres.

The breaking weight in the first case is 20 tons per square inch, in the second $13\frac{1}{3}$ tons, and in the third $6\frac{2}{3}$ tons per square inch; thus the breaking weight in the three cases have the proportions $3 : 2 : 1$, or $1 : \frac{2}{3} : \frac{1}{3}$.

As an example of the first case, we may instance the links which connect the balance weight chain of a slow-moving hoist to the cage or to the balance weight; as an example of the second, the column's head, cylinder, &c., of an hydraulic press; and as an example of the third, the piston rod of a steam engine, or the spindle of an overhead pulley of a hoist.

In treating of the safe working loads, as determined from the test stress, we shall in all that follows suppose that the metal is stressed in one direction only, but that the stress is applied and removed continually in the ordinary working of the machine. If the stress be alternately applied in opposite directions, one half the working load, as determined by the following considerations, must be taken as the safe working load.

We may divide working loads roughly into four classes: (1) perfectly steady loads; (2) ordinary loads, not perfectly steady, but nearly so, and perfectly steady loads applied to machines in which failure would involve considerable loss or annoyance; (3) loads applied with more or less but not excessive shock; (4) loads in which failure must result in danger to life or limb.

As types of the first class of loads may be taken hand-worked hydraulic presses operating on yielding materials. Here we have the class of stress most favourable to the life of the machine, and the working stress may be four-fifths the test stress. Hydraulic punching beams, and hydraulic jacks, and similar small tools will also fall under this head, and may be worked up to four-fifths their test stress if otherwise properly proportioned. Indeed, machines of this class are often worked up to their full test load. As types of the second class may be taken, large hydraulic baling presses worked rapidly and frequently.

High-pressure hydraulic accumulators, fitted with safety valves, and high-pressure work in general: For this class the working load may be two-thirds the test load. Medium pressure hydraulic work, in which the load is very steady, may also be included in this class. As types of the third class may be taken medium-pressure hydraulic hoists, accumulators, &c., chain hooks and similar parts, and medium pressure in general, for which the working load should not exceed one-third to one-half the test load, according to the degree of shock incidental to the working of the machine. For the fourth class, which is intended to cover such work as hotel lifts, &c., the working load should not exceed from one-fourth to one-fifth the test load—abundant strength being specially provided in all parts liable to deterioration or wear. If frequent skilled supervision cannot be guaranteed, a still larger margin should be allowed.

Gun-metal high-pressure hand pumps may be worked up to two-thirds the test pressure. Gun-metal high-pressure pumps driven by steam cylinders direct, or by belt, may be worked up to half the test pressure, or, if of cast iron, up to one-third the test pressure.

Having now established the test stresses suitable for the materials most frequently used in hydraulic machinery, and the proper proportion of working load to test load, we must next examine a peculiar description of stress which is only found in the thick cylinders of high-pressure hydraulic work.

Fig. 5 represents a cross section through a thick cylinder. Internal radius $= r$, external radius $= r + t$ when unstressed. These radii become, when stressed by internal fluid pressure, say r_1 and $r_1 + t_1$, respectively. If the stretch of the material follow the elastic or Hooke's laws, the circumferential tension of any ring of fibres will be proportional to the whole extension of the ring directed by the whole circumference of the ring. In other words, the tension will vary as the extension per unit of length. Hence the stress at the internal circumference of the cylinder will be to the stress at the external circumference as

$$\frac{r_1 - r}{r} : \frac{r_1 + t_1 - r - t}{r + t}$$

and since the internal pressure tends to compress the material radially, and thus cause a reduction in the thickness, and as the circumferential tension also tends to reduce the thickness, t_1 is necessarily less than t, and the fraction $\frac{(r_1 - r) - (t = t_1)}{r + t}$ less than the fraction $\frac{r_1 - r}{r}$. Hence the tension on the fibres of the external circumference is less than that on those of the internal circumference, and the former do not take their fair proportion of the work of resisting the disruptive effect of the internal pressure. Lamé was the first writer to accurately determine the effect of this inequality of stress throughout the thickness of the cylinder on the supposition of extension being directly proportional to stress. He obtained the formula $f = \frac{P\,(R^2 + r^2)}{R^2 - r^2}$, where f is the tension at the internal circumference, P the internal pressure, R the external radius, and r the internal radius. We have omitted from the formula the term involving the external pressure, since, in such cases as we are concerned with, the external pressure will, in general, be comparatively very small. The steps by which this result is arrived at may be consulted in Lamé's "Traité de l'Elasticité," or Ibbetson's "Theory of Elasticity," or Rankine's "Applied Mechanics," the result obtained being the same in each.

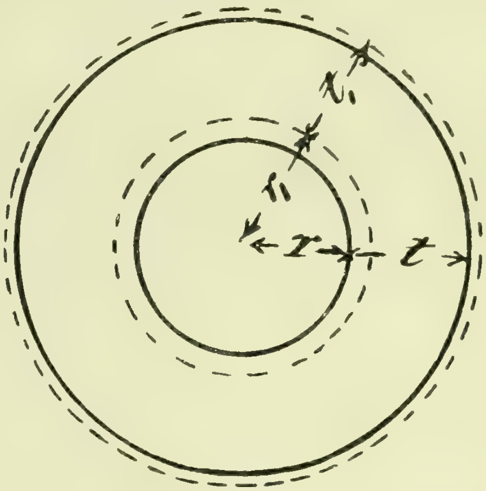


FIG. 5.

The formula may also be put in this form: $f = \frac{P}{T} \cdot \frac{R^2 + r^2}{R + r}$ where T is the thickness of the cylinder, P and f may be taken in tons or pounds per square inch, and R, r and T in inches, or any other units of length or weight at pleasure, provided the same units be used for P as for f, and the same unit for T as for R and r.

If R be nearly equal to r, we obtain the usual formula for the tension on the metal of a thin cylinder, viz.,

$$f = \frac{P.\,r}{T}$$

Professor Pearson (see foot notes pp. 550 and 552 of Todhunter's "History of Elasticity") considers that Lamé's formula for the strength of a thick cylinder errs on the side of assigning too high a value to the strength of the cylinder. The writer does not, however, consider this conclusion to be confirmed by experience. On the contrary, he knows the actual materials used in construction do not follow Hooke's law in their extension with precision, and there is, so to speak, a sort of "give-and-take"

TABLE I.

THICKNESS IN INCHES OF CAST-IRON CYLINDERS FOR TEST PRESSURES OF

Inside Diam. Inches	Lbs. per Sq. In.				Tons per Square Inch.								
	800	1,000	1,200	1,500	1	1¼	1½	1¾	2	2¼	2½	2¾	3
3	⅜	7/16	½	½	⅝	¾	⅞	1⅛	1¼	1½	1⅝	1⅞	2
3½	7/16	½	½	½	¾	⅞	1	1¼	1⅜	1⅝	1⅞	2⅛	2¼
4	½	½	½	9/16	⅞	1	1⅛	1⅜	1½	1⅞	2⅛	2⅜	2⅝
5	½	9/16	⅝	¾	1	1¼	1⅜	1⅝	1⅞	2¼	2½	2⅞	3⅛
6	½	⅝	⅝	¾	1⅛	1⅜	1⅝	2	2¼	2⅝	3	3⅜	3¾
7	9/16	⅝	¾	⅞	1¼	1⅝	1⅞	2¼	2½	3	3½	3⅞	4¼
8	9/16	¾	⅞	1	1⅜	1¾	2	2½	2⅞	3⅜	3⅞	4⅜	4⅞
9	⅝	¾	⅞	1⅛	1½	1⅞	2¼	2¾	3¼	3⅞	4⅜	4⅞	5⅜
10	¾	⅞	1	1¼	1¾	2⅛	2½	3	3½	4¼	4¾	5⅜	6
11	¾	⅞	1	1¼	1¾	2¼	2¾	3¼	3⅞	4½	5¼	6	6¾
12	⅞	1	1⅛	1⅜	2	2½	3	3⅝	4¼	5	5¾	6½	7¼
13	⅞	1	1¼	1½	2⅛	2¾	3¼	3⅞	4½	5⅜	6⅛	7	7¾
14	⅞	1⅛	1¼	1½	2¼	2⅞	3½	4⅛	4⅞	5¾	6⅝	7½	8¼
15	1	1⅛	1⅜	1⅝	2⅜	3	3⅝	4½	5¼	6⅛	7⅛	8	8⅞
16	1	1¼	1½	1¾	2½	3¼	3⅞	4¾	5½	6½	7½	8½	9½
17	1⅛	1¼	1½	1⅞	2⅝	3⅜	4⅛	5	5⅞	7	8	9	10
18	1⅛	1⅜	1⅝	2	2¾	3⅝	4⅜	5⅜	6¼	7⅜	8⅜	9½	10½
20	1¼	1½	1¾	2⅛	3	3⅞	4¾	5⅞	6⅞	8⅛	9⅜	10⅝	11¾
22	1⅜	1⅝	1⅞	2⅜	3⅜	4⅜	5¼	6⅜	7½	8⅞	10¼	11⅝	12⅞
24	1½	1¾	2⅛	2½	3⅝	4¾	5¾	7	8¼	9¾	11⅛	12⅝	14
26	1½	1¾	2¼	2¾	3⅞	5⅛	6¼	7⅝	8⅞	10½	12	13⅝	15⅛
28	1⅝	2	2⅜	2⅞	4¼	5½	6¾	8⅛	9½	11¼	13	14⅝	16¼
30	1¾	2⅛	2⅝	3⅛	4½	5⅞	7¼	8¾	10¼	12⅛	13⅞	15⅝	17⅜

TABLE II.

THICKNESS OF STEEL CYLINDERS (UNHAMMERED CASTINGS) FOR TEST PRESSURES OF

Inside Diam. Ins.	Tons per Square Inch.											
	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½	4	5
3										1	1⅛	1¼
3½										1⅛	1¼	1½
4									1	1¼	1⅜	1⅝
5							1⅛	1¼	1¼	1½	1⅝	2
6					1	1⅛	1¼	1⅜	1½	1⅝	1⅞	2¼
7				1	1⅛	1¼	1⅜	1½	1⅝	1⅞	2⅛	2⅝
8			1	1⅛	1¼	1⅜	1½	1⅝	1¾	2⅛	2⅜	3
9		1	1⅛	1¼	1⅜	1⅝	1¾	1⅞	2	2⅜	2⅝	3¼
10		1⅛	1¼	1⅜	1½	1¾	1⅞	2	2¼	2½	2⅞	3⅝
11	1	1¼	1⅜	1½	1⅝	1⅞	2	2¼	2⅜	2¾	3⅛	4
12	1	1¼	1½	1⅝	1¾	2	2⅛	2⅜	2½	3	3⅜	4¼
13	1⅛	1⅜	1½	1¾	1⅞	2⅛	2⅜	2⅝	2¾	3¼	3¾	4⅝
14	1⅛	1⅜	1⅝	1⅞	2	2¼	2½	2¾	2⅞	3½	4	5
15	1¼	1½	1¾	2	2⅛	2⅜	2⅝	2⅞	3⅛	3¾	4¼	5¼
16	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3⅞	4½	5⅝
17	1⅜	1⅝	1⅞	2⅛	2⅜	2¾	3	3¼	3½	4⅛	4¾	6
18	1⅜	1¾	2	2¼	2½	2⅞	3⅛	3⅜	3⅝	4⅜	5	6¼
20	1½	1⅞	2⅛	2½	2¾	3⅛	3⅜	3¾	4	4¾	5½	7
22	1⅝	2	2⅜	2¾	3	3⅜	3⅝	4	4⅜	5¼	6	7⅝
24	1¾	2⅛	2½	2⅞	3¼	3⅝	4	4⅜	4¾	5⅝	6½	8¼
26	1⅞	2⅜	2¾	3⅛	3½	4	4⅜	4¾	5⅛	6⅛	7⅛	9
28	2	2½	2⅞	3⅜	3¾	4¼	4⅝	5⅛	5½	6⅝	7⅝	9⅝
30	2⅛	2⅝	3⅛	3⅝	4	4½	5	5½	5⅞	7	8⅛	10¼

action, which tends to cause a greater equality of stress throughout the thickness of a cylinder than Lamé's formula would indicate. On the other hand, however, the internal circumference of the cylinder in the case of castings is usually the most unsound, owing to the exterior of the cylinder cooling first, and the inner rings of metal later, while at the same time it is the part most severely stressed in actual work.

The plan of circulating water through the core bar, as adopted in America in the casting of ordnance, may be employed with advantage in the case of important hydraulic cylinders, in the inner layers of the cylinder.

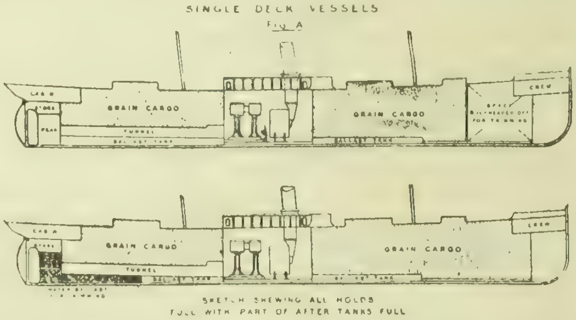
On the whole, the writer considers it better to be guided by the results of successful practice in assigning the test pressure for hydraulic cylinders, rather than by a formula based on a defective theory. Tables I. and II. exemplify his own practice, and have been used successfully in fixing the dimensions of many hundreds of hydraulic cylinders. For low-pressure work, the following dimensions may be adopted for pressures (test) not exceeding 500lb. per square inch.

Inside diameter in inches	3	3½	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30
Thickness in inches .	⅜	7/16	½	½	½	9/16	9/16	⅝	⅝	¾	¾	¾	¾	⅞	⅞	⅞	⅞	1	1	1	1	1⅛	1⅛

THE DEVELOPMENT OF THE "WELL-DECK" CARGO STEAMER.*

In tracing the development of raised quarter-deck vessels, better known as "well-deck" steamers, the writer will endeavour to explain to the members of this institution the reason why such a class of vessel was introduced, and to point out the many considerations that have arisen from time to time to bring this type to its present design.

Previously to the year 1865 the shipowners of the North-East Coast ports did their carrying trade with "flush deck" steamers, as in accompanying fig. A. As long as these vessels were employed in the dead-weight trade no inconvenience was experienced as regards trim, but when homogeneous cargoes were carried of such a density as to completely fill the holds, these vessels trimmed by the head. To prevent this, and to get them into proper trim, it was found necessary to bulkhead off a large portion of the fore-hold; this of course meant the shutting out of cargo, and the curtailing of the earning powers of the vessel.



The more extended use of water ballast suggested the idea of trimming tanks at the ends, but these could only be used when the cargo was of the lightest description. Although this, in one sense, got over the difficulty of trim, yet the filling of these tanks for trimming purposes meant the carrying of a large amount of dead weight upon which no freight was earned.

One of the principal faults in the design was that the cubical capacity of the fore-hold was considerably in excess of the after-hold, this being due in a large degree to the engine and boiler room being placed so far aft. To overcome this objection the machinery space was moved further forward. This certainly assisted the loaded trim; but when these vessels were in ballast it was found they had great difficulty in moving from port to port on account of the propeller being so lightly immersed.

As this type increased in size the second deck was introduced, as shown in fig. B, page 161. There can be no doubt that the additional deck was of use in strengthening the structure; but it was found that it was a source of danger when the vessel was loaded with coal or grain in bulk. It is well known to shipowners that there is always a certain amount of settling of bulk cargoes,

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Paper read before the North-East Coast Institute of Engineers, by G. W Sivewright, M.I.N.A.

and this is most likely to take place at the underside of decks, as shown in figs. C and D, below; and should these cargoes be loaded hurriedly or carelessly trimmed, this settling develops into a most dangerous feature, for when vessels loaded under these conditions experience heavy weather the result proves most disastrous; indeed there is good reason to suppose that a large number of this type have been lost through no other cause than the shifting of their cargoes. This intermediate deck, however, is of great service when loading general cargo.

In the "long full poop" steamer, as shown in fig. E, below, the objectionable feature of trimming by the head was overcome by carrying a portion of the cargo in the poop; but, by trading with these vessels, shipowners paid for a large amount of tonnage that gave no pecuniary return, the full benefit of the poop being only obtained when filled with cargo of the lightest description, and when loaded under these conditions the vessels trimmed too much by the stern.

DOUBLE DECKED VESSEL

FIG B

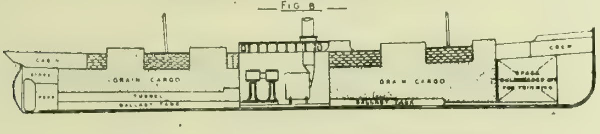


FIG C.

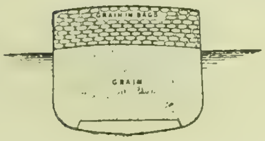
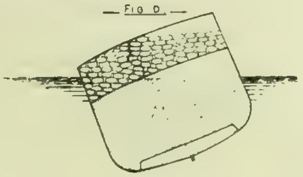


FIG D.

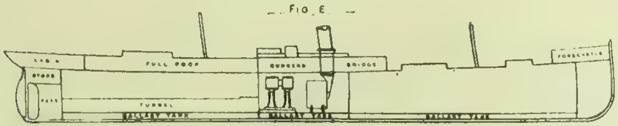


Many of the North-East Coast shipowners found from experience that the carrying of general cargoes represented a very small proportion of the carrying trade of the world, and they were not long in arriving at the conclusion that by using flush or double-deck steamers, in their opinion, they were trading with a class of vessel most unsuitable for their work.

It was felt that a type of vessel was wanted that would be reasonably safe when loaded with bulk cargoes, and in good sea trim—that is, as near as possible on an even keel; also that they should be well down by the stern when in ballast. To carry out these requirements the "raised quarter deck" type of vessel was introduced, as shown in fig. F, below. By the addition of the raised quarter deck in this description of steamer the after-hold is made as nearly as possible of the same capacity as the fore-hold, so that when the holds are quite full of cargo the vessel is in good trim. Being single-decked ships—that is, having no intermediate deck—very little trouble is experienced from the shifting of bulk cargoes; but should a portion of such a cargo shift through the vessel meeting with heavy weather, it becomes a simple matter to trim it into position again.

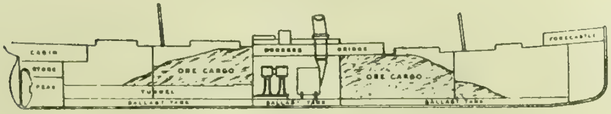
LONG FULL POOP VESSEL

FIG E

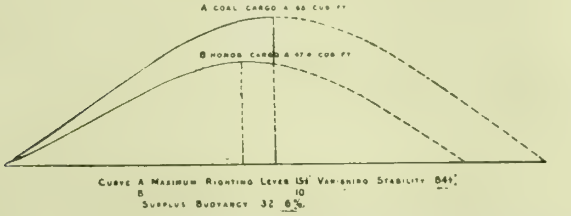


RAISED QUARTER DECK, & BRIDGE
COVERING MIDSHIPS

FIG F



CURVES OF STABILITY

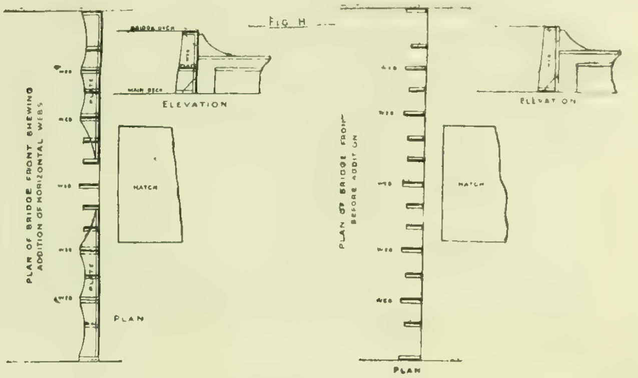


The curves of stability for this type of steamer, laden respectively with coals and with homogeneous cargo supposed to completely fill the holds, are shown in fig. G, above, and it is thought that there can be no possibility of difference of opinion as to these vessels satisfying all the necessary requirements in regard to stability; their righting levers and the general character of their curves are quite equal to what is deemed necessary by the authorities and experts on this special branch of the subject.

Some of the earliest "well-deck" vessels were built at the Hartlepools, where to date upwards of 350 such vessels, having an aggregate tonnage of over half a million tons, have been added to the mercantile marine, and the writer thinks that it will be a matter of interest in stating that, during the past four years, all the vessels built at the Hartlepools for local owners have been exclusively of this type.

The general behaviour of these vessels at sea is all that can be desired; and, having extended their area of trading and the length of their voyages, a corresponding increase in the dimensions of these vessels has taken place. To make them more suitable for Atlantic trading, the erections have been increased in strength and the alley-ways through the bridge dispensed with. The addition of the topgallant forecastle is a further improvement. These structures being made as nearly as possible water-tight, the buoyancy or lifting power of the vessel in a heavy seaway is correspondingly increased.

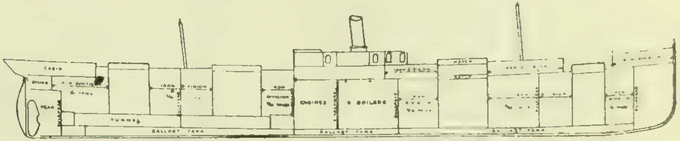
FIG H



Suitable as this class of vessel is for carrying cargoes of ordinary description, such as grain and coal, yet when carrying large ore cargoes evident signs of straining at the top sides and bilges were noticeable, the straining of the structure being more pronounced when this kind of cargo was stowed amidships, as shown in fig. F. The substitution of iron for wood decks and the thickening of the upper shell plating reduced the top straining, and the introduction of the continuous bottom on the cellular principle, with the addition of web frames and intercostals in holds and machinery space, remedied the bilge straining.

RAISED QUARTER DECK & LONG EXTENDED BRIDGE.

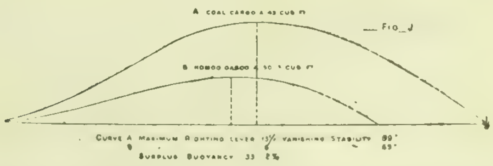
FIG I



VESSEL BUILT ON THE WEB FRAME & CELLULAR BOTTOM PRINCIPLE

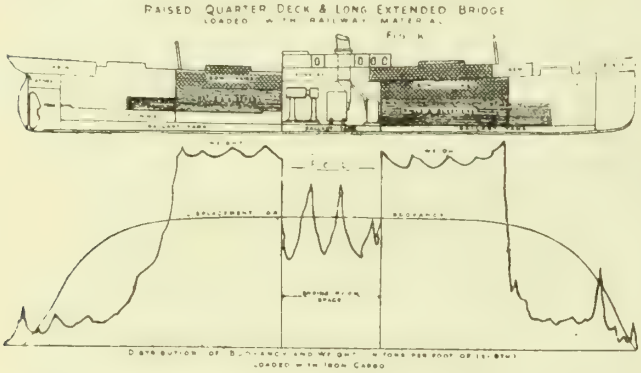
CURVES OF STABILITY

FIG J



Satisfied as local shipowners were with the results of the all-round trading of these vessels, yet a very critical time in the history of this type took place in the year 1880, and this was due to the manner in which the Board of Trade detained these vessels for alleged overloading. It was a difficult matter for shipowners to account for this action, for according to the statistics prepared by local insurance clubs the loss of life from the foundering of this type compared very favourably with all other classes of vessels. The practice followed by owners in loading was to immerse these vessels to a freeboard representing about one-tenth of the depth moulded, but according to the rules formulated by the Board of Trade very much more freeboard was required. Naturally, shipowners resented the action of these authorities when they realised that if the Board of Trade freeboard was to become law it meant a large pecuniary loss to themselves, and would lead eventually to the condemning of a very useful class of cargo boat. Matters became so strained with these authorities that decided action had to be taken on the part of the shipowners, this action resulting in the appointment of the Load Line Committee; and the shipowners in giving evidence before this committee were able to prove that the "well-deck" type of steamer was one of the safest class of cargo boats in use. In further proof that their contentions were correct, the writer may state that since Lloyd's Register have taken over the control of freehold assignments, this body are allowing these vessels at this day to sail at their old freeboard, provided a slight addition is made to the strengthening of the bridge front, as shown in fig. H, page 161.

During the time that this freeboard dispute between the Board of Trade and the shipowners occupied so much attention, another type of "well-deck" steamer was introduced, and this is known as the "long" or "extended bridge" type, as shown in fig. I, page 161. There can be no doubt that the favourable freeboard granted to these vessels is one of the reasons of this design meeting with so much favour, and by the shortening of the fore-well the principal objection made by the Board of Trade to the old type is overcome. The lengthening of the bridge is of service when carrying light cargoes, and by not quite closing in the fore-well a certain amount of tonnage is saved when these vessels are trading with dead-weight cargoes. By comparing the curves of stability it will be seen that the length of the righting levers is not so great as in the old type, yet the range is ample, thus giving a good margin of safety under all conditions, as shown in fig. J, page 161.


Raised Quarter Deck & Long Extended Bridge
Loaded with Railway Material
Fig. K
Weight
Weight
Fig. L
Displacement or
Buoyancy
Engine Room Space
Distribution of Buoyancy and Weight in Tons per Foot of Length
Loaded with Iron Cargo

The general expansion of trade in India led to the Government purchasing large quantities of material for the making of railways, bridges, and other iron structures. Most of this material is shipped from the North, and the cargo steamers owned on this coast carry the largest proportion of this material to its destination. In the earlier cargoes carried it was divided into about equal weights into each hold, but it was found when these vessels were loaded in this manner they laboured very much at sea on account of this heavy material being stowed so low, and as the result of experience these cargoes are now stowed more amidships, until we have them carried as shown in fig K, above.

In checking over the load draughts of several vessels loaded with railway iron, the owners had found that the depth moulded to the disc did not agree with the draught at each end of the ship, and to investigate the matter the writer made a number of sighting tests along the deck when the vessels were empty and when loaded, and found in a number of the earlier types of cargo boats that a certain amount of sagging took place amidships, and this sagging was verified by the draughts taken at each end and amidships.

The stowing of these cargoes in the manner described, and as shown in fig. K, above, may possibly have a tendency to make the vessel more sea-kindly, but at the same time there can be no difference of opinion that to carry such large weights amidships would subject vessels to heavy strains. It will be readily seen by comparing the displacement curve with the curve of weight, viz., that showing the disposition of the iron cargo and other weights, as shown in fig L, above, that it is almost certain that sagging would take place over the amidship portion of the vessel.

Another feature to be considered is the lying of the vessels aground when taking in or discharging cargoes of the heaviest description. It will be well known to many of the members present that there is a clause in charter parties which states that vessels are "always to load and discharge afloat." Practically this clause is now a dead letter, for the reason that many steamers of large dimensions can only take in a portion of their cargo in dock, on account of the want of water over the sills, and they move into the river to complete the loading, thus taking the ground every tide.

Shipbuilders might reasonably complain that it was never intended to stow such heavy iron cargoes in the manner described, and that it is not fair treatment to vessels of large dimensions to load them whilst lying aground; but, seeing that a considerable amount of trading can only be done under these conditions, it is for the shipbuilder to design vessels so that they will withstand strains of any unusual nature.

The firm of Messrs. Edward Withy and Co., with whom the writer has the honour to be connected, determined, in building their vessels, to make it their universal practice that the design should be on the web frame and cellular bottom principle. This decision was arrived at as the result of a series of calculations of the hogging, sagging, and racking strains likely to occur in cargo vessels under all conditions at sea, and which by actual results have been verified.

To increase the longitudinal strength of the structure, the introduction of longer plates has been decided upon, and for some time past plates have been used from 20ft. to 30ft. in length, thus considerably reducing the breaking or straining points of the shell plating and other vital parts of the vessel. To further increase and assist the longitudinal stiffening and general structural arrangement, the fore and after grain divisions in the holds and 'tween decks are made of iron, well stiffened by angles, and also the substitution of iron for wood bulkheads in the holds is of use in giving increased transverse strength to the structure. Seeing that a considerable amount of deck straining at the butts had been noticed from time to time in the vicinity of the engine and boiler space, to assist in reducing this, larger through beams were fitted, and these, being plated over and also well supported by stanchions, have been found to give increased strength; and lately, the writer is stiffening the lower bunker sides with extra large-sized angle iron, so closely spaced that these bunker sides form a strong vertical support, instead of being, as in the past, merely receptacles for coals, for which sketch see fig. M, above.

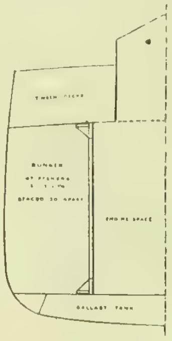


Fig. M.

But probably one of the most important additions to the strength of the structure was the making of the bridge and quarter deck side plating of the same thickness as the main shell plating of the vessel. Signs of movement at the top side butts had been noticed when vessels were loaded with railway iron in 'tween decks, as shown in fig. K, above, and to back up this plating more effectually, Z frame bars rolled in solid section were introduced. By this arrangement the Z frame (which represents a frame and reverse bar) is carried to the top of the structure on every frame, instead of to the lower and main deck stringer as hitherto in cargo boats. Before adopting this frame of solid Z section, the writer made a number of exhaustive percussion tests, and found that the Z bar is very much superior in strength to the riveted frame and reverse bar, the riveted bars being destroyed at the sixth blow, and the Z bar being only fractured at the fifty-third blow; this superiority of the Z section being further verified by a number of tensile and bending tests made by Messrs. Kirkcaldy and Co., of London.

To show the large increase of iron or steel in the construction of vessels, in the year 1870 there was 14 per cent of wood used in the structure, and in vessels built during the last year there was only 7 per cent of wood used. The gain in strength to the structure by the substitution of so much iron or steel for wood can be readily understood.

The design of the raised quarter deck type of vessel has been so carefully studied out and improved during the last ten years, that, from actual sea experience, this type has proved to be one of the strongest class of cargo boats that are now being built; and it is a matter of congratulation when we consider that vessels of this class can be built to carry iron cargoes of over 4,000 tons weight, and to be able to do this work without straining the structure, or in any way endangering the safety of the vessel at sea.

In presenting this paper to the members of this institution, the writer trusts that, where so many of its members are so closely connected with the interests of shipbuilders and shipowning, such an expression of opinion may take place that further improvements may be suggested in this useful class of cargo boat, and at the same time he regrets the brief manner in which so many important points have had necessarily to be dealt with in this paper.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

(*Continued from page 147.*)

The value of n for the expansion process is 1·264, which, with the volumes given above, corresponds to a fall of temperature of 970 deg., so that the temperature at F should be 2,020 deg. absolute. The work done during the expansion is 4,280 foot-pounds, but the loss of internal energy corresponding to the fall of temperature is only 3,010 foot-pounds. It is clear, therefore, that a large quantity of heat must have been received by the charge during the expansion; in other words, that combustion must have continued throughout the expansion. More detailed examination of this matter shows that the quantity of heat received per inch of the stroke was about the same towards the end as towards the beginning of the expansion, so that it may fairly be expected that combustion was not completed even when the point F was reached.

One of the essential data for the working out of these problems being the specific heat of the charge, this has been worked out with the results given in Table IV., on the assumption that complete combustion had taken place. The first figures in Table IV. are obtained from those given at the end of Table II.

The net work per explosion, calculated from the ideal card, comes to 3,390 foot-pounds; from the actual mean indicated H.P. it is 3,030 foot-pounds, or about 89 per cent of the calculated, which corresponds very closely to the difference between the ideal mean diagram of fig. 6, and the particular actual card which has been drawn with it.

The "Heat Account" for the process, as represented by the ideal mean diagram, stands therefore as follows:—

	Foot-pounds per explosion.	Percentages
Calorific value of the gas used per explosion 0·000896 × 19200 × 772	13,280	100
Heat turned into work..........................	3,390	25·5
Heat rejected in jacket water	3,590	27·0
Heat rejected in exhaust........................	5,030	
Heat unaccounted for	1,270	·6
	13,280	100·0

There seems little doubt that the largeness of the percentage unaccounted for is due to the fact, already mentioned, that combustion was not completed at the time the point F was reached, so that the charge did not actually receive the whole amount of heat with which it has been credited. A heat account constructed in this way ought, in fact, to over-balance, for it cannot be doubted that the jacket water carries off a certain amount of the heat which is here credited to the exhaust, and therefore counted twice over.

The following table gives the actual percentages of heat actually turned into work, &c., the heat per explosion being taken as above, at 13,280 foot-pounds:—

	Per cent.
Heat turned into work, as shown by indicator diagrams	22·8
Heat rejected in jacket water..........................	27·0
Heat rejected in exhaust, lost by imperfect combustion, and otherwise unaccounted for	50·2
	100·0

The actual expenditure of heat was at the rate of 11,250 thermal units per I.H.P. per hour, which corresponds to the absolute efficiency of 22·8 per cent just given. It is very interesting to notice that the heat expenditure per I.H.P. per hour is little more than half of the Paxman engine, a difference due, of course, to the greater range of temperature within which the engine works.

The efficiency of the engine, as compared with a perfect engine working between the same limits of temperature, and receiving the same amount of heat, is 28·2 per cent. The limits of temperature assumed are, of course, those which have just been calculated from the ideal mean diagram.

TABLE IV.

Constituent.	Weight of each pound of coal gas admitted.	Proportions by weight in each pound discharged.	Mechanical equivalent of the heat necessary to raise the temperature one degree Fahr. of			
			One pound (specific heat)		The quantity in one pound discharged.	
			At constant volume.	At constant pressure.	At constant volume.	At constant pressure.
Steam..................................	2·112	0·089	286	371	25·4	33·0
CO_2	2·125	0·089	132	167	11·7	14·9
N	11·217	0·471	134	188	63·1	88·5
Air	8·346	0·351	130	183	45·6	64·2
	23·800	1·000			145·8	200·6

$$200·6 - 145·8 = 54·8 = \kappa$$

$$\frac{200·6}{145·8} = 1·376 = \gamma$$

The jacket water used amounted to 680lb. per hour, as measured through the meter, and the total heat carried away by it was 33,938 thermal units per hour. This is equivalent to 3,590 foot-pounds per explosion. The exhaust waste, of which a part, as mentioned below, may go to the jacket water, is practically equivalent to the amount of heat which would bring the charge back from the conditions of pressure, volume, and temperature at point F to those at point B. This can easily be calculated, and amounts to 5,030 foot-pounds.

Trial B.—This was a trial at half-brake power, and lasted three hours. The speed was the same as on Trial A. The engine ran at 129·6 revolutions per minute, its brake power being 4·74, and its I.H.P. 6·59 (see fig. 7), corresponding to a mechanical efficiency of 71·9 per cent. The consumption of gas in the cylinder per I.H.P. per hour was 19·29 cubic feet, and per brake H.P. per hour 26·8 cubic feet. Taking into account the ignition gas, these figures become 20·18 and 28·10 cubic feet respectively. The horse power expended in driving the engine was 1·85.

The expenditure of heat was approximately as follows:—

	Per cent.
Heat turned into work	22·3
Heat rejected in jacket water..........................	23·2
Heat rejected in exhaust, &c. (by difference)	54·5
	100 0

Trial C.—In this experiment the engine was run for half an hour empty. Six sets of indicator cards were taken, and give the mean I.H.P. as 2·3. The gas used in the cylinder per I.H.P. per hour was at the rate of 20·5 cubic feet. The engine ran at 131·9 revolutions per minute. The heat turned into work corresponds to 21·0 per cent of the whole heat of combustion. It is noteworthy that in this engine the H.P. necessary to drive the engine itself increases as the load diminishes, and is much greater when the engine is running empty than when it is loaded. This is doubtless due to the fact that the negative work of the "pumping" strokes (which is given in the tables, but which has not in any case been deducted from the H.P.) not only becomes proportionately larger because of the increased proportionate number of blank strokes (misses), but also absolutely larger per stroke. Working full power, the light spring diagrams (fig. 5) show that when there is no explosion the charge receives so much heat from the hot end of the cylinder at the end of the compression that in expanding again it does not follow the compression line, but goes considerably beyond it. The diagram for the missed stroke is therefore a double loop, and the area of its positive and negative halves are practically equal. When a number of misses follow one another, as in Trial C, this reception of heat cannot well continue—the positive loop will disappear and the negative one become larger.

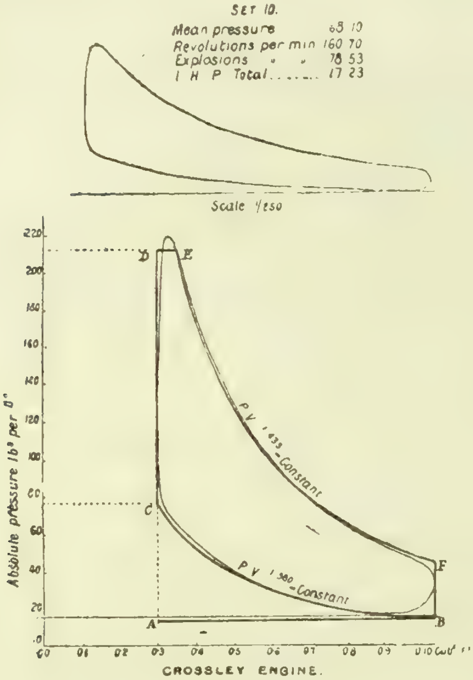


Fig. 7.

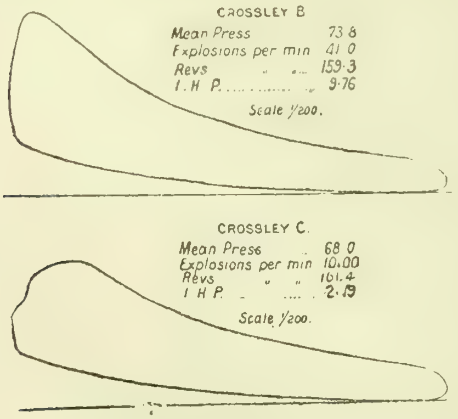


Fig. 8.

Trial D.—In this experiment the engine was run with about the full brake load, but at a lower speed than before, viz., 110·5 revolutions per minute. The brake H.P. was 8·29, and the gas used in the cylinder per brake H.P. 22·75 cubic feet.

Trial E.—On this trial the speed was still further reduced to 100·5 revolutions per minute. The brake H.P. was 7·08, and the gas used in the cylinder per brake H.P. per hour 22·29 cubic feet.

The Crossley Gas Engine.

Four experiments were made upon this engine—A at full power, B at half power, and C empty (corresponding to the three similarly lettered experiments made with the other engines), and D to ascertain the power necessary to drive the counter shaft. The principal results of these trials are given in Table V. below.

Table V.—Crossley Gas Engine.

1	Date	Sept. 19	Sept. 20	Sept. 20	Sept. 27
2	Trial	A	B	C	D
3	Duration	6 hours	3 hours	½ hour	½ hour
4	Power	full	half	empty	With & without counter-shaft
5	Revolutions per minute	160·1	158·8	161·0	162·3 & 164·8
6	Explosions per minute	78·4	41·1	10·2	19·0 & 10·5
7	Mean initial pressure	196 9	196·2	148·0	....
8	Mean effective pressure	67·9	73·4	66·7	72·3 & 74·1
9	Indicated H.P.	17·12	9 73	2·19	4·40 & 2·50
10	Brake load, net	177·4	89 9	....	....
11	Brake H.P.	14 74	7·41	....	....
12	Mechanical efficiency	0·861	0·762	....	....
13	Gas per hour, main	351·8	202·6	49·0	....
14	" " ignition	3·5	3·2	....	....
15	" " total	355·3	205·8	....	....
16	Gas per indicated H.P. per hour, main	20·55	20·8	22·38	....
17	Gas per indicated H P. per hour, total	20·76	21·2	....	....
18	Gas per brake H.P. per hour, main	23 87	27·34	....	....
19	" " " " total	24·10	27·77	....	....
20	Gas per net H.P. available for electric lighting per hour, after allowing for counter-shaft, as per trial D, main	27·4	36·8	....	....
21	Water per hour	713lb.	4 0lb.	...	....
22	Rise of temperature	128·0°	102·3°	....	....
23	H.P. in driving engine	2 38	2·31	2 19	2·50
24	Mean pressure during working stroke, equivalent to work done in pumping strokes, about	2·19	....	....	....
25	Corresponding indicated H.P.....	0·55	....	....	....

Trial A.—This experiment was made on the 19th of September, and lasted six hours continuously. The exhibitors elected to run under 15 brake H.P. and with 160 revolutions per minute. The actual mean brake H.P. was 14·74, and the actual mean speed 160·1 revolutions per minute. The greatest speed during any quarter of an hour was 161·8 revolutions per minute, and the least 155·1 revolutions per minute. The engine ran quite cool throughout the whole trial. The oil used for cylinder lubrication was Price's gas-engine oil, the value of which is about 3s. 3d. per gallon, or about 4·4d. per pound, and 0 92lb. was consumed during the run. The value of this lubricant is about equal to that of 1·54 cubic feet of gas per I.H.P. per hour, taking the gas, as before, at 2s. 6d. per 1,000 cubic feet. The mean initial pressure was higher than in any of the other engines, being 196·9lb. per square inch above the atmosphere. The mean effective pressure was 67·9lb. per square inch, and the I.H.P. was 17·12. The I.H.P. for driving the engine was, therefore, 2·38, and the mechanical efficiency reached 86·1 per cent. The gas used per I.H.P. per hour in the cylinder was 20·55 cubic feet, and per brake H.P. per hour 23·87 cubic feet. Taking into account ignition gas, these quantities became 20·76 and 24·1 cubic feet respectively. The work done during the pumping stroke (fig. 5) was equivalent to a mean pressure of about 2·19lb. per square inch during the working stroke, which corresponds to an I.H.P. of 0·55. The following working out of the thermal efficiency of the engine corresponds to that already given for the Atkinson engine: Table VI. gives, as in the former case, an analysis of the gas by weight and the calculation of its calorific value, which amounts to 19,826 thermal units per pound, which corresponds to 626 thermal units per cubic foot under standard conditions. For purposes of calculation, the value of the gas has been taken at 19,800 thermal units per pound. It will be noticed that this is somewhat higher than for either of the other two engines, the gas on September 21st being of distinctly lower value than on the 19th. The ideal mean indicator diagram, and an actual card for comparison, are shown in fig. 7.

(To be continued.)

WIND AND ITS USES AS A MOTOR.

Mr. Robert Godfrey, Assoc.M.Inst.C.E., read a paper on this subject before a meeting of the Association of Birmingham Students of the Institution of Civil Engineers, in which it was stated that the use of the wind as a motor was not so well understood as it might be, which was owing to several causes. One was the deficiency of means for measuring the strength of the wind, and another that nearly all engineers were accustomed to treat it as an enemy, for the purpose of providing strength to resist its action.

Many had tried their inventive powers in constructing wind meters, or anemometers, but as yet no completely reliable instrument had been devised, although since 1667 no less than 140 different machines had been produced by which its velocity and force could be measured with more or less accuracy. There were four factors to be estimated before a correct estimate of a wind could be formed, viz., direction, force, velocity, and inclination, and for each of these separate instruments were required. Professor Robinson, who invented the cup anemometer, divided anemometers into four classes:—

1. Windmills kept facing the wind, and winding on their axles a string against some form of graduated balance.
2. Spring pressure on boards kept facing the wind, and acting on a spring balance.
3. Tubes in which a difference of level was due to pressure.
4. Pendulum anemometers.

With regard to the direction of the wind, the ancient weathercock had never been improved upon; but the main condition of success was the avoidance of obstruction or frictionless working.

For the estimation of the force of the wind several very ingenious instruments had been devised, determining either on the pressure of the wind on a suspended plate, or on a fluid. The best of the former was by Osler, used at Greenwich and Birmingham, in which a plate of 192 square inches area was exposed, and the pressure recorded by springs behind.

For measuring velocity the variety of instruments was still greater. At present the one most in use was Robinson's cup anemometer, and it consisted of four cups at the ends of rods. The pressure of the wind, no matter from which direction it might come, caused the cups to rotate, and the axis, acting on the gearing below, recorded the velocity. It had been computed that the wind travelled at a velocity of 2·5 times that of the cups, but allowance had to be made for friction, and, consequently, such delicate construction was required that only approximations could be obtained.

Another instrument, by which both the velocity and force were marked upon a self-registering drum, consisted of a pair of miniature windmills, which were acted upon by the wind and connected with gearing on a plane table, which caused the faces of the instruments to be always at right angles to the wind.

The position of an anemometer was one of great importance. It was well known that the force of a current of water was not uniform in all parts of its section, and a current of air was subject to the same laws. The secretary of the Scottish Meteorological Society said that the most uniform results were obtained at a height of 50ft.

A number of experiments had been conducted by Smeaton about the middle of the last century, with a view to determining the best form and angle of sails for the ordinary four-arm mill for pumping or grinding, and as the result of the experiments several rules were laid down in the form of tables of velocity and pressures, which were mainly adopted by engineers at the present time. Other observers made similar experiments, notably Leiher and Borda, with nearly the same results. In the year 1881 Hawksley read a paper before the British Association, at York, and went into the subject very fully, stating as his opinion that designers might safely take 40lb. per square foot as the maximum of wind pressure to be provided against, although the engineers of the Forth Bridge, warned by the Tay Bridge disaster, had made their calculations on 56lb. In this country, during the last five years, there had only been twelve days on which a pressure of over 20lb. on the square foot had been registered at Greenwich, and the greatest gale of recent years was on October 29 and 30, 1886, when the gauge there was broken. A pressure of 30lb. to 40lb on the square foot would overthrow a railway carriage, but this had not happened as yet, probably due to the fact that the lateral pressure of the wind was so limited, and that the speed of the train went to secure its stablility. The amount of energy flying about over the surface of the land had been estimated by Mr. Price, M.I.C.E., of Dublin, to be, in the case of Ireland, above 360,000,000 foot-tons per day, or six times the power of Niagara.

In deciding on a suitable motor there were several considerations to be taken into account. Having ascertained the work to be done and the power at command, the next step was to decide on the best machine. A wind-motor must comply with the following conditions: (1) It must be self-adjusting to the variable direction of the wind; (2) it must be self-adapting to the variable force of the wind. There were two types of mill in use at present, viz., the Warner and the Halliday mills. Both these mills claim to be self-adapting to variable force, Warner's by means of springs which yield to pressure, and Halliday's by simple balance on pivots. The latter had less chance of getting out of order. There were several mills besides these in use, but some were very curious and impracticable. One set of theorists advocated mills with horizontal arms, but Smeaton had condemned these, as it was evident that only one sail at a time could be receiving the full effect, and the returning sails were so many impediments to the speed. The efficiency of a horizontal mill was only about 1 in 10. Another idea was the pantanemone, and at Poissy and Villejuif, in France, two were at work with the following results: At Poissy this pantanemone was said to raise 8,800 galls. per day to a height of 65½ft., equivalent to 4,000 foot-pounds per minute; and at Villejuif another was said to raise 33,000 galls. of water to a height of 32¾ft. in 24 hours, equal to about 7,500 foot-pounds per minute. The former had a velocity of 23ft. per second, and the latter 16·5ft. per second.

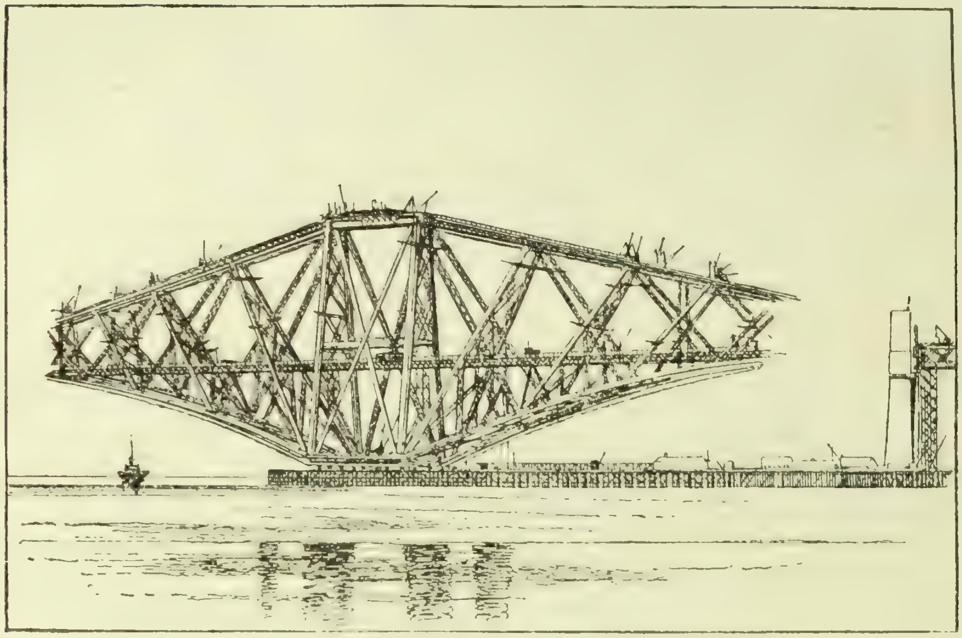
The principal uses of wind as a motor at present were for grinding and pumping. At Faversham the waterworks company used it as an adjunct to steam, and during the year 1888, out of a total of 7,300 hours work in pumping, the windmill did 2,900 hours, or an average of eight hours a day, which was excellent. The mill was erected in 1873, and had four arms, each 34ft. long from centre of wind shaft, and in a good breeze developed 15 H.P. At Caswell Bay, near Swansea, a 30ft. Halliday mill was used for water supply. The mill stood on some rocks about 200ft. above the sea, and the spring of water came out of the base of the rocks about 250ft. from the mill. The pump was at the spring, and the power was conveyed from the mill by ½in. wire rope running in grooved pulleys. A 4in. double-acting Curtis pump was used, and this forced the water through a 5in. main fully a mile long, with an elevation of 287ft. in the mile, and delivered 3,000 gallons per hour. The effective H.P. might be roundly stated as five.

Windmills were largely used in Western Australia for pumping water on the farms, and even in the Fenlands in Lincolnshire there were still scores at work pumping.

The latest development of the utilisation of wind power was in generating electricity. At Cape la Hève the Duke de Seltre had accomplished an installation with the aid of accumulators. The motor was a Halliday mill, the possible power of which was 20 horse. There were two dynamos of variable velocity, and the accumulators were charged by the dynamos. This plant had been successful, and was to be applied to the lighthouses at La Hève. He thought this was the first instance of electric lighting by the motive power of wind, and though it was not so cheap as water, still there was a large field open for improvements.

THE FORTH BRIDGE.

(Concluded from page 144.)



SOUTH CANTILEVER.

Erection of Superstructure.

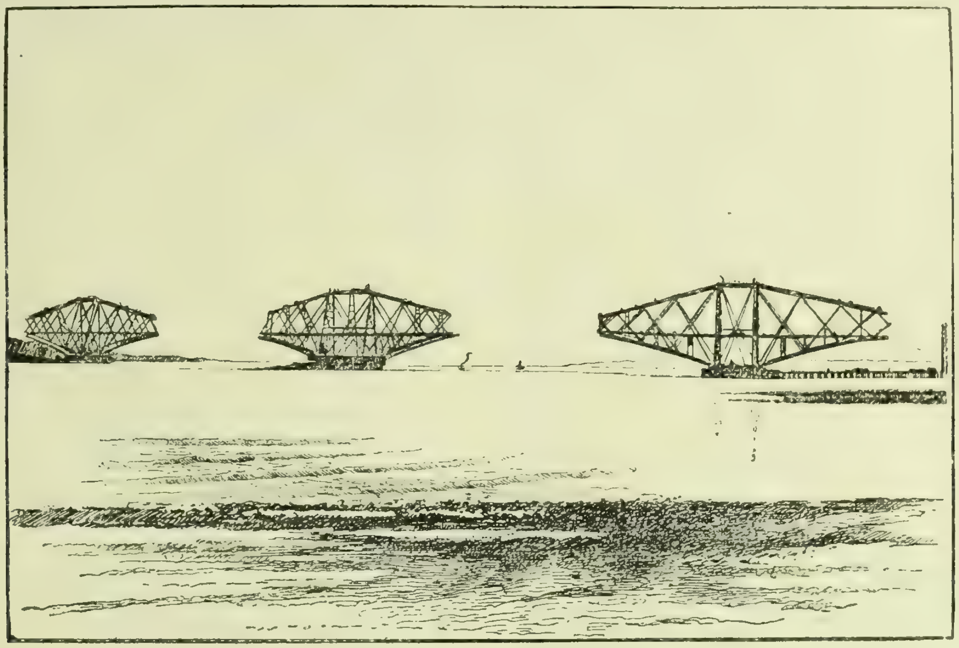
In ordinary cases bridges are built on scaffolding, but owing to the great depth of water and other considerations, this would obviously be impracticable in the case of the Forth Bridge. The method determined upon was to first build the great steel towers, 370ft. high, and then to add successive bays of the cantilevers right and left, until the whole was complete. The central connecting girder will be similarly erected in two halves, temporarily connected with the projecting ends of the cantilevers. This system offers great advantages as regards safety during erection, for there is no critical time, every part being securely bolted up as the work goes on. We have had ample evidence of this, for at no time have we suffered any danger from storms; and a few weeks ago, during a very heavy gale, the maximum movement, even in the unriveted part of the work, was under half an inch.

The great towers were erected with the aid of lifting platforms and cranes, raised gradually from ground level to the full height of 370ft., by four hydraulic rams, one in each main tube. As the platform was raised all the work immediately above and below it was built, bolted, and riveted. The first half bay of each cantilever was similarly erected.

Our experience so far has been that whilst the work of erection has been somewhat slower and more costly than we anticipated, it has, on the other hand, been less difficult, and subject to fewer contingencies. We thought at first that the cranemen and erectors would require practically to be close together, but we have found out, or rather the men have found out for themselves, that cranes 370ft. up in the air can handle work at ground level, and that the long steel wire ropes hanging from the crane jibs, instead of being destructive of their usefulness, are often of great advantage, as plates and bars can be swung out pendulum fashion to a distance far beyond the reach of the jib itself. This result of experience, combined with the boldness of the men, enabled us to dispense with the use of lifting platforms for the outer bays of the cantilevers, and in lieu of this mode of erection to use steam cranes, travelling on the top member and internal viaduct, commanding, therefore, all the steelwork below. With increased experience we have erected as much as 2,350 tons of steelwork in a single month.

Everything connected with the Forth Bridge, except the rolling of the steel plates, has been done on the spot. This has necessitated the establishment of one of the largest bridge-building works in the kingdom, capable of turning out 1,500 tons to 2,000 tons of girder work per month, for the special purposes of the Forth Bridge. As the cost of these works has to be charged to a single undertaking, instead of distributing the cost—as in ordinary manufacturing works—over many, the expenses in connection with the Forth Bridge are necessarily heavy. More than £500,000 has been expended on machinery, staging, railways, steamers, buildings, and lighting. The granite piers have cost about £400,000, and the steelwork about £1,300,000 in addition; 42,000 tons of steelwork have been erected up to the present date, and a good deal more is ready for erection. It is believed that the bridge will be finished in October. Mr. Arrol has charge of the operatives, as chief contractor, with Mr. Biggart as chief assistant. Mr. Stewart has had responsible charge of the drawings, and the chief resident engineers have been Mr. Cooper and Mr. Meik.

The number of men employed on the works has at times been as high as 4,300. The average number during the past five years has been 2,300. Much of the work of the Forth Bridge requires men possessed of coolness, courage, and other qualities characteristic of the finer specimens of humanity, irrespective of nationality. The lantern views exhibited will have brought vividly home to you the fact that the men erecting the bridge have to dismiss from their minds all unpleasant reminiscences of what students of dynamics call "the motion of a falling body under the unbalanced action of its own weight," for any nervousness on the part of men lying out along a projecting angle bar, as many do, with a clear fall of between 300ft. and 400ft. below them, would only lead to an unnecessary verification of Newton's laws respecting the accelerating force of gravity. Unfortunately, men have fallen from all heights on to the staging or into the sea. In most cases the falls arose from too reckless courage or indifference of the men; in some few cases from the fall of the staging. One instance of the latter class was mentioned by me at Dundee, some time ago, and has since gone the round of the world, being cited in American and Colonial newspapers as an instance of modern heroism. Six men were on a stage, which suddenly gave way, leaving half the number hanging to the steelwork, and letting the other half take the headlong plunge of 140ft. downwards. One of the men left hanging declined the assistance offered him until his companion was first rescued. As an instance of indifference, I need only mention the case of a man who, carrying a lump of coal on his shoulder, stood on the fence-rail of the topmost platform, and, overbalancing, fell backwards the full height of 360ft. A fruitful source of accident is, of course, falling bodies, planks, hammers, drifts, and other tools dropped by men on their fellow-workmen below. We take all possible precautions, by arranging wire nettings, to intercept falling objects, and often find drifts, nuts, and bolts, which have come down like bullets on these nettings at the average rate of one per square yard, but nothing avails if the men themselves are indifferent to their risks. Some physiologists contend that we of the present day have more highly strung nerves than our ancestors; but if I am to believe what I read in the 1797 edition of the *Encyclopædia Britannica*, under the article "Bridges," and remember what goes on daily, as a matter of course, at the Forth Bridge, I doubt this assertion. The writer of the article referred to, speaking of a natural bridge across a ravine 205 feet deep says: "Though the sides of this bridge are provided in some parts with a parapet of fixed rocks, yet few men have a resolution to walk to them and look over into the abyss. You involuntarily fall on your hands and feet, creep to the parapet, and peep over it. Looking down from this height, about a minute gave the author a violent headache." Well, all I can say is, that I see more than one lady present to-night who, not content with going merely to the top of the bridge, would insist upon my taking her out to the end of the slewing jib of the 50ft. cranes to get a clearer view of the waves rolling 300ft. or 400ft. beneath our feet. As for the men, they know no difference between 4ft. and 400ft. The loss of life, so far, has been about half a hundred, which, having reference to the number of men employed, is a rate of mortality about two-thirds of that which occurs with guards and brakesmen of goods trains; so there are far more dangerous employments than erecting the Forth Bridge.



THE FORTH BRIDGE.

We have now been at work at the bridge for six years, and I may be reasonably asked if all of the anticipations formed by Sir John Fowler and myself have been realised. Well, I am happy to say that, so far, the anticipations of the croakers have been falsified. Six years ago the late Astronomer Royal wrote to the papers saying that "the safety of the structure depends entirely upon a system of end thrusts upon very long rods; there is a liability to ruinous disturbance by the lateral power of the wind. The proposed construction is not a safe one, and I should be happy to hear that it is withdrawn."

The "rods" referred to by Sir G. B. Airy are the 12ft. diameter tubes which have stood forth so prominently in many of the views exhibited to-night; and, as I have already said, so far from there being any ruinous disturbance from wind action, even in the incomplete work, the "very long rods," and every other part of the structure, are as steady as a rock during the heaviest gales.

The best test of the success of an affair, however, is to see whether other people are inclined to follow your lead. In that respect we have nothing to complain of, for since the commencement of the Forth Bridge many important bridges have been successfully completed on the same plan, and the contractors have in all cases been well satisfied with the economy and speed of the operations, and the stability of the structure at all stages of the work. The Forth Bridge at present heads the list of great bridges, but it may soon be displaced. Last year a charter was granted for a 2,800ft. span bridge at New York, and Mr. Lindenthal, the engineer, asked me to assist him in this matter. Our enterprising idealist friends on the other side of the Channel will be satisfied with nothing less than a bridge from Calais to Dover; and a few days ago the great firms of Schneider, of Creusot, and Hirsent, the original contractor for the Suez Canal and early part of the Panama Canal, brought over to me their preliminary designs for discussion. As an engineering question, the works we have done in the way of large spans at the Forth and deep foundations at Sydney have placed beyond doubt the practicability of a Channel bridge; but, of course, the enormous cost precludes the question being one of other than scientific interest. There is, however, undoubtedly a great future before bridge builders. Only ninety years ago the standard definition of "bridge" was "a work of masonry or timber, built over a river or canal for the convenience of passing the same." There was no mention of iron, nor was there of railway. In scientific treatises suspension bridges were referred to, for some forgotten reason, as "philosophical bridges." The introduction of cheap steel will account for a great deal of the progress in modern bridge building, but not all; for if the Forth Bridge were built of iron instead of steel, of the same scantling, it would still be stronger than either Stephenson's great bridge across the Menai Straits or Brunel's Saltash bridge. The fact is that a great bridge, like all great things, is a product of the age—a resultant of many forces—and not the work of one nor of a hundred individuals.

DISCUSSION.

The Chairman having invited discussion, to which there was no response, said he was not surprised that no one rose, for the paper, coupled with the admirable illustrations, afforded absolute information on every point; and, except with the object of requiring information, there was not much room for remark. The paper contained a description of certainly the most extraordinary work that he knew of in any branch of engineering. This bridge was rapidly approaching completion after years of hard work. The foundations, which in themselves, although not unprecedented, were works of great magnitude, and must have been the cause of great anxiety, having regard to the shelving character of the central foundation, had been successfully accomplished; the piers were in their places, and had a large portion of the total superincumbent weight upon them, which they had stood perfectly well. With respect to the effect of the wind, they had more experience of that now than they would have when the bridge was finished, because there was an enormous percentage of the whole work which would be exposed to the wind action already completed, but the bridge as a whole was in an uncompleted condition; and it must be said, therefore, that when it was completed it would not be so severely tested by the wind pressure as it was at the present moment. Mr. Baker would, in a few words, be able to tell them how much of the total weight of the superstructure was devoted to the purpose of withstanding wind pressure, but he believed it was a very large proportion of the whole. Nothing was much more striking than to look at this enormous framework, and see that its object was to carry the central roadway, which was all but lost in the midst of that which supported it. The actual roadway on which the trains would run was quite insignificant compared with the structure which carried it ; and as regards the live load, the bridge would know as much about the trains passing over it as an elephant would of a bluebottle settling on its back. It would be absolutely a matter of indifference whether there was one train upon it or ten. In this respect it was totally different to an ordinary bridge. The real load on the bridge was its own weight, and nothing was more striking as bridge spans increased than the need there was to increase, in a much greater ratio, the height of bridges at the points whence they derived their strength ; if it were an arch, the depth of the arch at the sides, or in a cantilever bridge the depth or height of the part which formed the root of the cantilever. These proportions had to increase enormously as compared with the span, or else it would be impossible to make a bridge even self-sustaining. The problem was first to make the bridge sustain itself, and, having done that, it was very easy to provide for the load which passed over it. The other problem was the mode of resisting the wind pressure, and they knew the enormous pains which had been taken by Sir John Fowler and Mr. Baker in calculating the effect of the wind in this structure. Continuous observations had been made on the wind pressure by means of an anemometer such as had never been seen before in point of magnitude, which had been in operation for some years, and had afforded results of the greatest value from a scientific point of view. There were, therefore, all requisite data for judging what the wind pressure would be when distributed over a large surface, not isolated on some small surface, as it would be in an anemometer of the ordinary construction. Then, having ascertained this, the question arose how this pressure was to be resisted, and nothing could be more satisfactory than the manner in which this problem had been sought out and happily solved by the engineers of this bridge. He trusted that when, at the Newcastle meeting of the British Association, Mr. Baker fulfilled his promise of giving the workmen's lecture on the subject of this bridge, he would be able to show photographs in which the bridge would be shown still nearer completion than it was in those exhibited that evening. As a matter of form, he would ask the meeting to pass a hearty vote of thanks to Mr. Baker for his paper.

The vote of thanks having been passed unanimously,

Mr. Baker, in replying, said it must be very gratifying to any reader of a paper to have the opportunity of delivering it before such an audience, and it was always especially pleasing to him to have Sir Frederick Bramwell as chairman. As usual, Sir Frederick had put his finger on the most important point in the whole design, the provision to resist wind pressure. It would be seen from the complicated appearance of the structure in some of the photographs what a network the whole thing was, whereas on the diagram it only looked like a single plane surface, the number of square feet in which, multiplied by the wind pressure per square foot, would give the pressure of the wind which might come against it. But taking a perspective view, it showed that, behind the front surface there were no end of lattice work girders, the area of which might be anything. The way he began the investigation was to make a metallic model of the bridge exactly to scale, with every cross-piece and strut, and then to put it into water, and tow it slowly behind him in a boat, the model being attached to one end of a bar, at the other end of which was a flat plate, the area of which he could vary at pleasure. This plate was regulated until it exactly balanced the resistance of the model of the bridge, and then by measuring the area of the plate he found the equivalent area of the model, and from that of the bridge itself. It was about double the front surface, as shown on the diagram. Having got that, the Board of Trade rules said they must provide for a wind pressure of 56lb. per square foot. From the wind gauges, which they placed at different parts of the structure, they could not see much difference in the pressure at the top and at the bottom, though, as indicated by one's own personal feelings, you would be infinitely happier at the top than down below. Up 400 feet you were out of the cold damp feeling which came from the water, and there seemed much less wind, as it was so broken up by the structure below. Several persons whom he saw present had expressed the opinion that on the top of that bridge was where they would like to live. The wind pressure on each span was calculated at 2,000 tons laterally, whilst the heaviest trains would be two coal trains of 400 tons each, or 800 tons in all. The lateral action of the wind, therefore, would be two and a half times as much as the heaviest trains, and you had to pay a great deal more attention to the wind than to the trains. The essence of the design as regards wind pressure was the straddleleg arrangement of the main columns and struts. The top member had no cross-bracing at all, because whatever wind pressure came there had finally to come down to the masonry piers and the rock. Since everything had to come to the ground ultimately, obviously the principle was to take it down by the shortest route, and the shortest route always was from the top member down the nearest strut. It resulted from this that the heaviest stressed portion of the structure was the lower tube at the piers, which had to bear the wind pressure, the dead load, and the live load. The stress at the top member was 4,000, and at the bottom nearly 7,000 tons. As a matter of fact, the stress on the tube from the weight of the bridge was 2,700 tons, and when the heaviest trains came on you might put on 40 per cent more, or about 1,100 tons ; but the wind put on 3,000 tons, or more than either the dead load or the live load.

THE INSTITUTION OF CIVIL ENGINEERS.

(Concluded from page 152.)

THE following table gave the value for k for different cases, all referring to poles of rectangular shape, and coils in which the active wires were straight :—

1. Width of poles equal to pitch, toothed armature and winding concentrated in the recesses ... $k = 2{\cdot}000$
2. Width of poles equal to pitch, smooth armature and winding spread over the whole surface. $k = 1{\cdot}160$
3. Width of poles equal to pitch, smooth armature and winding covering only one-half the surface .... $k = 1{\cdot}635$
4. Width of poles equal to one-half the pitch, smooth armature and winding spread over the whole surface .... $k = 1{\cdot}635$
5. Width of poles equal to half the pitch, smooth armature and winding covering only one-half the surface .... $k = 2{\cdot}300$
6. Width of poles equal to one-third the pitch, smooth armature and winding covering only one-third of the surface .... $k = 2{\cdot}830$

According to the ordinary sine formula the coefficient was $k = 2{\cdot}220$; and this agreed fairly well with case 5, which was most frequently met with in practice. The formula for e presupposed the knowledge of the total induction z, which depended upon the shape and size of the field magnets, their arrangement, the amount of iron in the armature, the interpolar space, and the exciting power. This subject had been very fully treated by Drs. J. and E. Hopkinson, and the author had also dealt with it. These methods had subsequently been improved by the introduction of certain terms due to Professor Forbes, by means of which the magnetic leakage could be more accurately ascertained. With the knowledge of the total induction z, and the coefficient k, it was thus possible to determine the relation between exciting power and electromotive force of any given alternator. The effect of self-induction was to produce an electromotive force, the phase of which was at right-angles to that of the current ; and the electromotive force available for doing work in the circuit was the resultant of the induced electromotive force, and that due to self-induction. The author then described some graphic methods by which the problem could be treated in a simple and easily understood manner.

In alternators used for parallel distribution the object aimed at was generally to keep the terminal pressure constant for all currents, and this could be attained by working with a constant field and suitably varying the speed, or by maintaining a constant speed and adjusting the exciting current so as to suitably vary the electromotive force. The latter plan must be adopted if several machines were worked in parallel ; and in this case the graphic method might be used to determine the limits between which the exciting current must be varied to keep the terminal electromotive force constant for all loads from no current to the greatest current the armature was intended to pass. The mean induced electromotive force e was found by the above formula, and its maximum value was obviously

$$E_i = \sqrt{2}\, e.$$

The maximum value of the electromotive force of self-induction was given by

$$E_s = 2\, \pi\, n\, L\, I,$$

where L was the coefficient of self-induction, which could be determined by various well-known methods ; or by running the armature in a constant field, and measuring the terminal electromotive force with and without a current passing through the armature. The electromotive force lost in resistance was simply the product of the current I and the resistance R of the armature. With the knowledge of these quantities it was easy to determine the strength of field required for any current.

The problem of parallel working was of the greatest importance for central stations, as only by such an arrangement of machines was it possible to insure absolute continuity of the service and the greatest economy at all times. Alternate current distribution should, if possible, be carried on in the same simple manner as direct current distribution—

that was to say, the number of machines at work should correspond as nearly as possible to the output at any time; the addition or withdrawal of machines should not even momentarily interrupt the supply of current to any part of the system of distribution. These conditions, it would easily be seen, could only be fulfilled if the machines were capable of working in parallel, and the problem might be stated somewhat in this fashion: Given an alternator with excited field and running at a proper speed, and a pair of terminals from which any desired strength of current could be obtained at a constant pressure, and having a frequency approximately corresponding to the speed of the alternator, what would be the condition under which the alternator would fall into step with the supply current, and what would be the relation between the current passing and the mechanical energy given off? Also, how would this relation be affected by variations in the strength of the field? This problem was also treated by graphic methods, and it was found that the only and sufficient condition for successful parallel working was a sensible amount of self-induction in the armature circuit. It was well known that alternators having no iron in their armatures could not be run in parallel except by the adoption of some such expedient as choking-coils; also that parallel running was feasible with those alternators which had iron-cored armatures. If a machine were run at constant speed on open circuit, and with different strengths of exciting current, different terminal electromotive forces were obtained. A characteristic could then be plotted, the abscissas of which represented exciting power, whilst the ordinates represented terminal electromotive force, which in this case was the same as the induced electromotive force. Having obtained this curve, which the author suggested should be called the "static characteristic," the dynamic characteristic of the machine was determined for a certain current through the armature, by so adjusting the resistance in the external circuit that for all exciting powers the current remained the same. The curve so obtained must obviously lie wholly under the first curve, and the difference between the ordinates of the two curves depended upon the choice of current for which the second test had been made, and upon armature resistance and self-induction. Besides these two curves there was a third, viz., that obtained when the machine was driven as a motor running light. To find this curve it would be necessary to have at disposal at least two similar machines, using the one as generator and the other as motor, and during the test the field-strength of both machines would have to be regulated, so as to keep the current at its predetermined value. Thus, a "motor-characteristic" would be obtained, lying wholly above the "static characteristic." As the last experiment was, however, only possible if two machines could be tested at the same time, and was also somewhat delicate, another method of investigation was desirable. This could be done by using one of the author's diagrams to deduct the motor-characteristic from the two other curves, the experimental determination of which presented no difficulties whatever, and would, indeed, be made as a matter of course in the ordinary test of the machine before it was sent out from the manufacturers. Diagrams were shown which contained these various curves as determined for one of the author's machines, constructed for an output of 60 kilowatts.

In any dynamo machine there were two causes for heating, in addition to purely mechanical friction. These were the resistance of the conductors, and the change of magnetisation of the iron parts of the machine. As regarded the first cause the liability to the generation of eddy-currents in the armature conductor was much greater with alternators than with continuous-current dynamos, and in alternators it varied with the construction of the armature to a greater degree. When the armature contained no iron, the heating from eddy-currents was much greater than when such a core was used, and the armature conductor must therefore be made in the form of a very narrow strip. The other cause of the generation of heat, the change of magnetisation in the iron parts, could be minimised by lamination, but never entirely avoided. In direct-current machines the heating from this cause was, however, generally so small that no account was taken of it, except when the induction in the armature core was pushed beyond 18,000 or 20,000. In alternators a much lower induction produced sensible heating, and it was for this reason that the maximum induction must be fixed at a very low figure. With a perfectly laminated core, the heating was attributed to an effect which Professor J. A. Ewing called "hysteresis," and which might be described as molecular friction. This scientist had experimentally determined the energy required to carry certain samples of iron through a complete cycle of magnetisation of varying degree, and the results had been published in the "Philosophical Transactions." They were given in ergs per cubic centimetre; but as these units were rather inconvenient for application in the workshop or drawing-office, the author had in the following table, which referred to annealed wrought iron, translated them into watts per ton and horse power per ton.

Induction.	Watts per ton $n = 100$.	HP. wasted in Heat.
2,000	650	0·87
3,000	1,100	1·48
4,000	1,650	2·21
5,000	2,250	3·02
6,000	2,900	3·89
7,000	3,750	5·03
8,000	4,450	5·97
9,000	5,550	7·43
10,000	6,650	8·90

Modern transformers were provided with a core of laminated iron, which was symmetrically placed in respect to the two windings, so that the same induction passed through both the primary and the secondary coils. Under these conditions, the electromotive force induced in the two circuits was simply proportional to the number of convelutions they respectively contained, and the terminal electromotive forces were found by adding in the case of the primary, and substracting in the case of the secondary, the loss of pressure due to the resistance of the coils. In a properly designed transformer, this loss of pressure should not exceed about 1 per cent of the terminal pressure, so that the maximum difference the pressure maintained in the secondary circuit between the lamps, when the apparatus was used for parallel distribution, did not exceed 2 per cent between full load and no load, provided the pressure in the primary circuit was kept constant. Such a small variation in the pressure was well within the limits attainable in direct lighting, when a compound-wound dynamo was driven from an engine with a fairly good governor, and the corresponding variation in the illuminating power of the lamps was sufficiently small to be tolerated. A greater variation, especially if it occurred suddenly, would, however, not be permissible; and the question, therefore, arose as to what rules should be followed in designing transformers so that they might as nearly as possible be self-regulating. The obvious answer was, make the resistance of the circuits as small as possible, and this might be accomplished in three ways: 1. By using wire of large area. This expedient naturally increased the weight, bulk, and cost of the transformer, and must, on account of commercial reasons, not be pushed too far. 2. By employing a core approximating to a circular of quadratic section, so as to decrease the perimeter of the coils. 3. By working with a high induction, or with a high frequency.

The mean electromotive force in volts, induced in the coil of a transformer, could be expressed by the following formula—

$$e = (q)\, 2\, \pi\, n\, z\, \tau\, 10^{-8},$$

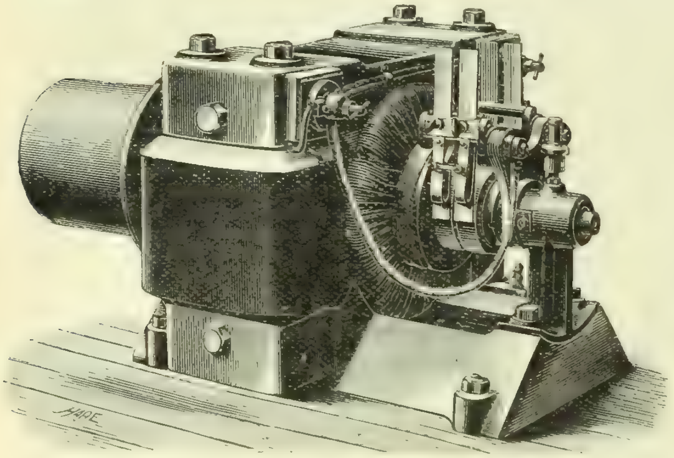
in which (q) was a coefficient denoting the ratio between the maximum and the mean electromotive force, n was the frequency, z the total induction in absolute units, and τ the number of turns contained in the coil. The larger z, and the smaller n, might be the length of wire, and therefore its resistance. On purely theoretical grounds it would thus seem that a small core strongly magnetised, and as high a frequency as the alternator could be constructed to give, would produce the best results. In practice, however, this conclusion was wrong, and the heating of the iron core in consequence of hysteresis must be taken into consideration. Since a transformer was an apparatus at rest, and was frequently placed in a position where the cooling effect of the air was small, the ratio between heat generated and available cooling surface must be very different from that permissible in a dynamo, and it was this ratio which was the true limit to the output of a transformer. The armature of a dynamo was not subjected to excessive heating if a cooling surface of about one square inch per watt was provided. In a transformer, the amount of cooling surface should be at least three times, and if possible, four or five times as great, especially as it was somewhat difficult to determine, in a body of such complicated shape, what was and what was not effective cooling surface. From the above table, it was easy to calculate for any induction, frequency and weight of the active iron in a transformer, what the heat of the iron would be; and, adding to this the heat of the copper, the total cooling surface required to keep the apparatus at a safe temperature could at least approximately be determined, or the limit of output for any given transformer could be approximately found.

The question of frequency, alluded to in connection with alternators, was also of considerable practical importance with regard to the transformers, and it was much to be desired that electrical engineers should adopt a common standard. The following was a list giving the average frequencies adopted by several designers: Ferranti, 67; Lowrie-Parker, 88; Mordey, 100; Zipernowsky, 42; Kennedy, 60; Kapp, 80; Westinghouse, 133. Taking the average of European practice, the frequency was 73, or 8,750 reversals per minute; whilst the American practice was 16,010 reversals per minute. This large difference might, to a certain extent, be accounted for by the general preference of European engineers for machines running at moderate speeds; but even when making due allowance for this circumstance, it could hardly be assumed that, had actual practice shown the value of a very high frequency, electrical engineers would not have found means to obtain it. As a matter of fact, most makers of alternators had started with a much higher frequency than they had finally adopted. It should also be remembered that the higher the frequency, the greater was the loss of conductivity in the mains, owing to the unequal distribution of current throughout their cross-section.

The author then discussed the questions of alternate-current motors on the Ferranti principle, and next passed on to a description of the different modern alternate-current machines most in use. Constructive data were given for the Ferranti, Mordey, Kennedy, Kapp, Lowrie-Hall, Westinghouse, and Zipernowsky machines; and in most cases the actual performance of the machine was compared with the calculated electromotive force, so as to show within what limits the author's formulas for alternators of different types were in accord with experimental results.

PUMPING WATER ELECTRICALLY.

We have lately heard much of the electrical transmission of power, and many experiments have been made with, it must be confessed, but indifferent success. In so far as we are aware, no considerable amount of power is at present transmitted from a great distance in this way. With low intensity currents causes operate which give great loss when energy has been transmitted for a few miles, and such losses are indeed common to all systems of power transmission. For comparatively short distances electrical transmission possesses many advantages over other modes, and should, when properly arranged, give a much greater economy than is possible with the use of compressed air, for instance.



Messrs. Immisch and Co. have been very successful in applying the electrical method to the work of pumping in mines, and they have had for some considerable time a complete pumping plant at work at Messrs. Locke and Co.'s, St. John's Colliery, Normanton. It consists of a steam-driven dynamo, supplying current which actuates an electric motor, driving powerful pumps at the pit bottom, and raising water continuously at the rate of 120 gallons per minute, through a single lift of 900ft. This is equivalent to nearly 30 horse power in the water actually lifted, and, allowing for friction of rams and resistance of valves, the electric motor cannot be developing power far short of 50 horse. This is quite a large power for such work. The economy of the arrangement is very considerable when compared with that of compressed air; even at low pressures an efficiency of 70 per cent is claimed for the electric method with short leads, while the best done by compressed air does not exceed 25 per cent.

Messrs. Immisch are to be congratulated upon their success in overcoming the numerous difficulties of such an installation, and we have pleasure in illustrating here the electric motor used by them for the work. We hope to give a more complete account of the whole plant used for similar work at an early date.

COMPOUND LOCOMOTIVES.

One of the papers read before the Institution of Mechanical Engineers, at their London meeting, was on Compound Locomotives, by Mr. R. Herbert Lepage, lately locomotive superintendent, Argentine Government Railway.

The object of the paper was to furnish an account of some recent practice in designing and working two-cylinder compound locomotives.

The author pointed out the advantages of compounding, and the fact that comparatively little attention had been paid to its application to locomotives, due, it appeared, to the considerable complication of parts necessary for starting the locomotive, and the development of equal power in the high and low pressure cylinders. These objections had now been overcome in what was known as the Worsdell and V. Borries system, in which the two-cylinder compound locomotive had been brought to a high pitch of efficiency.

The locomotive described was a six-wheeled coupled goods engine, which had been made by Messrs. Dubs and Co., Glasgow, in 1886, and designed by the author. After investigating the excellent results obtained by the Worsdell and V. Borries plan, he had decided to compound it. The only difference between it and the other goods engines in use on the Government Railway in the Argentine Republic consisted in a low-pressure cylinder and a combined intercepting and starting valve; the axles, connecting the coupling rods and eccentrics, &c., were all duplicates of those in the ordinary engines.

One of the interesting features was the starting arrangement, which consisted of an intercepting disc valve for the purpose of shutting off the low-pressure steam-chest from the high-pressure exhaust at the moment of starting. The object of this combination of valves was to enable the engine to start always with boiler steam in both cylinders, as in an ordinary locomotive, and also to prevent an unequal strain on the machinery or the couplings of the vehicles, thus enabling a heavy train to be moved easily and smoothly without any shock, with full power on both pistons, and without wasting steam.

Cylinders.—The cylinders were placed outside the frames, according to the custom on the Argentine railways, which enabled the crank axle to be dispensed with, a distinct advantage in a country far away from the maker. The high-pressure cylinder was 16in. diameter, and the low-pressure 23in., which gave a ratio of 2·1 to 1. The stroke was 24in. These proportions had proved very efficient in practice.

Slide Valves and Valve Motion.—The valve gear consisted of the usual Stephenson link-motion, with a simple device for effecting a very advantageous distribution of steam for the compound locomotive. By a slight difference in the length of the lifting links, or in the position or angle of the levers on the reversing shaft, the cut-off in the high-pressure cylinder was kept at an earlier point of the stroke than in the low-pressure cylinder, when running in forward gear. This had been ascertained to be more economical, and also equalised the amount of work done in the two cylinders.

Pistons.—The low-pressure piston was 23in. diameter, and was constructed of wrought cast steel, in order to make it as light as possible for so large a piston. The high-pressure piston was 16in. diameter, and made of cast iron, and of the usual form. The piston rods were made to work through the front cylinder covers. This was desirable where there was room, as the weights of the pistons were supported.

Boiler.—The boiler was made of best Yorkshire iron, and was double-riveted, with inside and outside butt strips at the longitudinal seams. All the rivet holes were drilled and the riveting done by hydraulic machinery. The boiler was made of seven plates—three for the barrel, one for the sides and top of fire-box, one throat plate, one back plate, and the front tube plate. The tensile strength of the plates used was 22 tons per square inch.

Inside Fire-box.—This was made of copper, average tensile strength 14·34 tons per square inch. The fire-box tube plate was 1in. thick where drilled for the reception of the tubes, and reduced to ⅝in. thickness below the tubes. The back, top, and side plates were ½in. thick, secured to the shell plates by ⅞in. copper stays. The stays were spaced 4in. apart, and screwed into the plates with twelve threads to the inch. The fire-box roof was strengthened with corrugated wrought-iron bridge stays and suspension links. This was considered by the author to be the best means of staying fire-box roofs, as it gave the fire-box longer life, owing to the freer expansion allowed.

Tubes.—There were 171 brass tubes, having an outside diameter of 2in.; their thickness at the smoke-box end was 13 B.W.G., or 0·095in., and at the fire-box end 11 B.W.G., or 0·125in. They were slightly enlarged at the smoke-box end, in order to allow of their being withdrawn. At the fire-box end they were rolled and leaded over, and a turned steel ferrule driven in tightly for assisting to secure the tube, and also for protecting its end from the fiercest action of the flame.

The heating surface was 912 square feet in the tubes, and 104 in the fire-box; total, 1,016 square feet. The grate area was 18 square feet.

The working pressure of this engine was 175lb. above atmosphere. In compound locomotives it was found advisable to increase the pressure as much as possible, because the expansion of high-pressure steam could be more effectually and economically carried out in two cylinders.

The author gave a description of some trial trips, all of which had proved satisfactory. He said that there were 360 engines, including train engines, on the Worsdell and V. Borries system, either at work or in construction. The economy in fuel over the ordinary engines ranged from 14½ to 20 per cent, and in some cases even more.

By order of the Belgian Government, engineers are thoroughly examining the old submarine cables between Belgium and England, in order to ascertain whether it is worth while to continue working them, or whether new cables must be laid.

OIL ILLUMINATION.

THE *Glasgow Herald* states that considerable attention is being given just now to the use of oil for lighting purposes. In some parts of the country oil has largely, if not completely, superseded gas, and in Scotland the consumption in the past few years has grown enormously. The advance made in the make of lamps used has no doubt greatly contributed to the favour now shown for oil, and as the savings effected are substantial, it seems not too much to expect that in country districts and small townships its use will become yet more general. We see it stated that at Erith, in the South, the authorities have given up gas, and concluded a contract for the lighting of the streets by the new pneumatic petroleum lamps for a period of three years, the cost being half less than that for gas, and the light very much better. Then it is reported from New Southgate that experiments made with oil give most favourable and satisfactory results in all respects. A 43-candle lamp, it was found, burned a pennyworth of oil in five hours, reckoning the oil at 8d. per gallon, while a three-jet gasalier, giving the same light, consumed gas to the value of 5d. in five hours, calculating the gas at 4s. 6d. per 1,000 cubic feet. Thus, by adopting lamps, a tradesman at New Southgate, burning £50 of gas a year, would only burn £10 of oil, effecting a saving of £40. Even, however, with gas at 2s. 6d. the 1,000 cubic feet, oil is pushing its way, as is seen in the experience of Woolwich and Plumstead, where 200 shops are now lighted with oil in place of gas. A number of demonstrations are being organised in England to show the advantages of oil over gas; and as the subject is one of great interest to the community as well as to the Scotch oil trade, the Mineral Association might do worse than arrange for some district demonstrations in Scotland. Mr. D. C. Defries maintains that while the cost for street lamps lighted with gas ranges from £3 10s. to £4 10s. a year for a light of 13 or 14 candle power, the cost for oil lamps is as nearly as possible £2 7s. per lamp per annum, averaging the burning of the lamp 10 hours a night in winter and summer, the light at the same time being twice that of gas, or 30 candles. These points are deserving of the careful consideration of many district authorities in Scotland, where lighting of any kind, it may be said, is at present practically unknown. We hear that the Paraffin Gas Lighting Company of Glasgow are also experiencing an improved inquiry for oil-lighting plant, and at present have contracts on hand for supplying such to Ballikinrain Castle, Invereck House, Kilmun; Armiddle House, Turriff; New Hotel, Silloth; and at Oakbank, Mid-Calder.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

ERROR IN "MODERNISED TEMPLETON."

To the Editor of "The Practical Engineer."

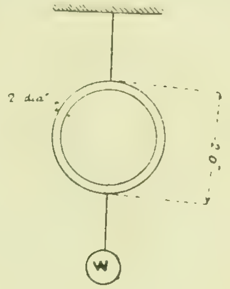
SIR,—Your correspondent is now pointing out a line in which there often is and often will be a great difference between theory and practice. If "Boiler-maker's" experience is a varied and extended one, he will certainly be aware of the fact that scarcely two men can make the same diameter of hoop from a given bar; and as most of these tables are more or less erroneous, many angle-smiths get out a list of their own, from their experience with a particular section of iron. For instance: 3in. by 3in. by ½in. boiler angle is quite a different section to 3in. by 3in. by ½in. ship angle, and bridge iron or warehouse angle again differ. Again, the mode of bending bars makes a difference. If bent out of the fire in short heats, a given bar will often give a much larger hoop than if bent by lever and pulley at one heat from a good furnace; and if bent in rolls, at a low temperature, a different size again obtains. The best table I know is in "The Practical and Theoretical Boiler-maker," a book by S. Nicholls (an old boiler-maker), now out of print. The rule he gives is as follows: Outside hoop or ring—to the inside diameter add one-third width of flange and thickness of bar at rivet hole. For inside hoop or ring—from outside diameter subtract one-third width of flange and thickness of flange. If the flanges are not both the same width, the flange forming the *face* of the ring must be measured. The bar must be measured along the root, and the ends must be cut by the smith to suit the inside or outside, as required; flanges for an outside being left longer, and for an inside shorter. Example: Angle, 3 × 3 × ½; hoop to be 3ft. inside diameter. The 3ft. + 1in. + ½in. = 3ft. 1½in., and 3ft. 1½in. × 3·1416 = 9ft. 9¾in., length of hoop measured along the root of angle. It seems to me that 1in. is a very full allowance for welding.—Yours, &c., CHALKLINE.

QUERIES AND REPLIES.

21. MARKING OFF CRANK.—Will some practical reader inform me the best way to mark off a two-throw crank shaft for "turning," after the webs have been "slotted" out; also how to get the position of the arms to turn the "throws?"—CRANK.

Answer.—First turn up the shaft part, leaving say enough for a finishing cut, and, of course, make both sides the same size. Then put crank shaft on a true surface, on two V blocks, and with a square get one crank perpendicular by packing up the lower one. Next put the arms on shaft, and with the scribing-block get to the centres you have turned the shaft part by, and set the centres on the arms the same height (with scribing-block). Then turn up and finish crank pin, and then serve the others the same way. Next take off the arms and finish shaft part.—P. C. S.

15. STRENGTH OF RING.—Will some reader show how to find the strength of a ring made of 2in. diameter wrought iron, and 2ft. outside diameter, which has a weight suspended from its lowest point, and is supported by a chain fixed above, as shown in sketch? I wish to see the calculation, ultimate strength, safe load, &c. How would it resist collapse if the tensions became compressive pressures?—STYLEX.



16. SETTING CORLISS VALVES.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—ENGINEER.

17. CAN anyone inform me where a copy of "The Practical Boiler-maker," by S. Nicholls, published by the author, can be obtained? I have written to Blackpool, where the author formerly resided, but the letter has been returned.—I. W.

22. ANTIMONY.—Will any reader kindly inform me of the best way to melt ground antimony? The only means at my disposal for doing so are in a ladle over gas or over a large stove, and this is not effectual, as the powder simply cakes.—H. P. S.

23. LIGHT MIXING MILL.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—EASTERN.

24. TEMPERATURE OF FEED WATER.—What is the highest temperature of feed water attainable in surface condensing engines with a vacuum of from 24in. to 28in.?—CROSS.

25. VELOCITY OF DISCHARGE.—A cylindrical tank, 40ft. high, 9ft. diameter, is full of water. A horizontal pipe 2in. diameter is connected to the bottom of this tank, and is 15ft. long. What is the velocity of discharge, and how long would the tank be in emptying itself through the horizontal pipe?—DERBYSHIRE.

TO CORRESPONDENTS.

I. R. J., Sheffield.—We thank you for your letter, with details of compound engine performance and indicated diagrams. The consumption of fuel per I.H.P. is fairly satisfactory, but the diagrams are not particularly good.

AIR, Birmingham.—To supply two pipes of ⅜in. diameter, arranged as you describe, one discharging air freely into the atmosphere, from a reservoir filled at 40lb. per square inch above atmosphere, would require a double-action air pump of 5in. cylinder, 10in. stroke, running at 150 revolutions per minute, and it would absorb, allowing for friction and other resistances, about four horse power. You will find it somewhat expensive to blow a smith's fire in that way by an induced jet.

J. TUCKER, Briton Ferry.—There is no such society as you inquire about in existence. If you inform us upon the nature of your invention, we may be able to advise you on it.

YORKSHIRE.—Ordinary coal tar does not injure steel ropes. Your description is not clear enough to enable us to answer your query upon compound engine. Write again, and explain your experience more fully.

SLIDE VALVE.—The diagrams you send show that the expansion valve acts badly and throttles the steam instead of cutting off sharply.

GAS ENGINE.—You will find a simple form of brake described in our leader this week. We propose publishing an article, with illustrations, on brakes in an early issue. To calculate the brake power, multiply the circumference of the brake circle in feet by the number of revolutions of the engine per minute, and by the weight suspended in pounds. The product gives the number of foot-pounds performed by the engine per minute; divide by 33,000, and you have the brake horse power. The brake circle is the circle passing through the point of suspension of the brake weights concentric with the shaft; its radius is the distance from the point of suspension to the centre of the shaft.

HORIZONTAL ENGINE.—Your query is not sufficiently clear. Write again, and be explicit.

MISCELLANEA.

AN electric headlight on locomotives has been on trial for a month past on the Indianapolis, Decatur, and Western R. R. It is said to throw a light fully one-half mile ahead, and works very successfully. By improvements in the dynamo mechanism, 295 revolutions per minute give as perfect a light as that formerly obtained with 1,300 revolutions, and the expense is proportionately reduced.

THE GRAPHOPHONE.—The Graphophone Syndicate has been registered with a capital of £100,000, to acquire the seven British patents issued to Bell and Tainter, together with applications for others now pending. That the graphophone, according to the *Electrical Review*, cannot become commercially successful in this country is a moral certainty, whatever may be its fate in the States.

BOILER INSURANCE.—It is Sir W. H. Houldsworth's intention to introduce a bill to regulate steam boiler insurance by joint-stock companies. At present boilers can be insured without inspection. The bill provides penalties against any insurance company which neglects to have a boiler inspected before making the insurance, and a certificate of inspection must be attached to the policy. Periodical inspection of insured boilers is also required. The bill will be backed by Sir H. Roscoe and Mr. Burt.

THE DEVELOPMENT OF RUSSIAN RAILWAYS.—A Moscow correspondent says that the development of the Russian railway system is progressing rapidly, and in 1888 the total length of the lines amounted to 276,222 versts, or rather less than 207,160 miles. The Government possesses and controls 5,488 versts, and 223 versts belonging to the Russian Government are leased to several small private companies; 20,416 versts of railway are held outright by the various companies, and the remaining 1,450 versts represent the Finnish Railways, which are not subject to any control on the part of the Russian Government.

A NEW COMPETITOR IN THE SPIEGEL IRON TRADE.—During the last few months the North Chicago Rolling Mill Company has been producing spiegel iron, containing about 30 per cent of manganese, at the rate of 600 tons a week. The ore is obtained by these works from Batesville, in the State of Arkansas, and the company, which has hitherto been importing 20,000 to 25,000 tons of spiegel iron from Great Britain and Germany every year, believes that it will henceforth be in a position to be independent of those countries and cover its own requirements. This is the first time that spiegel iron has been produced in large quantities in the Western States of America.

THE proposed New Congo Railway has been surveyed over its entire route, and work on it will probably soon be begun. The length of the route is variously stated at from 200 to 250 miles, the precise length to be built now being still not fully decided; the engineers estimate that it will take two or three years to build it, and cost about $5,000,000. When finished, it will be the most important means yet secured for opening the heart of Africa to civilisation, as it operates in connection with steamer lines above and below it. The work of reducing the heart of Africa to civilisation is going rapidly forward, more rapidly than is generally appreciated.

THE Conservative members of the House of Commons representing Lancashire constituencies intend holding a conference on the subject of steam in weaving sheds. There is a proposal before them for introducing a bill dealing with the matter; but before coming to a decision on it they desire to give due consideration to the arguments on both sides. The arguments for legislation include, for instance, the undisputed fact that the excessive use of steam is injurious. On the other hand, a committee of the Blackburn Corporation appointed to inquire into the matter has reported that a moderate amount of steaming is not injurious to the operatives engaged.

THE steel gunboat Spanker, sister ship to the Sharpshooter, was recently launched at Devonport. Miss O. H. Grubbe, daughter of the admiral superintendent, performed the christening ceremony in the presence of Admiral Sir W. Dowell, Sir C. Ryan, the comptroller and auditor-general, and many other officers and civilians. The length of the boat is 230ft., breadth 27ft., with displacement equal to 730 tons. Besides her guns she will carry three torpedo tubes, and will be propelled by twin screws driven by triple-expansion engines. Phœbe and Philomel, of the Pandora class, are about to be laid down on vacant slips.

AN ELECTRICAL FARE REGISTER.—A want has long been felt for an apparatus of a simple kind which should give an absolutely accurate registration of the fares in street cars. An instrument which seems to be capable of circumventing the ingenuity of the conductor who, if he is so inclined, can generally get the best of any check which may be placed upon his propensities for appropriating that which does not belong to him, is about to be put upon the market by the American Electric Register Company, of Boston. It is worked electrically, and, from the description and drawings which we observe in *Practical Electricity*, we think that by its employment the dividends to shareholders in omnibus and tramway schemes might be increased, for it is well known that a certain percentage is always allowed for the defalcations of employes.

The Westinghouse Electric Company is now engaged in putting up an electric plant at Portland, Ore., where the generating station is twelve miles distant from the lamps, an electrical feat which has never been accomplished by any electric company, either in Europe or America. At Portland water power is used for the generation of the electricity, which the company obtains from waterfalls about twelve miles above the city. A pole line will be laid across the country to the distributing station in the city, and from that point the lines will radiate to the different parts of Portland. The company contracting for the plant will start with 3,000 lights.

RUSSIAN PETROLEUM.—During the last few years the position of the international petroleum trade has undergone a great change, and, it appears, to the detriment of the United States. In the year 1887-8 the exportation of petroleum from the United States barely reached 456,500,000 gallons, and showed a decrease of nearly 24,500,000 gallons in comparison with the previous year, which may be mainly attributed to the development of the Russian petroleum trade. During the year 1884 the exportation of mineral oil of all kinds from Russia did not reach 7,000,000 poods, but had risen to nearly 19,000,000 poods in 1887, and a further increase took place last year. Moreover, Russian petroleum used formerly to be principally exported over the Asiatic frontier, but lately it has been shipped in large quantities to all parts of Europe, and even to more distant quarters of the world.

SHOULD STEEL REPLACE IRON IN TUBING?—During the last few months steel tubes have been manufactured at some works in Western Virginia to replace the iron tubes hitherto employed, and if we are to credit the statements made by the Americans themselves, the result of the experiment has been highly satisfactory. As regards corrosion, steel seems to be a much more suitable material than iron, for samples cut off iron tubes and submitted to the action of diluted nitric acid lost 3·6 grains in 24 hours, while pieces of steel tubing only lost 1·15 grains under the same conditions. At the end of 48 hours the respective loss in weight was 6·53 and 2·21 grains. Samples of machine-welded steel tubes stood a breaking test of 52,000lb. to 66,000lb. per square inch, while iron tubes gave way under the test of 35,240lb. to 42,480lb. The steel tubes also stood a far greater tensile strain than iron.

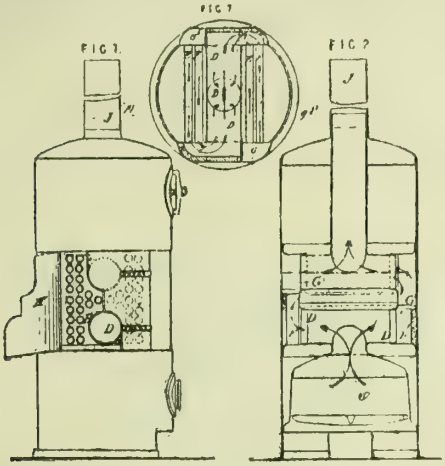
ELECTRIC LIGHTING IN LONDON.—A few days ago a special meeting of the City Commission of Sewers was held at Guildhall to consider the report of the Streets Committee on the subject of electric lighting in the city. Mr. George Manners presided. The report recommended the conditions upon which proposals for lighting by electricity should be advertised for. The main thoroughfares and public streets of the entire area of the city are to be lighted, and for convenience divided into three districts, and the contractors are at liberty to tender for either one or two districts, or the whole city. The three districts are denominated the west, the central, and the east, and the positions of the arc and glow lamps, as well as those of the existing gaslamps, are to be expressly indicated, and, in addition, the positions of the mains and service-pipes. So soon as the main thoroughfares have been lighted, the contractor must proceed when called on to light the other public ways. The whole of the lamps are to be efficiently lighted nightly, from sunset to sunrise, and when otherwise necessary, but the existing system of gaslighting is in no way to be interfered with. The duration of the contract is to be 21 years, and it is provided that, if the profits arising from the contract exceed a cumulative dividend of 10 per cent per annum on the capital invested, the excess is to be divided equally between the contractor and the consumer by the reduction of the charges. Power is reserved to the comissioners to acquire the undertaking and works by purchase at the end of 21 years. The report was carried by a large majority.

TRIALS OF PATENT STERN WELL HOPPER DREDGER OTTER. The patent hopper dredger Otter has left the Clyde for Port Natal, where it will be employed in connection with the extensive harbour improvements. The Otter was launched a short time ago by Messrs. Wm. Simons and Co., Renfrew, and in the water presents rather an unusually smart appearance for a dredger, having its funnel and bridge placed well forward. This arrangement is necessary owing to the bucket ladder opening being at the stern instead of the bow, as is generally the case. The vessel is propelled by two pairs of compound surface-condensing engines and twin screws. Two rudders are provided, and controlled from the bridge forward by patent steam-steering gear. The dredging and steaming trials recently took place on the Clyde. The former was at the entrance to the new Cessnock Dock, where all the dredging machinery underwent a thorough trial, and with most satisfactory results. After being worked by each pair of engines separately, the gear was worked by both pairs. One pair, however, is perfectly able to do the dredging. Having loaded its hoppers with fully 500 tons of *débris*, the dredger proceeded down the river, and the steaming trial was made, with and against the tide. When loaded fully a knot over the contract speed was obtained. The speed trial when light was even more satisfactory. The Natal Harbour Board, for which the Otter has been constructed, was represented by Mr. D. Macalister, C.E., who superintended the construction of the dredger, and Mr. Jas. Stewart, the resident inspector. Messrs. Simons have on the stocks, almost completed, the Beaver, another hopper dredger of similar capacity. This vessel, instead of being fitted with the bucket ladder, has two very powerful centrifugal pumps for raising sand, &c. It is also intended for Natal.

ILLUSTRATED PATENTS.

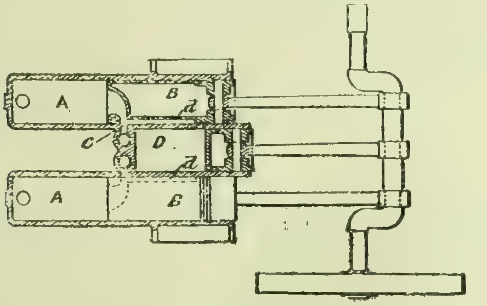
13,891. Vertical Steam Generator, J. J. Tinker, 89, Ashton Road, Newton, Hyde, near Manchester.

Fig. 1 shows an elevation of the boiler with the door H of one of the combustion chambers open. Fig. 2 a central sectional elevation, and fig. 7 a horizontal section through the flue D. The furnace gases from the firebox C enter the transverse flue D and pass in contrary directions to the combustion chambers F and F¹, arranged on the same level and next to similar chambers G and G¹, receiving the gases from opposite sides of the boiler through smoke tubes E. From the latter chambers the combustion products enter the upper transverse flue before reuniting at the base of the uptake J.—October 13, 1887. [8½d.]



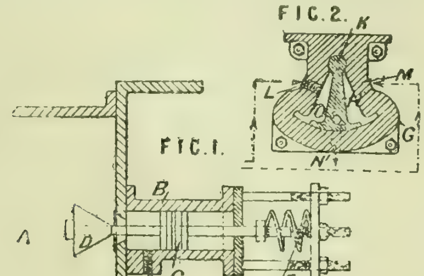
13,916. Gas Engines, C. Davy, Sheffield.

In four-stroke cycle engines the cylinder is flushed with air during the exhaust stroke. The drawing shows a twin engine with an air pump D between the two cylinders A. Lateral ports *d* with bell mouths are formed in the pistons B to admit air from the ports *c* throughout the exhaust strokes. The pump flushes each cylinder alternately. In single engines the pump piston makes one stroke to two of the motor piston. The air may be admitted in the back end of the cylinder and guided to impinge against the piston. The charge of gas and air is admitted through a perforated cap so as to thoroughly mix it with the scavenging charge of air. For governing, stepped tappets controlled by a governor actuate the gas valve or gas and air valves. The gas tappet is formed so that it will miss the valve stem after it has passed the point for admitting the minimum quantity of gas to form a combustible mixture.—October 13, 1887. [8½d.]



13,972. Railway Brakes, J. T. Hewitt, Southampton.

Relates to apparatus for use either as a simple or automatic fluid pressure brake, and consists in an improved construction of the auxiliary reservoir (by which air can be stored in it up to but not beyond a certain fixed pressure) and of the distributing valve. Fig. 1 shows a section of the front part of the reservoir A, on the cover of which is fixed a cylinder B fitted with a piston C. On one end of the piston rod is fixed a plug valve D controlling the inlet passage to the reservoir, and to the other end is attached an adjustable spring E, which keeps the valve D normally open. The train pipe is attached to the cylinder at F, and air can pass into the reservoir so long as the pressure on the piston C does not overcome the spring E; but if this should take place, the valve D will be closed by the motion of the piston, and no more air can enter the reservoir. Fig. 2 shows a section of the distributing valve, which consists of a segmental casting G, having a hollow in which works a valve H pivoted at K. The train pipe is attached at L and a pipe from the auxiliary reservoir is attached at M. So long as the pressures in these two pipes are equal, the valve H will remain in its normal central position, and a hole N in the casting open to the atmosphere will coincide with a hole O in the valve, which hole will also coincide with an opening in the back of the casting, at which point the pipe from the brake cylinder is attached. The brake cylinder will thus be open to the atmosphere and the brakes will be off. If now the train pipe pressure be increased, the valve D (fig 1) will be closed, and the pressure at M (fig ?) will remain constant, while the increased pressure on the other side of the valve H will move the latter so as to close the atmospheric opening N and allow the air from the train pipe to enter the brake cylinder and apply the brakes. A reduction instead of an increase of pressure in the train pipe would cause the valve H to move in the opposite direction and allow the air from the reservoir to enter the brake cylinder. A similar effect will be produced if the train pipe should break at any point.—October 14, 1887. [8½d.]



13,973. Safes and Strong Rooms, Sir G. H. and H. W. Chubb, London, W. H. Chalk, East Dulwich, and G. G. Exton, Binfield Road, Clapham.

Methods of forming the edges and other joints in safes and strong rooms. In fig. 3 a bar A is shown for forming an edge. The panels B, B are inserted into grooves and secured by wedges C, C, which may be held in place by hammering over the edges of the grooves, as shown, or by other means. The panels may be secured by rivets or screw pins, and their edges may be bent to adapt them to bars of different sections. Two panels may be joined in the same plane by bars or plates of H-shaped or other sections, to which they are attached by wedges, rivets, &c. Fig. 19 illustrates one form of this joint. The plates B, B are secured to the bar A by a screw pin G and cover-plate or washer F. The edges of the safe, &c., may be made of curved plates joined to the side panels by joints, such as that described, special forgings or castings being used to form the corners.—October 14, 1887. [11½d.]

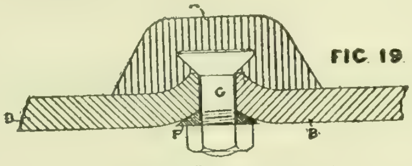


FIG 19

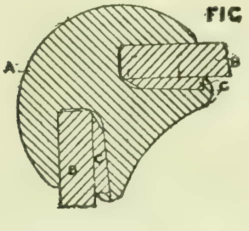
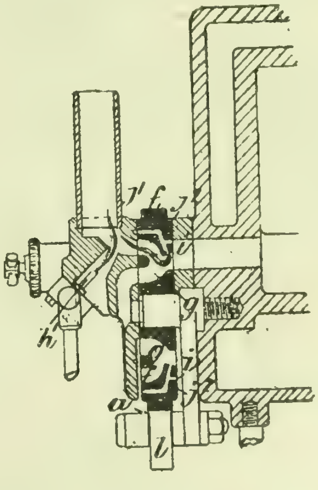


FIG 3

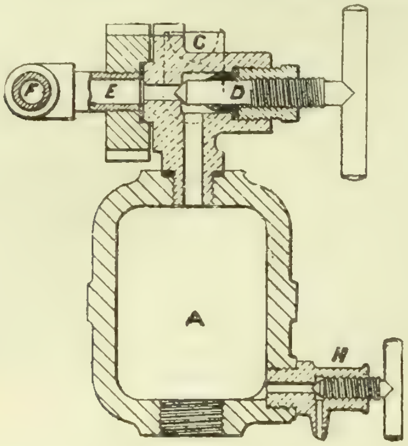
14,027. Gas Engines, T. B. Barker, Birmingham.

Improvement on the igniting arrangement described in Specification No. 1,388, A.D. 1881. The igniting valve *a* is of the intermittent rotary disc type; teeth are cut on its periphery, and it is actuated by a leather-faced pawl *l*, there are as many igniting cavities in the valve as teeth. The jets j^2 in the valve are supplied with gas from the passage j^1 in the cover. The gas is ignited by the flame h^1 and burns in the cavity *f*, air being supplied through *g*. Just before the cavity in the valve opens to the cylinder the jet j^2 is fed from the cylinder through the passage *i*. To allow of the residuum being expelled from the cavity in the valve, the latter is not quite closed to the cylinder until the charging commences. When the speed is excessive and the governor by controlling a cam prevents the latter from opening through a lever the gas supply valve, it also prevents a cam on the said lever from disengaging the pawl *l* and permitting it to actuate the igniting disc.—October 15, 1887. [8½d.]



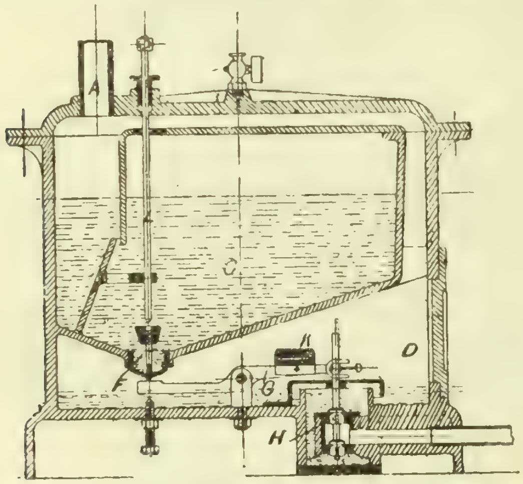
14,073. Lubricators for Hydraulic Machinery, J. S. Stevens, and C. J. Major, Battersea, Surrey.

The oil is contained in the reservoir A provided with filling aperture C, closed by a valve, and with a drain cock H. From the pipe F leading to the apparatus to be lubricated is a branch E communicating with the oil vessel and provided with a valve D. The water in the pipe E flows down to the bottom of the vessel A, and the oil, which is of less specific gravity, rises and passes into the pipe F. In the case of a hydraulic lift, which is only used at intervals, the apparatus is somewhat modified. The valve D is nearly closed, so that the oil cannot rise through it rapidly, as in the former case; as soon, however, as the water pressure is turned on the water enters the chamber A and expands it slightly, and when the pressure is removed the chamber contracts again and a small quantity of oil passes into the pipe E. The elasticity of the chamber A can be increased by making it of corrugated metal, or connecting with a chamber containing air, &c., or fitted with a spring piston.—October 17, 1887. [8½d.]



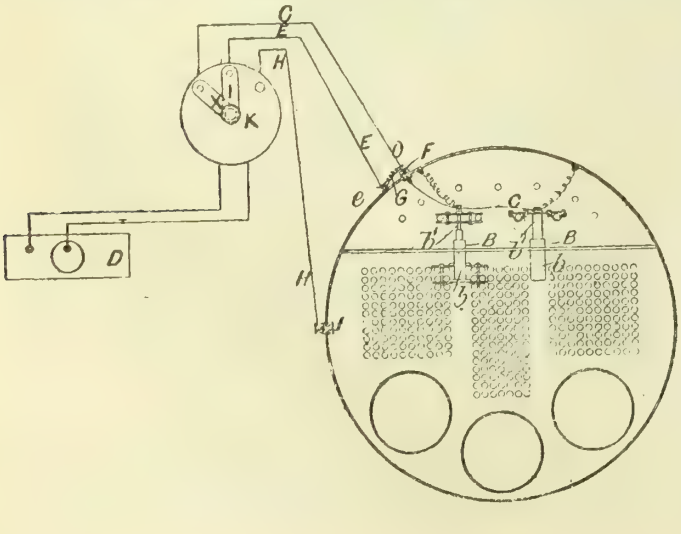
14,197. Steam Trap, H. Woffindin, Leeds.

The water to be discharged collects in a pocket in the outer casing, at the bottom of which is a valve on the end of a lever the other end of which carries the discharge valve in the outer casing, and which is held closed by steam pressure assisted by a weight until the column of water in the said pocket is sufficient to open the pocket valve and at the same time the discharge valve in the main casing. A section of one is shown. The water enters by a pipe A and falls into the pocket C at the bottom of which is a valve F on the end of the lever G. This lever carries at its other end a valve H, which in this case is an equilibrium valve. A weight K keeps the valves closed until a sufficient quantity of water has collected in the pocket. In place of having the valve F movable, the receiver C may be supported on one end of the lever G, the valve being fixed. A spindle L to open the valve by hand is provided.—October 19, 1887. [8½d.]



14,209. Electrically Preventing Corrosion and Incrustation in Steam Boilers, W. H. Rusden, Cardiff.

A current is passed from electrodes under water to the boiler shell by a battery or by the difference of potential between the metals in the water. The electrodes B, B, in the drawing, are of zinc b, b under water, and of copper b^1, b^1 above, and are connected to the positive poles of a battery D by a wire C passing through an insulator F in the shell. The negative pole of the battery is connected by a wire E to a terminal e fixed to the shell. When no battery is employed the terminals e, F are connected by a wire G. To remove oxidation from the electrodes they are disconnected from the battery, the positive pole of which is then connected by a wire H to a terminal I, passing into the water through an insulator in the shell.—October 19, 1887. [6½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq. *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

February 14th.

2587 Pistons, C. T. Davenport and E. J. Horsley, Manchester.
2598 Projectile, J. M. Fletcher, Cheadle.
2599 Gas Regulators, W. F. Fletcher, Birmingham.*
2603 Centrifugal Pumps, W. Beaumont, London.
2614 Electric Meters, J. Oulton and J. Edmondson, Halifax.
2625 Milling Cutters, C. J. Reynolds, London.
2631 Rotary Printing Machines, J. Michaud, London.
2633 Lock Nut, J. W. Smallman, London.
2637 Petroleum and Gas Engines, A. Miller, London.*
2640 Springs, I. A. Timmis, London.
2642 Dynamo-electric Machines, G. Forbes, London.
2649 Gas Engine and Generator, C. F. L. Gardie, London.
2663 Cold-air Machine, J. Bustin, London.

February 15th.

2685 Governors, A. G. Brown, London.*
2707 Cable Haulage, W. E. Winby and W. M. Winby, London.

February 16th.

2757 Gate Valves, J. Dewrance, London. (R. N. Pratt, United States.)
2762 Starting Engines, B. Smith, London.
2764 Valves, J. S. Walker, T. A. Walker, and E. R. Walker, Liverpool.
2765 Couplings, R. B. Seddon and J. Heaton, Liverpool.
2769 Steam Engines, C. Wells, London.
2772 Pistons, W. G. Kent and H. S. Price, London.
2775 Pulleys and Wheels, E. Edwards, London. (L. A. Burot, France.)
2777 Lifeboats, J. F. Green, London.
2779 Safety Lamps, J. Thorne, London.
2784 Guns, T. Perkes, London.
2787 Fire-arms, B. Willcox, London. (E. Couturier, France.)
2788 Valves, B. Willcox, London. (C. E. G. Sundstedt, Sweden, and C. J. F M. Lillichöök, United States.)
2791 Belt Pulleys, J. A. J. Shultz and B. C. Alvord, London.*
2793 Smoke Consumer, G. W. Merrett and W. Worthington, Middlesex.

February 18th.

2798 Mixing Concrete, J. Stansfield, Manchester.
2804 Torpedoes, D. Taylor, Chatham.
2810 Feed Heaters, H. MacColl, Glasgow.
2813 Lubricating Machinery, C. H. Ridsdale and A. Jones, Yorkshire.
2815 Differential Motion, W. E. Marchington, Manchester.
2816 Shuttles, J. E. Camm, London.
2818 Metallic Packing, W. Roadhouse, Sheffield.
2822 Tools, R. H. Brandon, Paris.*
2835 Carding Engines, J. Edge, Manchester.
2837 Centrifugal Separators, C. Baron, London.
2842 Augers, P. H. Bettle, London.

February 19th.

2873 Driving Straps, W. Oliver, Manchester.
2881 Friction Clutch, J. Anderson, Newcastle-on-Tyne.*
2885 Charging Secondary Batteries, R. H. C. Nevile, Grantham.
2887 Waste Heat, D. A. Cormack, Portobello.
2888 Road Engines, J. H. Roberts and R. R. Doan, London.*
2889 Steam Boilers, D. McQueen, Glasgow.
2897 Starting Gear, W. B. Thompson, Dundee.
2898 Plating, W. B. Thompson, Dundee.
2907 Hydraulic Lifts, G. Pinker, London.
2909 Shuttle Relief-motion, J. Nightingale and F. Blackburn, London.
2913 Steam Generators, W. Chambers, London.
2914 Gas, J. D. Averell, London.*
2918 Covering Steam Boilers, C. C. Gilman, London.
2933 Rolling Seamless Tubes, W. P. Thompson, Liverpool. (C. Kellogg United States.)
2943 Dynamo-electric Machines, S. D. Williams, Newport.
2948 Steam Engines, H. H. Lake, London. (F. H. Lafarge and H. J. Parker United States.)*
2950 Heating Water, H. H. Lake, London. (R. P. Barnstead, R. H. Spalding, and J. C. Bullard, United States.)
2967 Wheels, W. H. Melaney, London.*
2971 Locomotive Engines, A. Beöthy, London.*

February 20th.

2986 Steel Castings, T. Middleton, jun., Sheffield.
2989 Bending Metal Plates, R. Baird, Glasgow.
2991 Cut-off Gear, A. E. Teague, Birmingham.
2999 Steam Boiler, J. Bielenberg, Glasgow.*
3001 Screw, J. J. Gilbert, Peterborough.
3006 Valves, Elisa de Vries and H. Willem van Raden, London.
3023 Silk Waste, G. F. Priestley, Halifax.
3028 Safety Lamp, S. A. Johnson, London.
3030 Propelling Tramway Cars, F. H. Lloyd, Middlesex.

February 21st.

3063 Cup-and-ball Gas Joints, J. W. Thompson and J. Kirby, Stepney.
3068 Firing Retorts, A. McDougall, Manchester.
3077 Steel Sawing Machines, J. Hill and I. Hill, Derby.
3088 Joints of Stoneware Pipes, W. Assiter, London.*

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10, can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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TO OUR READERS.

During the interval which has elapsed since the enlargement of "THE PRACTICAL ENGINEER" *we have received so many letters from subscribers complimenting us upon the improvement in the Journal, that to acknowledge each separately in our columns would not only occupy much valuable space, but would probably become wearisome to our readers. We must content ourselves, therefore, with a general acknowledgment and thanks for these communications, with an assurance to our readers that we shall do all in our power to attain the highest possible standard of excellence.*

THE

PRACTICAL ENGINEER,

MARCH 15TH, 1889.

CYLINDER CONDENSATION.

THE precise explanation of all the causes which act in steam-engine cylinders and produce by their combination the percentage of water commonly observed in practice is an exceedingly difficult matter, and accordingly both practical engineers and authorities upon thermo-dynamics differ among themselves in the theories held to account satisfactorily for the phenomena.

Our contemporary the *Engineer* has paid a great deal of attention to the subject, and has zealously discussed it many times. We fear, however, that the zeal and energy of its articles somewhat exceed the exact knowledge. Indeed, in our opinion, writing of the kind indulged in is calculated to provoke derision from those who have seriously considered the matter. In an article upon "Theories of Cylinder Condensation," in last week's issue, inaccuracy in reasoning and imperfect understanding of the nature and behaviour of steam are more than usually manifest. The climax of absurdity, however, is reached in a theory propounded as accounting for condensation during the admission part of the stroke. According to the *Engineer*, when steam is admitted at boiler pressure and follows the piston at full pressure, some must be liquefied in the cylinder because of the work done by the steam previous to cut-off and expansion. Now, this hypothesis proves an entire misunderstanding of the nature of the liquefaction, or, in the case of gases, of cooling due to expansion. We now propose to state shortly the present knowledge of the well-determined laws which govern such adiabatic cooling, and to point out where the *Engineer* falls into error.

When air is compressed it becomes heated to a degree depending upon the intensity of the compression. Take the case of an ordinary air-compressing cylinder pumping into a reservoir, and suppose air taken into it at atmospheric temperature and pressure, and compressed on the return stroke. First consider that portion of the stroke from the commencement of compression to the point where the pressure rises to equal that within the reservoir. At this point a very small further movement of the piston causes the discharge valves to lift. Up to this point the pressure increases with considerable rapidity, and if there are no losses due to cylinder cooling, the pressure and temperature invariably rise on the curve known as the adiabatic. In actual compressors this line is never attained, but the indicator curves show a close approximation, especially when working at considerable piston speeds. The whole indicated work performed by the piston upon the air, previous to opening the discharge valves, is done upon the weight of air contained in the cylinder alone. The heat equivalent to the work done upon it is, therefore, accumulated in that air.

When the discharge valves open the case changes entirely, and the work done by the piston is done not only upon the air contained within the cylinder, but upon that air to which is added the whole volume within the reservoir. The temperature of the air when entering the reservoir is, therefore, but little increased, although the work done in that part of the stroke may far exceed that done in the earlier part. In the converse case, where air is admitted from a reservoir to a cylinder, and does work upon the piston, the cooling due to the work done does not occur in the cylinder alone, but is distributed throughout the whole contents of the reservoir; that is, the work done in the cylinder during the admission is not performed by the air actually within the cylinder, but is due to the expansion of the total volume of air contained in the reservoir and the cylinder. The fall of temperature during the admission part of the stroke, while the reservoir remains open, is exceedingly small, and can be reduced to any given amount by sufficiently increasing the reservoir capacity. In the case of a reservoir of practically infinite capacity, or in the case where a compressing pump is supplying it with air as fast as it is taken away, there is no fall of temperature whatever. Whenever the inlet valve closes and the supply to the cylinder is cut off, the work is done upon the piston by the air contained in the cylinder alone, and consequently the temperature falls rapidly.

In the case of a steam boiler the volume of steam taken away by every stroke of the engine is so nearly balanced by the volume generated within the boiler that no appreciable variation of pressure is occasioned by the successive strokes. In such a case there is no fall whatever of temperature in the steam entering the cylinder and performing work upon the piston during the admission part of the stroke. The work performed previous to cut-off is not really done by the steam in the cylinder, but is done by the steam generated in the boiler. Wherever no fall of pressure is occasioned by the successive strokes of the engine, the steam within the boiler, the steam pipes, and the cylinder acts merely as a cushion, or indeed an incompressible fluid, and the real work is done at the surfaces of steam evolution. This is equivalent to the case of the air reservoir where a pump supplies as fast as the air is withdrawn to do work. Here the work done in the cylinder is not done by the air within it, but by the piston of the pump, and the intermediate air merely acts as a transmitter in the same manner as water or any other incompressible liquid. When pressure varies within the cylinder during admission, there is, of course, work done by the heat of the air or steam within it to the extent of the variation in pressure. When the supply of air or steam is cut off, and the work done in the cylinder is entirely performed by the fluid within it, then, and then only, does the fluid lose heat equivalent to the total work upon the piston. It therefore follows that in a well-constructed engine there can be no condensation whatever due to work performed during admission. Any absorption of heat occurs within the boiler, and no absorption of heat occurs within the cylinder unless the pressure falls. From this it follows that condensation during admission is due to cooling by the cylinder walls, and to nothing else, and if the steam cylinder and piston were throughout heated to a temperature equal to that of the entering steam, there would be no initial condensation; but after the point of cut-off, when the whole work upon the piston is due to the heat contained in the steam within the cylinder, it is impossible to avoid condensation and fall in temperature, even if it were desirable that it should be done. It is not, however, desirable to prevent fall in temperature during expansion, as an engine working with an isothermal expansion line could not give economy equal to present results.

Our contemporary is completely wrong in the illustration given of the existing state of knowledge of the actions proceeding within a boiler. In the case he gives of a cylinder containing little water, the piston loaded with a heavy weight, he supposes condensation necessary for the performance of work by the steam generated from this water by heat. If the cylinders and piston were as hot as the steam, there would be no condensation whatever under the circumstances supposed. Steam is more difficult to deal with and less easy to understand than a permanent gas; but in the articles referred to the difficulties are much exaggerated. No doubt the problem is a very difficult one, but it is by no means so ill understood as is there supposed, and much good work is now being accomplished which will in time greatly elucidate the few remaining difficulties.

There are other points of error in the *Engineer's* understanding in this and similar matters, into which we can enter if occasion arises. We would only protest against the acceptance of writing of the character to which we have referred as in any way representing the opinions of educated practical engineers.

THE BASIC STEEL PROCESS.

Mr. T. Turner has delivered the fourth of a series of lectures on steel in the Chemistry Lecture Theatre of Mason College. The subject of this lecture was "The Basic Process of Steel Manufacture." He said it had been observed, even before the Bessemer process became a recognised success, that only irons of special chemical purity could be used, since the whole of the phosphorus originally present in the cast iron remained in steel, and hence the steel made from phosphoric irons was worthless. The Siemens process also laboured under the same disadvantage, and hence up till about ten years ago only a limited quantity of the world's production of pig iron was suitable for conversion into steel. Numerous attempts had been made to overcome this difficulty, the more successful being those of Heaton, who used nitrates of soda or potash; Henderson, who employed fluorides; and Bell, who used oxide of iron. It thus became recognised that the prime necessity was the use of a non-silicious (or basic) lining and slag, since, when more than a certain proportion of silica is present in the slag, the phosphorus, which should be oxidised and combine with the slag, is expelled by the silica, and hence passes back again, and is retained by the iron. The difficulty, therefore, that encumbered metallurgists of about fifteen years ago was to find a practicable method of applying a recognised scientific principle. The first to indicate the proper line of action was Snelus, who patented the use of hard-burned lime for furnace-linings. Snelus was not himself successful, however, and the real credit of the practical solution is due to Thomas and Gilchrist, who brought before the world what is now known as the basic process in 1879, at the May meeting of the Iron and Steel Institute. This method of working can be applied either to the Bessemer converter or to the Siemens furnace, the essential difference being not in the form of furnace or general method of working, but in the use of a basic lining, made from burnt dolonite, a variety of limestone containing magnesium. Suitable additions of lime are made during the working of the charge, and the metal requires longer time, so that the phosphorus, which remains usually longest in the crude iron, may be removed. By means of the basic process a specially soft or mild steel is produced, which possesses many of the properties of the best wrought iron. There is now, after ten years' experience, no doubt as to the complete success of the Thomas-Gilchrist method; and in 1888 no less than 1,953,200 tons of steel were produced in this way. Of this large total, about three-quarters, or 1,493,000 tons, was of the mild variety. The Germans have hitherto reaped the greatest benefit from this invention, since in 1888 Germany, with Luxemburg and Austria, produced no less than 1,276,000 tons, as compared with only 408,500 tons in Great Britain. It is very remarkable that with two of the greatest inventions in modern times in the iron and steel trade—viz., the Bessemer and the basic process—the inventions originated in this country, while other nations have reaped the greatest benefit, for America now stands well ahead in Bessemer steel production, and Great Britain makes a very poor second in the basic process. With a very few exceptions, South Staffordshire and the adjoining counties have been very slow in taking up the modern improvements in steel-making, and while a number of manufacturers are avowedly waiting to see the results of the experiments of some of their more enterprising immediate neighbours before themselves running any risk, and while others have been at the expense of costly experiments conducted by inexperienced persons, the trade is getting well and firmly established in other hands. The lecturer then gave a detailed account of the method of working adopted with both a Bessemer and a Siemens plant, giving analyses of the metal used and of steel obtained.

ROLLER FLOUR MILLING.

A PAPER by Mr. Henry Simon, of Manchester, was recently read before the Institution of Mechanical Engineers on "The Latest Development of Roller Flour Milling," in which it was stated that the completeness of the revolution that had taken place was exemplified by the fact that in about ten years the machinery and methods of corn milling had been entirely altered, at the cost of an immense amount of capital. The old historic millstone had been replaced by machinery designed on scientific principles, and of superior mechanical construction and design. This change had called forth a new class of milling engineers with the special qualifications alluded to, as early as 1878, by Professor Kick, recognised as the leading continental authority upon milling. A further striking difference between the present and the old style of milling flour was that, whereas formerly the intermediate products had to be repeatedly handled, they were now entirely treated without being touched by hand throughout the process. The wheat entered the mill at one end and went through all the mills automatically until it was delivered at the other end in the shape of such different grades of flour and offals as it might be desired to produce. Automatic action in roller milling had been attained almost simultaneously in the United States and in this country. In Austria-Hungary, formerly the leading school for milling, automatic action was not yet believed in, and accordingly a very large number of mill attendants were still required there.

The first complete roller mill acting without the use of stones in England was built by the author, in 1878, for Mr. Arthur McDougall, of Manchester, and the first automatic roller flour mill in England in 1881, for Messrs. F. A. Frost and Sons, of Chester. The total number of complete mills or important reconstructions of old mills executed by the author alone, since 1878, amounted to considerably over 200, varying in cost for machinery, exclusive of motive power, buildings, &c., from £1,000 to £40,000 for each mill.

The most recent improvements in roller milling would be best described (the writer thought) from a description of the machinery and arrangement of a large mill which was at present being erected in Brazil for the Rio de Janeiro Flour Mill Company, of London. The site of the mill was on the shore of the Bay of Rio de Janeiro, and within easy access of the city, and in order that the largest sea-going vessels might be able at all times to discharge their grain, an iron jetty was constructed, projecting 125ft. from the wharf's edge. The mill consisted of two buildings, each 234ft. long and 46ft. wide, with five floors of an average height of 13½ft. One was the store, while the other was the mill proper. The motive power consisted of two engines of the horizontal compound tandem type, with cylinders respectively of 19in. and 35in. diameter, and a stroke of 48in., making 70 revolutions per minute. The indicated horse power was 800, and the guaranteed coal consumption was 2½lb. per horse power per hour. The power was transmitted through one crank shaft to a rope pulley 20ft. in diameter, grooved for twenty 1¾in. ropes. Steam was supplied by four Lancashire steel boilers, 7ft. diameter and 30ft. long, the two flues being each 2ft. 9in. diameter, and fitted with nine Galloway tubes.

Storage of Grain.—There was a tower at the end of the jetty, which contained a wheat elevator capable of lifting 65 tons per hour. The lifted wheat was delivered to the wheat-cleaning house upon an endless indiarubber band, also utilised to transmit the power necessary for lifting the grain. On entering the wheat-cleaning house the grain passed first through a self-acting weigher, and thence through three combined rotary separators and aspirators consisting of rotary sieves, with a powerful exhaust fan for removing all impurities both larger and smaller than the wheat. To meet special requirements in the present instance, two distinct modes of storing the grain had been provided, viz., on floors and in silos. This granary had sufficient capacity for the storage of about 5,000 tons of wheat.

Final Wheat-cleaning Machinery.—The wheat was next carried from the store by a band, and was first run again through an automatic self-registering weighing machine; after which it passed through four cylindrical reels provided with covers composed of steel wires. The cylinders sorted the wheat into three distinct sizes, which throughout the remaining cleaning process were treated separately. Each size then passed to a "dustless wheat separator," containing rapidly-vibrating riddles and fan aspirators, by which the loose dust, chaff, oats, &c., were removed. The next machines were those for lifting out all seeds, &c., smaller than the wheat, and from these the wheat travelled to three machines called "scourers" or "smutters," consisting of vertical stationary cylinders of steel, with diagonal perforations, inside of which ran rapidly-revolving shafts, carrying beaters composed of iron rods; the beaters scoured the grain in its passage down through the cylinder, breaking and removing smut balls, loose bran, &c., which were then drawn away through the casing by an exhaust fan. The scouring was followed by a brushing process, which was performed by three machines, each containing four pairs of horizontal circular brushes on a vertical spindle. The upper brush of each pair was stationary, but the lower revolved rapidly, so that by centrifugal action the grain passed from the centre of the machine to the circumference of the first pair of brushes, and thence by gravity to each of the lower pairs in turn. The effect of the brushes was further to remove loose bran, dust, &c. After passing through a final automatic weighing machine, whereby the amount of loss in the cleaning process was registered, the wheat was elevated into the cleaned wheat bins, where it was stored in readiness for the roller milling process.

Roller Mill Machinery.—Roller mills, which had replaced grinding stones, were of two kinds, used for two distinct purposes, namely, break mills, with flued rolls for extracting the kernel of wheat from the bran; and reduction mills, with smooth rolls for reducing to flour the broken kernel which constituted the middlings and semolina. In the Rio mill, four-roller mills were used for the breaks, and three high roller mills for the reductions; in both cases the rolls are made of the hardest chilled iron.

Four-roller Mill.—A four-roller break mill, with fluted rolls for breaking the kernel of the wheat, was described. The two pairs of rolls were entirely independent of each other, and could be used for grinding two distinct qualities of materials if required. The rollers were fed by a feed roller, and the feed was controlled by a regulator adjusted by hand and an automatic feed plate balanced by a spring. The top grinding roll, which ran at a higher speed, revolved in fixed bearings, and the slow-running lower rolls in bearings carried in adjustable levers. The rolls could be thrown apart by means of a combined lever and eccentric, with which was connected a link arrangement whereby a clutch on the feed roller was thrown out of gear, and thus the flow of material was stopped. The surfaces of the rolls were kept clean by scrapers. Power was transmitted by belt to the upper roll of each pair, and the correct differential speed of the lower roll was maintained by double helical toothed wheels running in oil-tight casing.

Three-high Roller Mill.—The three-high roller mill had smooth rolls, for reducing the broken grain to flour. The centre roll ran in fixed bearings, and the upper and lower rolls were carried in adjustable levers. Two distinct materials could also be treated in this machine. The principal advantages of the three-high roller mill were that the downward grinding pressure on the centre roll was counteracted by an equal upward pressure, so that the friction due to pressure was eliminated in the bearings of the centre roll; there were thus only four bearings under pressure, as against eight in the four-roller mill. Furthermore, the three-high roller mill occupied but little floor space.

Purifier.—The purifying apparatus used was a matter of vital importance in modern milling, for by its application a perfect purification of all middlings, from flour to the coarsest semolina, was possible without waste. The apparatus consisted of a combination of oscillating sieves having silk meshes. By the oscillation of the sieve the unsound middlings deposited were carried into one main central trough, which delivered them at the tail end of the machine. The stive and branning particles were continually removed from the filter cloth by the action of a strong blast discharged from fans, supplemented by suitable heating apparatus.

Centrifugal Dressing Machine.—Centrifugal machines had almost entirely replaced the large and cumbersome reels which not many years ago were the only machines at the miller's disposal for separating the flour from the other product. The material to be dressed was fed by a worm conveyer into the interior of the dressing cylinder. The flour which passed through the silk or wire clothing of the cylinder was collected by a worm underneath; while material too coarse to pass through the clothing was discharged from the end of the cylinder through a spout.

Milling Process.—From the clean wheat bins the grain is elevated to rotary graders, which sorted it into three sizes. Each sort passed between fluted rolls, set with great nicety so as to break every individual wheat grain as near as possible along its crease. The broken grain was then lifted with centrifugal dressers, which cleansed it from the dirt released from the crease or rubbed from the surface. The broken wheat was next passed to other roller mills, which further opened out the berry and extracted the kernel, until the bran was clean. From the break mills the kernels were sent through the smooth roller mills, and thus reduced to flour.

The flour went to the flour packing machinery; but the middlings and tailings from the dressing machines were first separated and purified by dusting reels and purifiers, until the separation of the flour from the offals was complete. The flour from each of the dressing machines was delivered at will into any one of the four main flour conveyers, which ran from end to end of the mill. This arrangement enabled the miller to combine the different kinds of flour into any number of quantities desired. From the mill the flour was conveyed across the yard by bands to the flour store, where it was packed into barrels or sacks by mechanical packers. The flour store had a capacity of 30,000 sacks of flour, and, besides the packing and weighing machinery, contained three double friction hoists, for raising the flour for storage in the upper floors, and for loading it into carts.

Dust Collector.—For the purpose of collecting the dust with which the air in flour mills was laden, a contrivance had recently been invented in the United States. This machine, called the "Cyclone" dust collector, consisted of a plain inverted conical chamber of sheet iron, and the dust-laden air, collected as usual by an exhaust fan and propelled through a wind trunk, entered the collector through an inlet spout. By the action of the air current, and by centrifugal force, the particles of dust kept close to the conical surface, and were swept round and round, gradually reaching an opening at the bottom, where they passed out, and were collected. The volume of purified air, finding itself confined as it worked down the cone, turned upward in the centre and escaped through a central tube at the top of the apparatus.

The process was so simple and effective, that without actually seeing the machine at work it was difficult to credit the result.

BIRMINGHAM ELECTRICAL AND INDUSTRIAL EXHIBITION.

According to the *Birmingham Daily Post* preliminary arrangements for the electrical and industrial exhibition which is to be held in Bingley Hall, Birmingham, in August, September, and October, are making satisfactory progress. Exhibitions of magnitude have become almost over common of late years, but they still meet with public approval; and the crowds of people who visit them clearly indicate that they must be a source of interest and instruction to all classes.

An electrical exhibition is, however, a novelty—at least, in the Midlands—and the one with which Birmingham is to be favoured in the summer and early autumn should prove a success. The important discoveries which are continually made by scientists respecting the uses to which electricity may be applied are of absorbing interest from the scientific point of view, while their interest for Birmingham, where much of the apparatus connected with its use is manufactured, is of a very practical kind. But the exhibition will not have to rely wholly upon the novelty of the electrical department for its success.

This branch will naturally be the main feature, but there is also to be a large industrial section. In the electrical department it is proposed to work all the exhibits by means of dynamos and various forms of electric motor. Fully two-thirds of the hall will be occupied by the industrial exhibits, and notwithstanding that the time for the opening of the exhibition is so far distant, and the fact that notice was only given the other week that application would be received, Mr. T. C. Sharp, of County Chambers, Corporation Street, the manager to the Executive Committee, has already received applications from fifty or sixty firms, and about a fourth of the whole space has been secured.

The most celebrated electrical firms in the country will be exhibitors, and among those who have thus early signified their intention of being represented are Messrs. Woodhouse and Rawson, the Acme Electric Lighting Company, Julius Sax, and other eminent London and provincial firms. Allotments of space will be made in about a month from now; but as some time has yet to elapse before the period of receiving applications for space is brought to a close, no anxiety need be felt in consequence of the whole of the room at the disposal of the committee not being early acquired, inasmuch as many firms prefer to wait until the last moment before sending in their applications.

The committee have very wisely decided that the lighting and transmission of power for the use of the hall shall be distributed among twelve of the exhibitors, and it is also arranged that medals or other prizes shall be awarded to the exhibitors generally for the best system of electric lighting. The work of adjudicating upon the merits of these interesting and perhaps complex systems will be exceedingly onerous, but the gentlemen secured as judges are of the highest eminence in the electrical world. Among them may be mentioned Sir William Thomson, Sir H. Roscoe, M.P., Sir David Salomons, and Professor Sylvanus P. Thompson. The electrical section will be divided into three departments, namely, lighting and transmission of power; secondly, dynamos, lamps, motors, electroliers; and, thirdly, telegraph and telephone apparatus, phonographs, electric bells, and various kinds of electric machinery. The industrial section of the exhibition will afford an opportunity for the display of the local trades, and arts and music will also have a place.

It is hoped that Mr. Edison will visit the exhibition on his way to Paris, but he has not definitely promised to do so. He has kindly consented to forward one of his phonographs, and this will be one of the curiosities of the exhibition.

The committee also propose to engage the gymnasium, and fit it up as a winter garden. Concerts at which popular vocalists are to appear will be arranged, organ recitals are to be given, and an orchestral band will be engaged for the season. The entertainments will be agreeably varied as time goes on, and everything is to be carried out on popular lines.

It may occur to some people to ask what pecuniary object it is desired to accomplish by means of the exhibition. It is, therefore, just as well to state that, while the exhibition may be a success from an artistic point of view, the profits will be devoted to the funds of the three principal charitable institutions—the General, the Queen's, and the Jaffray Hospitals. One may well hope that the financial aspect of the exhibition will be as successful as the more practical side, and that the three institutions named will receive a very substantial addition to their income. In the long and influential list of patrons of the exhibition will be found the names of the Marquis of Salisbury, the Lord Mayor of London, Mr. Edison, the nobility, gentry, and members of Parliament of Birmingham and the surrounding district; Sir David Salomons, Sir Frederick Abel, Sir Henry Roscoe, Sir William Thomson, Professors Hughes, Adams, Ayrton, Sylvanus P. Thompson, George Forbes, and J. Perry, Dr. Fleming, &c. The exhibition will remain open from the 1st of August to the end of October.

U.S. PNEUMATIC DYNAMITE GUN CRUISER, VESUVIUS.

A new dynamite gun cruiser has recently been built for the United States navy, of which we think a short account may be of interest to our readers. The vessel is 246ft. long, 26½ft. broad, and has a displacement of 700 tons. It is of steel, and is fitted with vertical triple-expansion twin-screw engines. The dimensions of the cylinders for each engine are: High-pressure, 21½in. diameter; intermediate, 31in. diameter; and low-pressure, 20in., with 20in. stroke. These and the auxiliary engines combined develop 4,400 horse power. Steam is supplied by four cylindrical locomotive boilers, working at 160lb. on the square inch. During her last trial a speed of 21·64 knots per hour was recorded; this was considered very successful.

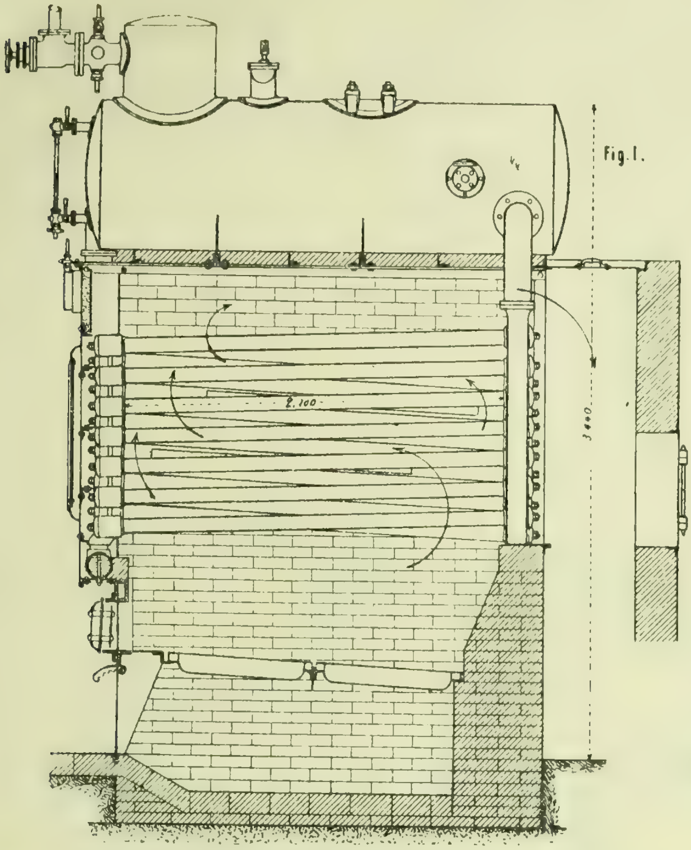
The cruiser is fitted up with pneumatic dynamite guns. These are placed side by side, and are 15in. bore, 54ft. long, and have an elevation of 18 degrees. They differ from ordinary powder guns in not being rifled, as well as many other particulars. To load the gun, its breech is swung downwards, so as to bring it in line with a revolving cylinder which contains five chambers for holding as many projectiles. By means of a hydraulic ram the projectile is pushed into the breech, which is then swung upward again.

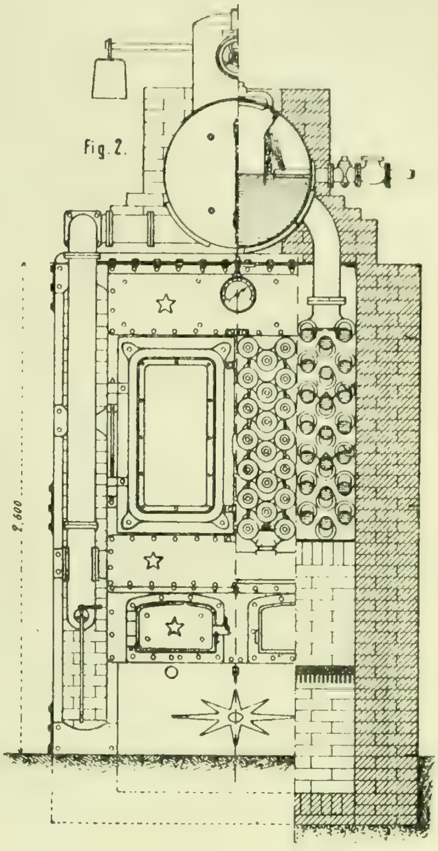
The body of each projectile is about 7ft. long, and is charged with 600 pounds of high explosive dynamite or gelatine. It is made of thin drawn brass tubing, and the total weight, when charged, is about 1,500lb. The cost of each projectile is about £180, whereas the cost of a shot for a 15in. Krupp gun is nearly double that amount.

In order to test the accuracy with which projectiles can be thrown, several official trials have been made with a 15in. pneumatic gun, using lighter projectiles than those on the Vesuvius; six out of eight projectiles thrown during the trial fell within a parallelogram 50ft. wide and 150ft. long. The average range was about 2,100 yards, average flight about 13sec., average elevation 18 degrees, and an average air pressure of about 1,000lb.

The Suez Canal.—The Suez Canal traffic is very satistorily increasing. Last year the net tonnage showed an increase of 540,000; and in the first two months of this year, though we have not a statement of the tonnage, the ships which have passed have been 60 more than in the corresponding months of last year. There are all the signs of very satisfactory financial results for the shareholders in the canal.

NEW STEAM BOILERS.





Our esteemed German contemporary, Dingler's *Polytechnic Journal*, gives an account of recent steam boilers, with illustrations, which will interest our readers. There is nothing particularly novel in many of them, but it is advisable to be familiar even with unusual and peculiar types; accordingly, we have pleasure in describing the various Continental and English forms mentioned in the articles to which we refer.

In figs. 1 and 2 we illustrate a French water-tube boiler, that of Messrs. Terme and Deharbe, designed to evaporate about 2,000lb. of water per hour at 150lb. pressure. It consists of 80 wrought-iron tubes about 3in. external diameter, $\frac{3}{16}$in. thick, and 6ft. 10in. long. Every three tubes unite to form one element, and produce, by their reverse positions, the edges of a three-sided pyramid, whose base rests on the vertical steam collector into which the tubes discharge. This is clearly shown in the detail illustrations given in figs. 3 to 7, where part is shown in section and part in elevation.

Both the upper tubes I of this arrangement incline upwards, parallel to one another, from their common case, while the lower middle tube H inclines downwards from it, and, when fitted with water and heated, a rapid circulation is caused. When steaming, the ascending steam moves in the direction shown by the arrows, figs. 3 and 4, and increases the rate of the water circulation, while the two upper tubes send their steam simultaneously in the collector J, and simultaneously the water enters the lower tube H. The steam freely rises into the vertical upper space, and upwards into the upper steam collecting chamber K through the collecting tubes. The feed water is forced into the upper steam space, fig. 2, and is made to spray against a plate depending from the shell.

The tubes and their cast malleable end cases form four precisely similar series, arranged side by side. The details of the cases are shown at fig. 8. According to our German contemporary, this boiler steams freely and is easily kept tight, while renewals are readily effected. It is also stated that it keeps clean even with bad water. The fact of the front ends of the tubes being free from attachment to the steam chamber seems to us a distinct advantage, as it allows of great freedom for expansion. The system whereby this end is attained and the water circulated from one end only is ingenious.

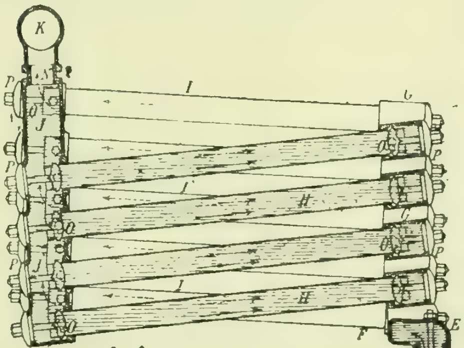


Fig 3:

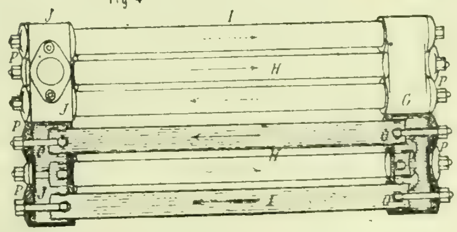
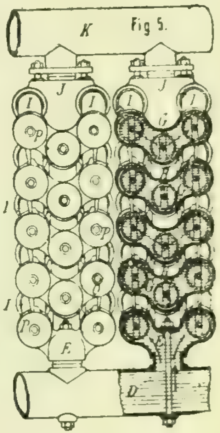


Fig 4



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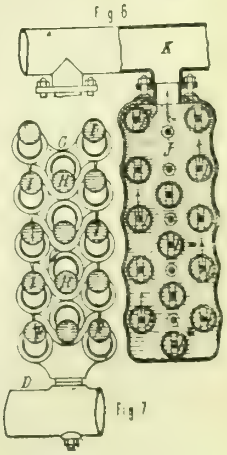
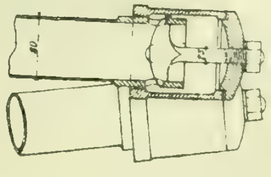


Fig 7

Fig 8



A boiler shown at work in the Vienna Jubilee Industrial Exhibition is seen at figs. 9 and 10, made by Messrs. Breitfield, Danĕck, and Co., in Prague. It is somewhat interesting. The heating surface is over 2,000 square feet; it is practically a Lancashire boiler, with Galloway tubes placed before a series of tubes. In order to keep the tubes free from ashes, dust, and soot, a steam jet blow-through arrangement is used (fig. 9) E, and for the purpose of further cleaning or getting at the tube ends the removable door K is provided. The passage B, with the automatic valve or flap B¹, is intended to carry off the ash and dust discharged from the tubes into the chamber containing the Galloway tubes; from thence it discharges into the ashpit W. A manhole and tube, to allow access to the other end of the tubes, are shown at G.

The boiler is fed from the tube A, which is also intended to serve as blow off.

We fear the arrangements are not such as would commend themselves to English engineers

(*To be continued.*)

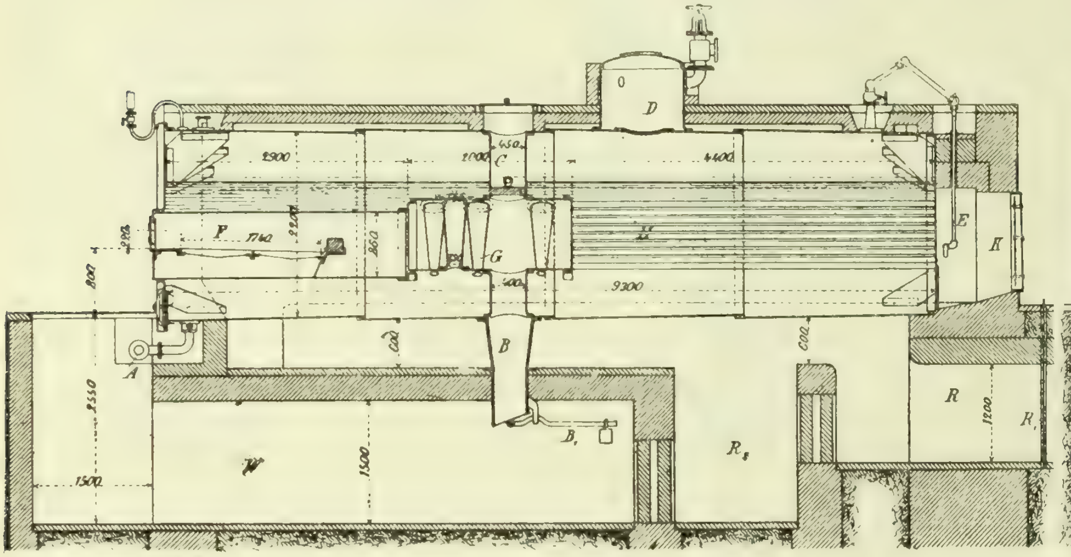


FIG. 9.

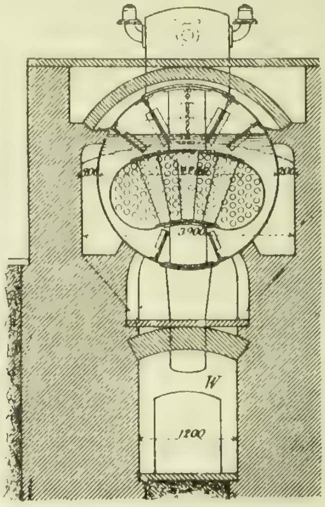


FIG. 10.

THE FIRST SHIP RAILWAY.

AT the moment when labourers are leaving the Panama Canal, and legal tribunals in Paris are wrangling over the administration of the affairs of the bankrupt company, Captain Eads' plan for connecting the two oceans seems likely to be tried in another part of the great American continent. The Chignecto Ship Railway, for which the Dominion of Canada has granted a subsidy of £35,000 per annum, payable half-yearly for twenty years, is designed to connect the Gulf of St. Lawrence with the Bay of Fundy, across the neck of land which connects Nova Scotia and New Brunswick. The conveyance of boats and their cargoes bodily overland from one waterway to another was not absolutely a novel idea when Captain Eads propounded it for the solution of the problem of interoceanic communication. Excavations in Greece have unearthed the remains of a road said to have been used by the Greeks for this purpose. Emanuel Swedenborg designed and put in operation a similar road in Sweden. In Germany vessels of 60 tons capacity have for many years past been conveyed overland from the upper to the lower part of the Elbing-Oberland Canal, and in Cornwall, as in China, barges and junks are hauled across intervening land from one canal to another. But these works can scarcely be compared to a railway on to which the great ocean-going steamers and sailing vessels of modern times, laden with cargo, are to be lifted by hydraulic power from one dock and to be drawn by locomotives to another dock 17 miles away; and therefore the Chignecto Ship Railway may be spoken of as the first of its kind. The idea of saving the tedious and often dangerous journey of 500 miles round the coast of Nova Scotia has been under consideration by the Canadian authorities since very early in the century. As far back as 1822 a survey for a canal across the isthmus was made by the New Brunswick Government, and successive schemes were subsequently presented and surveys made with the same object at frequent intervals up to recent years. The increasing demands of commerce, however, necessitated constant enlargements and other modifications in the plans for a canal, and the relatively great cost of constructing a waterway on an adequate scale, uncertainty as to its fulfilling the requirements of the day, its liability to be blocked by ice, with difficulties respecting the water supply and the consequences of the great difference in the elevation of the respective tides, have caused engineers and the Canadian Government to fall back on a ship railway as the simplest and indeed only practicable solution.

The Canadian Parliament has already passed a bill granting a charter of incorporation to a company with the subvention referred to above, and there seems to be every reason to believe that the work is about to be actually begun. According to the Government requirement, however, the weight of the vessel and cargo transported is not to exceed 2,000 tons dead weight, or vessels of 1,000 tons gross register laden. The line of the proposed railway has been set out and levelled and the woods cleared. There are to be four lines of steel rails of 110lb. weight per lineal yard. The hydraulic lifts are to be similar in construction to those in use on the Thames and at Malta and Bombay. A "gridiron," forming a portion of the actual railway when at the level of the land will be lowered into the water, a huge "cradle" running on wheels being first placed upon it. The vessel will then be floated over the cradle, and the gridiron will be again raised to its position as a portion of the line. The cradle with the ship will then be drawn across the isthmus and run on to a similar movable gridiron at the other extremity of the railway; and the lowering of this gridiron into the dock will of course float the vessel once more. The commercial advantages of the project seem to lie in its providing a short cut for coasting traffic between the United States and the ports on the gulf and river of St. Lawrence. It was pointed out by Sir Charles Tupper, for instance, that vessels will be enabled to make two voyages and carry two cargos between Boston and the St. Lawrence in the time required for one voyage by the existing means of navigation. The probable importance of the enterprise, if successfully carried out, may be inferred from the fact that the shipping entered and cleared at St. Lawrence and Bay of Fundy ports, which will be immediately affected by the construction of the railway, without including the American fishing fleet of 600 vessels, is returned as 10,182,327 tons for last year. As some of the vessels, however, probably called at more than one port, it may be assumed that the same tonnage has been counted more than once in these cases. Sir Charles Tupper gave the total as 2,687,550 tons, and estimated the probable actual traffic of the ship railway at 600,000 tons. Startling as such a scheme appears, the theoretical objections to it all seem to resolve themselves into the apprehension that a ship laden with cargo, if lifted from the water and hauled over dry land, would burst her sides. Many eminent authorities maintain, however, that there are no vibrations or jerkings, or strains of any kind which a ship could undergo to which she is not actually subjected at sea, especially in rough weather, when her sides are continually laid bare and a considerable portion of her mass is lifted bodily out of the water without any supports such as the railway cradle would afford.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

(Continued from page 165.)

The mean pressures and volumes used for calculation are given in the following table :—

	Pressure in pounds per square inch, absolute.	Volumes in cubic feet.
A	13·8	0·300
B	13·8	1·039
C	76 3	0·300
D	211·8	0·300
E	211 8	0·3505
F	44·6	1·039

It must be mentioned that the exhibitors were not able to state the precise volume of clearance in this engine as it worked during the trial. It has been taken at 40 per cent of the volume swept by the piston, which, if not exactly correct, is known to be a close approximation. The barometric pressure for the day was 14·9lb. per square inch. The temperature of the gas in the meter was 68·2 deg. F., and its pressure 1·34in. of water. The total weight of gas per explosion, corrected for these meter conditions, works out to 0·00223lb., its calorific value being 34,040 foot-pounds. Assuming, as in the former cases, that the temperature of the charge just before the beginning of compression was equal to that of the jacket discharge water, in this case 190 deg. F., the ratio of air to gas by volume works out to 9·50, and by weight to 24·2, and the total weight of the charge to 0·0561lb. The value of n for the compression is 1·380. The process was, therefore, very nearly adiabatic, only about 6 per cent of the heat of compression being carried off by the jacket water. The calculated temperature at the end of the compression is 1,064 deg. absolute. The calculated temperature at the point D is 2,950 deg. absolute, and at the point E, where it reaches its maximum value, 3,440 deg. absolute, or about 3,000 deg. F.

The value of n for the expansion process was 1·435, while for the adiabatic process it would be 1·376. The work done during expansion (above zero of pressure) amounts to 9,220 foot-pounds per explosion, while the temperature falls to 2,130 deg. absolute, which corresponds to a loss of internal energy of 10,700 foot-pounds. It appears, therefore, that combustion must have been completed before the expansion ended, and that the gas was losing, and not receiving, heat during its expansion (at least during its latter part), the expansion curve falling much more quickly than the adiabatic line.

It was found that 713·2lb. of jacket water were used per hour, and that the average amount of heat carried away per hour amounted to 89·575 thermal units, which corresponds to 14,700 foot-pounds per explosion. The calculated value of the exhaust waste is 12,100 foot-pounds per explosion, and with these figures the heat account stands thus :—

	Foot-pounds per explosion.	Percentages
Calorific value of the gas per explosion 0·00223 × 19800 × 772	34,040	100
Heat turned into work	7,515	22·1
Heat rejected in jacket water	14,700	43·2
Heat rejected in exhaust	12,100	35·5
		100·8

The heat account thus overbalances to a small extent. It has been already pointed out that an account calculated in this fashion, although it is the best that seems available, *ought* to overbalance if all the heat be accounted for, because it is inevitable that some of the heat included under exhaust waste, and here supposed to be carried into the atmosphere with the escaping gases, should be taken up by the jacket water, and therefore doubly reckoned above.

TABLE VI.—Crossley Trial, Sept. 19, 1888.

Constituents.	Proportion by volume.	Weight of one cubic foot.	Weight in one cubic foot of gas.	Proportion by weight.	Calorific value per lb. down to 100° C.	Calorific value per lb. of gas down to 100° C.	Proportional weight of O required for complete combustion of 1lb. of gas.	Weight of O required for complete combustion of 1lb. of gas.	Weight of products of combustion for 1lb. of ga .	
		At standard pressure and temperature.							Steam.	Carbonic acid.
	Per cent.	lbs.	lbs.		Thermal units.	Thermal units.		lbs.	lbs.	lbs.
CH_4	37·34	0·447	0·01669	0·528	21510	11357	4	2·112	1·188	1·452
C_2H_4, &c.	3·77	0·1410	0·00532	0·169	20100	3397	$2\frac{4}{7}$	0·579	0·217	0·531
H	50·11	0·00559	0·00282	0·089	52200	4646	8	0·712	0·801	–
CO	3·96	0 0783	0·00310	0·98	4350	426	$\frac{4}{7}$	0·056	—	0·154
N	3·98	0·0783	0·00312	0·099	—	—	—		—	
CO_2 and O	0·51	0·1060	0·00054	0·017	—	—	—	—	—	—
	100·00		0·03159	1·000		19826		3·459	2·206	2·137

Calorific value of one cubic foot = 19826 × 0·0316 = 626 thermal units.

The actual indicated work done corresponds to 7,210 foot-pounds per explosion, or 21 2 per cent of the whole heat of combustion, instead of 22·1 per cent as above. The heat rejected in the jacket water amounts to 43 2 per cent, and that rejected in the exhaust and unaccounted for to 35·6 of the whole heat of combustion. These quantities agree very closely with those corresponding to the ideal diagram. The actual heat supplied to the engine amounts to 12,120 thermal units per indicated H.P. per hour, which corresponds to the 21·2 per cent of absolute efficiency just given. The efficiency of a "perfect" engine working between the same temperatures as those calculated for this engine would be 81·1 per cent. The engine therefore reaches 26·1 per cent of this efficiency.

Trial B.—This trial lasted three hours. The engine ran at half-power (7·41 brake H.P.), at 158·8 revolutions per minute, with 41·1 explosions per minute. The mean initial pressure was practically the same as for Trial A, the mean effective pressure somewhat higher (see Table V.). The indicated H.P. was 9·73 (fig. 8), so that the mechanical efficiency of the engine was 76·2 per cent. The gas used in the cylinder per indicated H.P. per hour was 20·8 cubic feet, per brake H.P. per hour 27·34. Taking into account the gas used for ignition, these figures become 21·2 and 27·77 cubic feet respectively. The horse power expended in driving the engine amounted to 2·31. The gas consumed during this trial had a thermal value of about 119,450 thermal units per hour, the expenditure of which was, approximately, as follows :—

	Per cent.
Heat turned into work	20·9
Heat rejected in jacket water	41·1
Heat rejected in exhaust and unaccounted for (by difference)	38·0
	100·0

Trial C.—In this trial the engine was run for half an hour empty. Cards were taken every five minutes (fig. 8), and the explosions were counted throughout the whole time as before. The engine ran at 161 revolutions per minute, and made 10·2 explosions per minute. The mean effective pressure was 66·7, and the indicated H.P. 2·19. Gas was used at the rate of 23·8 cubic feet per indicated H.P. per hour. In this trial the work done corresponds to 19·4 per cent of the heat of combustion of the gas used.

Trial D.—The Otto engine was fitted, as has been already stated, with a high-speed counter-shaft, for the purpose of obtaining greater regularity in driving for electrical purposes. It was thought necessary to find the power expended in driving this counter-shaft as far as it was possible to do so. For this purpose a short trial was made with the engine driving the counter-shaft only. Three sets of indicator diagrams were taken with and three without the counter-shaft, and the difference between the powers developed in the two cases may be taken (with the limitation stated later on) as representing the power necessary to drive the counter-shaft at its proper speed. The indicated power found necessary to drive the counter-shaft amounts to 1·9 under these circumstances. This indicated H.P. has to be deducted from the brake H.P. of Trials A and B, in order to estimate the work which the engine could actually do against electrical resistances. The net brake H.P., reckoned in this fashion, comes therefore to 12·84 and 5·51 respectively, and the corresponding gas consumption per brake H.P. per hour becomes 27·4 and 36·8 cubic feet.

THE GRIFFIN ENGINE.

Four experiments were made upon the Griffin gas engine. Experiment A was a six hours run at full power. Experiment B was a three hours run at half power. Experiment C was a short run empty. Experiment D was a one hour's run at a somewhat higher speed and indicated H.P. than Trial A, and with an altered valve gear. Particulars of these trials are given in Table VIII.

TABLE VIII.—GRIFFIN GAS ENGINE.

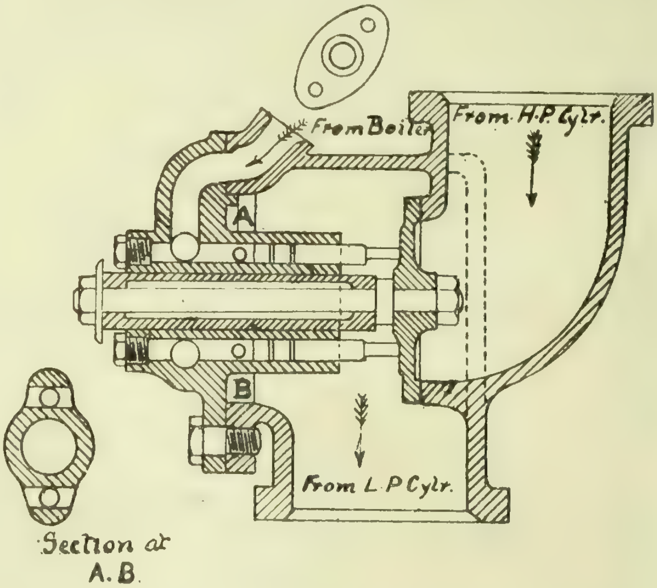
1	Date	Sept. 27	Sept. 27	Sept. 26	Oct. 1
2	Trial	A	B	C	D
3	Duration	6 hours	3 hours	½ hour	1 hour
4	Power	full	half	empty	full
5	Revolutions per minute	198·1	201·8	200·1	206·0
6	Explosions	129 0	82·6	30·6	136·5
7	Mean initial pressure	132·3	135·1	128·0	131·6
8	Mean effective pressure	54·15	55·85	56·60	54·20
9	Indicated H.P.	15·47	10·23	3·84	16·39
10	Brake load, net	130·7	64·67	....	134·48
11	Brake H.P.	12·51	6·30	....	13·39
12	Mechanical efficiency	0·809	0·616	....	0·817
13	Gas per hour, main	350·2	228·7	95·2	370·8
14	„ „ ignition	7·1	5·8	4·3	6·98
15	„ „ total	357·3	234·5	99·5	377·8
16	Gas per indicated H.P. per hour, main	22·64	22·35	24·79	22·63
17	Gas per indicated H P. per hour, total	23·10	22·92	25·91	23·05
18	Gas per brake H.P. per hour, main	28·00	36·30	....	27·69
19	„ „ „ „ total	28·56	37·20	....	28·21
20	Water per hour	1022	616·6	....	....
21	Rise of temperature	71·8°	71·31°	....	....
22	H.P. in driving engine	2·96	3·93	3·84	3·00
23	Mean pressure during working stroke, equivalent to work done in pumping strokes, about	2·40	....	....	....
24	Corresponding indicated H.P.	0·69	....	....	....

(To be continued.)

MODERN LOCOMOTIVE PRACTICE.

A PAPER on the above subject was read before a meeting of the Owens College Engineering Society, Manchester, by Mr. Ernest F. Lange, in which the author described the chief features noticeable in the standard designs of locomotives adopted by the principal railway companies in England. He mentioned the differences of opinion on the subject of high v. low boiler centre, and contrasted the old unsteady running engines, as designed by Beattie and Crampton, with the high-pitched boilers now used with great improvement in steady running by Mr. Worsdell on the North-Eastern, Mr. Webb on the London and North-Western, and other locomotive engineers.

The question of inside v. outside cylinders was far from being definitely settled. On the London and South-Western Railway outside cylinders were used for passenger engines; but on nearly all other lines the inside cylinders met with most favour. The best argument in favour of outside cylinders was the advantage gained by doing away with the dangerous crank axle, and by obtaining easier access to the working parts. On the other hand, the strains were removed further from the centre line of action, which tended to make high speeds unsteady; the cylinders also, being more exposed, suffered greater condensation. Engineers were divided as to the advantage of using "single" or "coupled" engines for fast passenger traffic; but he thought that, while the efficiency was equal, the single engine was the more economical. The experimental use of steam-sanding apparatus on several lines had, with "single" engines, been very successful in preventing slipping. The use of "Joy's" valve gear was rapidly extending, because of its great advantage of dispensing with eccentrics, and so allowing longer inside bearings.



The introduction of cast steel in modern locomotive construction was noteworthy; and, taking for example the recent compounds built by Mr. Webb, cast steel was used for the wheels, inside and outside slide-bar brackets, motion shaft for low-pressure cylinders, axle boxes, footsteps, piston crossheads, &c., while the rubbing surfaces were lined with Babbitt's white metal.

A new method of casting all the four eccentrics between the inside webs of the crank axle in one solid piece had been introduced by Mr. Holt, of the Midland works, at Derby, the eccentrics being afterwards turned up from four centres. This made a good solid job, but would appear to have the drawback of diminishing the flexibility of the axle. Mr. Worsdell had designed a new style of crank axle which was entirely finished in the lathe, the webs being circular, very deep and comparatively thin, thus combining great vertical strength with a certain amount of lateral flexibility.

The history of compounding was briefly dealt with, and it was said that the first attempt to compound locomotives was the "continuous expansion" system of Mr. James Samuel, proposed twenty years ago. It was, however, due to the work of Mr. Mallet, a French engineer, that the compound engine was made a practical invention. His locomotive was introduced on the Hanoverian State Railways by M. Von Borries, who improved it in many respects. One characteristic feature of these improved compounds was the ingenious starting and intercepting valve, as patented by Von Borries. In the event of the engine not starting, owing to the high-pressure crank being on a dead centre, live steam was automatically passed direct into the valve chest of the low-pressure cylinder by its means, and the engine set in motion.

We give an illustration here of Von Borries' starting valve. In it, live steam, entering from the boiler as shown (see illustration), would push the two small cylindrical pistons forward, and at the same time close the large disc valve and shut off communication between the high and low pressure cylinders. When this valve is shut, two ports are uncovered by the small pistons, which holes are shown at the points A and B on the diagram. By means of these the live steam passes direct to the low-pressure cylinder, and thus starts the engine. The exhaust from the high-pressure cylinder, after starting, acts on the large surface of the valve, drives this back, and closes the small port holes at A and B; thus the low-pressure cylinder is then worked by the high-pressure exhaust alone.

In describing the Webb's compound, the author said that it had two high-pressure cylinders outside the frames, and one low-pressure cylinder between the frames. The Experiment, the first of these, was built in 1881. In 1884 the heavy compounds known as the Dreadnought class were designed. This class had two high-pressure cylinders, 14in. in diameter, and a low-pressure cylinder, 30in. in diameter, the strokes being the same, viz., 24in. Joy's valve gear was used, and the boiler pressure was 175lb.

Mr. Worsdell had also adopted the compound system on the North-Eastern Railway for both passenger and goods engines, the cylinders being placed inside, the frames, &c., in both cases having the same ratio, the high-pressure cylinder 18in. in diameter, and the low-pressure 26in. in diameter.

Mention was made of the valuable experiments in compound locomotives made by Mr. Charles Sandiford, of the North-Western Railway, at Lahore, India, in which two and four cylinder tandem compound engines were used, and also of the researches into this subject by M. Borodin, of the Russian and South-Western Railway, in a large experimental shed, where the engines were fixed, and made to do the work of the crank axle.

WATER-GAS AS A STEAM BOILER FUEL.*

It is proposed to give in this paper an estimate of the cost at which carburetted and uncarburetted water-gas will have to be sold, in order to compete successfully for steam boiler use with anthracite coal.

The following are analyses of the gas direct from the generator, and of the same after it has been carburetted for illuminating purposes.

	Per cent by Volumes. I. Uncarburetted.	 II. Carburetted.
Nitrogen	4·69	2·5
Carbonic acid	3·47	·3
Ethylene	0	12·5
Oxygen	0	·2
Benzole vapour	0	1·5
Carbonic oxide	36·80	29·0
Marsh gas	2·16	24·0
Hydrogen	52·88	30·0
	100·00	100·0

Analysis I. is taken from a report on the Granger water-gas, by Dr. G. E. Moore;† II. is an average of a number of analyses of an illuminating gas made by a similar method.

By reducing the above analyses to percentages by weight, we obtain the results given in Table I.

In the use of this gas as a steam boiler fuel, the products of combustion are not reduced enough in temperature to allow the water-vapour contained therein to condense, and thus part with its latent heat. In calculating the calorific power of the gas, the heat that is imparted to the water-vapour will therefore be subtracted, in order to determine the amount that is available for heating purposes.

Table I.

	Uncarburetted.				Carburetted.			
	Per cent by Volume.	Density by Experiment.	Weight.	Per cent by Weight.	Per cent by Volume.	Density by Experiment.	Weight.	Per cent by Weight.
Nitrogen	4·69	0·972	0·045587	9·03	2·5	0·972	0·02430	3·84
Carbonic acid	3·47	1·524	0·052883	10·47	·3	1·524	0·00457	·72
Oxygen	0	—	—	—	2	1·1056	0·00221	·34
Ethylene	0	—	—	—	12·5	0·978	0·12225	19·35
Benzole vapour	0	—	—	—	1·5	2·770	0·04155	6·58
Carbonic oxide	36·80	0·973	0·358064	70·89	29·0	0·973	0·28217	44·66
Marsh gas	2·16	0·559	0·012074	2·39	24·0	0·559	0·13416	21·23
Hydrogen	52·88	0·069	0·036487	7·22	30·0	0·069	0·02070	3·28
Total	100·00		0·505095	100·00	100·0		0·63191	100·00
	Calculated density, 0·505 times that of air.				Calculated density, 0·632 times that of air.			

It is also assumed that the heat imparted to the gas during the process of its manufacture is lost by radiation and conduction, this being the case when the gas is stored in a holder and transmitted to the consumer by means of a system of piping.

The calorific power of the gases in British heat-units is given in Table II.*

Experiments were made to verify the ratio, indicated by the foregoing table, between the heats of combustion of the gas before and after being carburetted, by determining the time and quantity of gas required to evaporate a given weight of water contained in an open vessel, heated by means of a gas stove. The burner of the stove used for burning the carburetted gas caused air to be mingled with the gas before the latter was burned, thus producing a colourless flame. For the uncarburetted gas, the burner was of the Argand pattern, and air was not mingled with the gas before it was burned.

Table II.

	Uncarburetted.			Carburetted.		
	Per cent by weight.	Heat-units per pound.	Heat-units in portion contained in one pound of the mixture	Per cent by weight.	Heat-units per pound.	Heat-units in portion contained in one pound of the mixture.
Nitrogen	9·03	0	·0	3·84	0	—
Carbonic acid	10·47	0	·0	·72	0	-
Oxygen	0	0	·0	·34	0	—
Ethylene	0	20135	·0	19·35	20135	3896·1
Benzole vapour	0	17847	·0	6·58	17847	1174·3
Carbonic oxide	70·89	4396	3116·3	44·66	4396	1963·3
Marsh gas	2·39	21593	516·1	21·23	21593	4584·2
Hydrogen	7·22	51804	3740·2	3·28	51804	1699·2
Total	100·00		7372·6	100·00		13317·1

(To be continued.)

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* By D. S. Jacobus. Trans. of Am. Inst. of Mining Engineers.

† Mr. Emerson McMillin, in an article on fuel-gas, presented to the American Gas-Light Association, at its meeting held in New York, October 20, 1887, gives an analysis of uncarburetted water-gas, having the following constituents in percentage by volume: N, 2·0; CO_2, 4·0; CO, 45·0; CH_4, 2·0; H, 45·0; O, 0·5; water-vapour, 1·5. He adds, however, that since calculating the tables used in his paper he is satisfied that this sample of water-gas is not an average one, the CO being too high and the H too low. It would therefore appear that the analysis I have adopted is more nearly an average one.

* The heats of combustion of the several gases, as given in Table I., are those deduced by Mr. G. E. Moore from the experimental results of G. Thomsen. Since completing the calculations given in this article, I have made the necessary transformations in Thomsen's original experimental results, and find that my figures agree with those obtained by Mr. Moore to within the limits of practical error. As there is no record of the values of the atomic weights employed, it is probable that the variations which occur are caused by our having employed slightly different values for the atomic weights.

BERRY'S AQUA THRUSTER.

Messrs. Bailey and Co., Engineers, Salford.

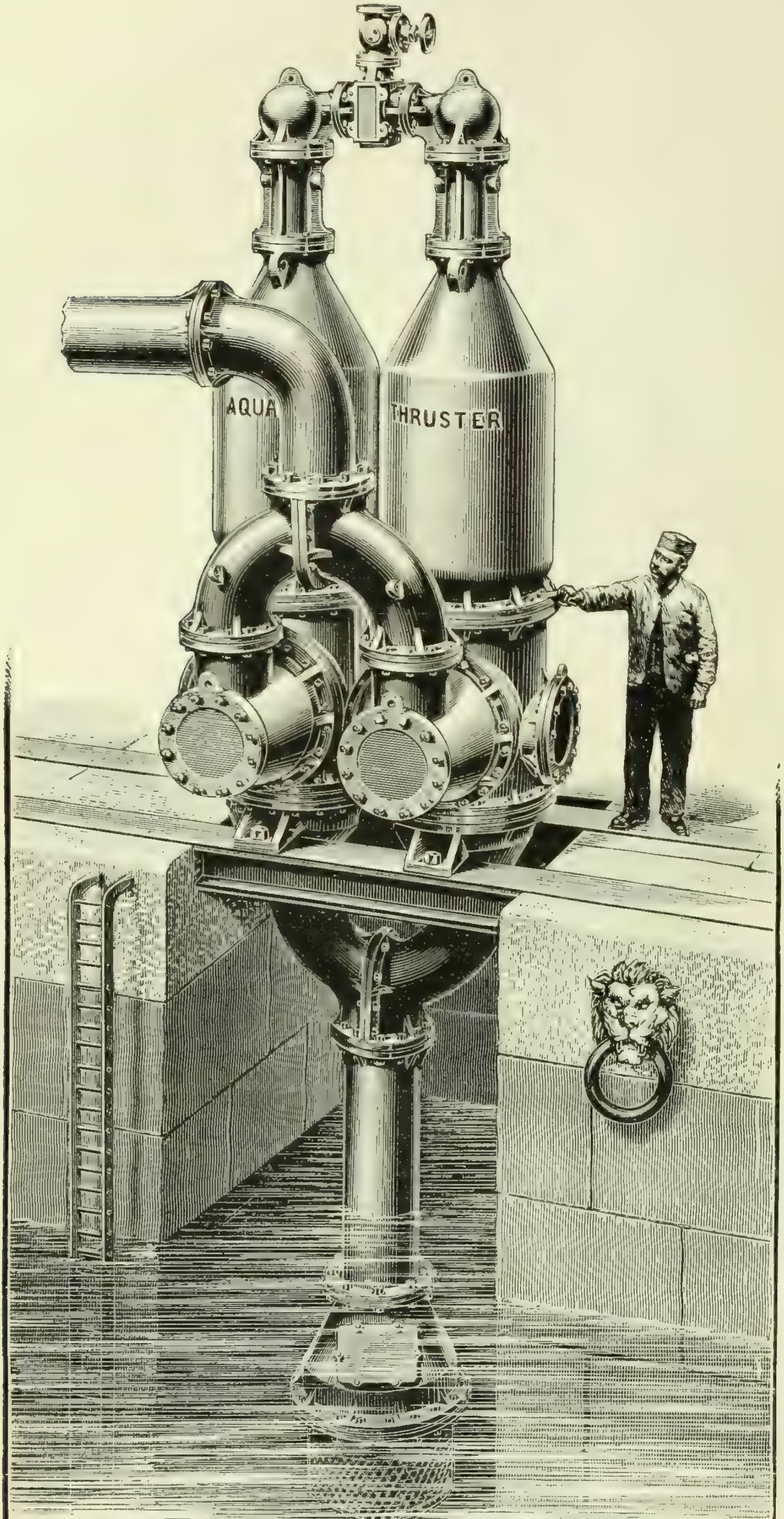

Fig. 1.

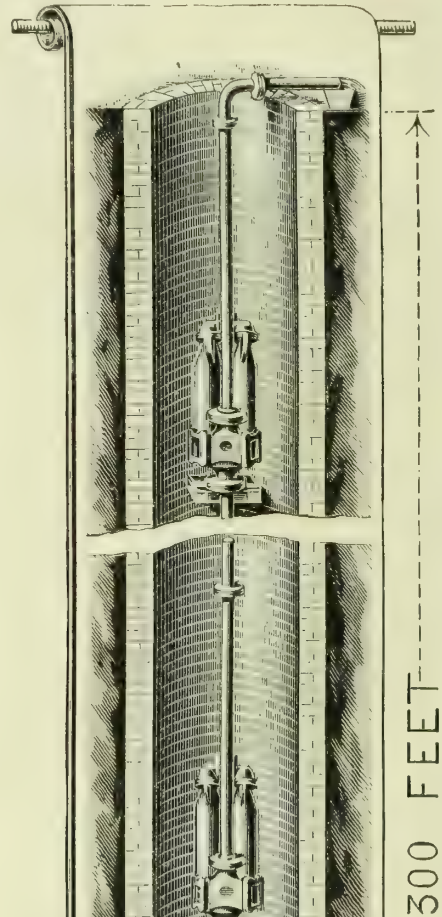

Fig. 2.

Pulsating steam pumps are now extensively used for numerous purposes where the highest attainable duty, so far as fuel consumption is concerned, may be to some extent ignored. It often happens that the application of motive power, such as steam, direct to its work, without intermediate mechanism, saves more by reason of excessive simplicity and the absence of frictional and other mechanical losses than it loses by apparent crudity. This is the case with the pulsating steam pumps, which in their essential principle, that of pumping by direct force of steam upon the surface of the water, may be dated back to Savery's water-compelling engine.

The modern pulsators are beautifully simple, and for numerous purposes quite sufficiently economical in fuel. We illustrate here and on the opposite page a new pump of this class made, under Berry's patent, by Messrs. W. H. Bailey and Co., of Salford. Fig. 1. is an illustration of a very large pump, probably the largest of the type ever made. Fig. 2 shows the application of the system to deep-well pumping, and fig. 3 is a section showing the valve details. Very great lifts may be arranged for, and any number may be worked in series, as in fig. 2.

It is stated that the efficiency of an ordinary centrifugal pump and engine combined is less than one of these. Knowing the difficulty of arranging for high efficiency in centrifugal pumps, and the difficulty of minimising friction when there are numerous working parts, we are not surprised to learn this.

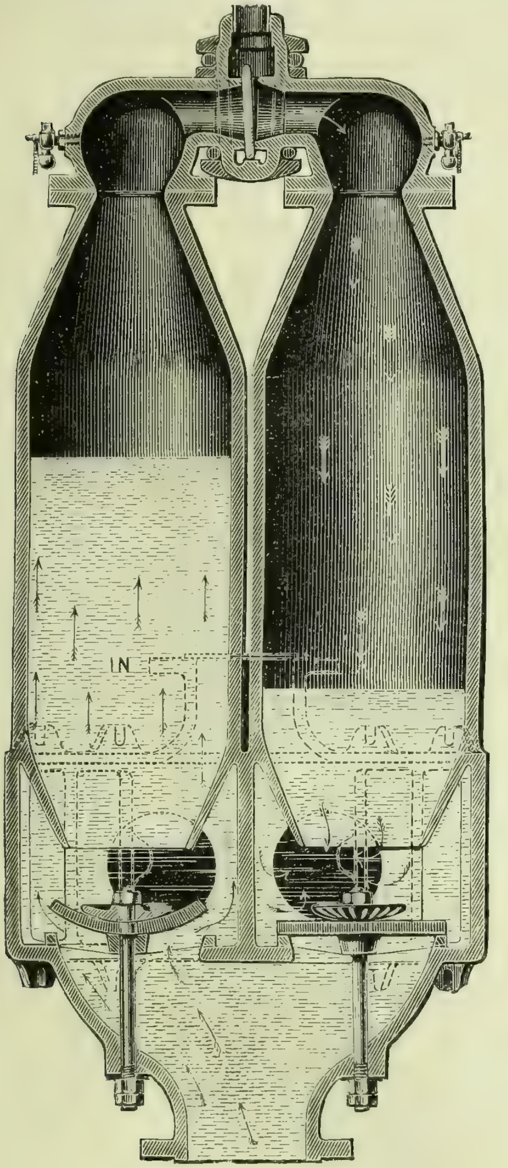

Fig. 3.

The entire suppression of frictional losses, and the narrowing down of losses to that produced by condensation alone, must have a favourable effect, notwithstanding the low theoretic efficiency of such pumps. The low first cost and the entire absence of working parts greatly favour the extended use of such inventions, and we doubt not but that Messrs. Bailey will do well with the invention.

We should be much interested to know if any attempts have been made to make float arrangements for indicating such pumps; the diagrams produced might throw an interesting light upon steam cylinder condensation.

Graphite Bearings.—According to an article in an American contemporary, graphite bearings are rapidly extending in their use. It concludes by saying that "enough is now known to show that dry lubrication by means of the graphite box has been very successful, simply in taking the place of the oiled box."

SPIRALLY-WELDED STEEL TUBES.*

The manufacture of light steel pressure pipes, made from strips of metal wound laterally and hammer-welded, is an entirely new industry, employing means and producing results wholly unlike any before known in the arts.

In iron and steel pipe it is desirable to use no more material than is needed to give the strength desired. This is true of all products, the progress of the arts tending steadily to a good constructive use of material, to secure a maximum of strength with a minimum of dead weight. As the rule, lap-welded tubes are enormously heavier than anything in the service to which they are subjected warrants. They are made so for no other reason than that lighter stock than that employed in making them cannot be used. If the stock is heated in sheets, drawn from the furnaces at the welding temperature, shaped on a mandrel and welded, a considerable body of stock is needed to hold the heat during the shaping and welding processes. With thin sheets one of two things would happen: either the metal would chill instantly when drawn from the furnace, and refuse to weld, or, if hot enough, would collapse upon itself, defeating all efforts to shape and weld it. Light pipes would have been made by lap welding long ago had it been possible. As it is, they are much heavier than their strength calls for, the longitudinal weld being, as the rule, a line of weakness. In spirally-welded pipes we have the material used to the very best advantage. The weld, instead of being a line of weakness, is a spiral reinforcement. A circumferential twisting strain is not created transversely to the weld, but longitudinally, or, to be more accurate, obliquely; and such pressure does not tend to open the seam, as in the case of a longitudinal weld, but to close it. The behaviour of a spirally-welded pipe under pressure is illustrated by a very simple experiment. Roll a ribbon of paper into a spiral tube, as children make lamp lighters, pinch one end tightly shut, and blow in the other. It will be found that the first effect of internal pressure is to tighten the seams, and the paper may be burst before any air will leak out between the edges of the parts in contact. I have seen a defective spirally-welded pipe leak under twenty pounds pressure, become tight at fifty pounds, and remain tight up to 350 pounds per square inch. Under an internal bursting strain, the strength of a spirally-welded tube is found in the testing machine to be as great as the theoretical strength of the stock.

The process of manufacture is simple and inexpensive, but has entailed many and serious difficulties. These, however, have been overcome. Steel of suitable quality—*i.e.*, weldable, and having a tensile strength of 65,000 pounds per square inch, with about fifty per cent reduction of area, and fifteen to eighteen per cent elongation—is rolled in grooves to the proper width, and as long as may be convenient. These strips are welded end to end in a machine built for the purpose, which works very well. As they are welded into long bands the strips are rolled on large reels, which are passed to the pipe machines.

The essential features of the pipe machine are a guide-table for the skelp, adjustable to the desired angle; feed rolls, to pass it forward with an intermittent progress, so that it shall advance when the former is raised and be at rest when it falls; a former, to curve the metal to the desired radius, also adjustable; a furnace, to heat the metal; a hammer to weld it, and an anvil to support the pipe and receive the shocks of the hammer. No mandrel is used. The pipe in the forming process is held in place by a pipe mould, which is a cylindrical shell, within which the pipe rotates as the stock is fed in. The anvil is of considerable mass, steel-faced, and extends the entire width of the skelp. The hammer is light, and at normal speed strikes 350 blows per minute. The heating is done in a furnace so constructed as to heat both the edges to be united for the space of several inches ahead of the point at which the welding is effected. The upper skelp enters the furnace flat, and the lower skelp curved, having already been through the forming jaws. The heat is imparted by one or two blow-pipes of water gas and air, discharging upon the metal through passages of suitable form in the refractory lining of the furnace. One gas-flame has been found sufficient, but two work better; and besides being more convenient to control, they heat the metal more rapidly and permit an accelerated feed. As very little gas is wasted, the greatest economy attends the most rapid production of pipe, irrespective of the quantity burned, which in any case is about thirty feet per foot of welded seam. The speed of production depends, as stated, upon the thickness of stock to be heated, and the relation of width of skelp to diameter. It averages a foot per minute to each machine, and it is probable this average can be raised considerably. The machines are so nearly automatic in operation that very little skilled labour is needed in running the plant. The operator has his gas, air, and feed under control by convenient means, and varies their relations until he has them just as he wants them. He can see the edges as they emerge from the furnace, and about all the skill he needs is that which will enable him to judge by its colour whether the iron is above, below, or at the welding heat. Unskilled labour prepares the stock and removes the finished product. The ends of the pipe are cut square by suitable machinery without reversing, and after testing and treating with asphalt the pipe is ready for shipment. As may be supposed, all the difficulties of mechanical development have centred in the pipe machine. To make this satisfactory in operation has probably been no more serious task than is usually entailed in the effort to make old mechanical motions perform new functions, but it has consumed a great deal of time and money.

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*By J. C. Bayles. "Journal of the Franklin Institute."

The strengths attainable in light pipe, if the material is used to the best advantage, are quite surprising. A 6in. pipe, made of No. 14 gauge iron of good average quality, showing under test 33,000 pounds elastic limit, and 50,000 pounds ultimate strength, has a proof strength of 913 pounds per square inch, and an ultimate strength of 1,383 pounds per square inch. A 12in. pipe of the same stock has a proof strength of 456 pounds, and an ultimate strength of 691 pounds. If a good grade of soft steel is used instead of iron, the 6in. pipe will carry 1,106 pounds pressure without deformation, and will not burst under 1,800 pounds; the 12in. pipe can be tested to 475 pounds, and will carry 900 pounds without fracture. This is very practical pipe. Using the same diameters and gauges of stock for comparison, we find that the 6in. spirally-welded pipe weighs 5·2 pounds per foot against 18·77 pounds per foot for standard lap-welded pipe, and 28·28 pounds for medium cast-iron pipe; the 12in. spirally-welded pipe weighs 10·46 pounds against 54·65 pounds for lap-welded and 77·36 for medium cast iron. Owing to its superior advantages, we shall use steel exclusively in future. It is twenty-five per cent stronger than good iron, works better, and costs less per pound.

The advantages of spirally-welded tubes over any other form of pressure pipes, as regards economy of transportation and handling, are very marked, as will appear from the comparisons of the following table :—

COMPARATIVE WEIGHTS OF PIPES, PER LINEAR FOOT, WITHOUT COUPLINGS OR HUBS.

	SPIRALLY-WELDED STEEL OR IRON.						LAP-WELDED IRON.	CAST IRON.		
Diameter of Pipe.	No. 18.	No. 16.	No. 14.	No. 12.	No. 10.	No. 8.	Standard.	½in. thick.	⅝in. thick.	¾in. thick.
In.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.				
4	2·06	2·73					10·72	22·05	28·28	34·94
5	2·58	3·42					14·56	26·94	34·34	42·38
6	3·09	4·10	5 20				18·77	31·82	40·56	49·6
8	4·13	5 47	6·98				28 35	41·64	52·68	64 27
10	5·16	6·83	8·72	11·44	14·08		40·64	51·46	65·08	78·99
12	6·18	8·20	10·46	13·74	16·90	20·80	54·65	61·26	77·36	93·7
14	7·22	9·57	12·20	16·02	19·72	24·86		71·07	89·61	108·46
16	8·25	10·93	13·95	18·30	22·54	27·72		80·87	101·82	123·14
								⅝in. thick.	¾in. thick.	⅞in. thick.
18	9·28	12·30	15 69	20·69	25·35	31·19		114·1	137·84	161·9
20		13·66	17·44	22·28	28·16	34·66		126·33	152·53	179·02
22		15·03	19·18	25·27	30·98	38 12		138·6	167·24	196·46
24		16·40	20·92	27·48	33·80	41·60		150 85	181·92	213·28

The question of durability in service is one which naturally suggests itself when light steel or iron pipes are discussed. Experience on the Pacific Coast seems to have settled this question, as the cheap expedients adopted for water conveyance during the days when hydraulic mining was most extensively conducted have been followed ever since in permanent engineering works. The best attainable data on this subject which I have found are presented in a paper read by Hamilton Smith, jun., before the British Iron and Steel Institute, and printed in Vol. I. of the *Journal* for 1886. Much of the information contained in this paper is quite surprising, especially in the case of the two mains across Humbug Cañon. These pipes were laid in 1868. They are of twenty-six inches diameter, 1,194 feet long, of common iron one-sixteenth inch in thickness, single riveted. During all this time they have been delivering water under 120 feet head, and Mr. Smith gives the maximum tensile strain in pounds on the metal per square inch as 11,500. Large as these figures look, they are simply the result of applying to the conditions given in Rankine's well-known formula for their cylindrical shells.

Riveted pipe in its best estate labours under the disadvantage of inherent structural weakness, and liability to rust between the overlapping edges and around the rivets. Pipes of this character on the Pacific Coast are very roughly tarred in position, and the coating is quite liable to be pulled off by the adobe clay in which most of them are laid; but they have a record of useful life since 1853, and many towns are supplied with water under considerable heads from pipes of this kind, which have been more than twenty years in service. A welded pipe carefully coated with asphalt should, with fair treatment, have a record at least as good, and probably much better.

The coupling of light-pressure pipes involves no difficulties, but it entails new methods. These are convenient and inexpensive, and make perfectly tight joints. The couplings are chiefly of cast iron, and their form depends upon the service in which the pipe is to be employed. Steam, water, petroleum, compressed air and gas, all present different problems in couplings, but no difficulties which have not already been fully met. The couplings are as practicable as the pipe. The one generally preferred is the "trumpet flange." The pipe is slipped through the flange, and the projecting end is expanded and laid flat against the face of the flange. The ends of the pipes are thus brought in contact with the gaskets, making perfect joints under all circumstances.

Spirally-welded tubes are adapted for every use calling for pressure pipes. In the paper before referred to, Mr. Hamilton Smith, jun., after reciting American engineering experience with light iron tubes, concludes as follows:

"The query presents itself, Why should not wrought iron, or, still better, steel be used for conduit pipes in preference to cast iron? If it answers the desired purpose in California, why should it not do so in other parts of the world? To one, like myself, who has for years been accustomed to the Californian practice, it seems as irrational to build a pipe of cast iron carrying water under considerable pressure, as it would be to build a suspension bridge with the supporting chains made of cast iron.

"Experience in the United States has shown that the practicable limit of size for cast-iron mains is a diameter of about four feet, even when the pressure is less than 100lb. It is evident that a pipe of wrought iron or mild steel can be safely made of almost any desired size, and this may be of much advantage if it be desired to conduct a large supply of water through pipes for city or other use. For instance, with an inclination of three feet per mile a single pipe eight and one-fourth feet in diameter will carry 280 cubic feet per second, while seven pipes, each four feet in diameter, would be required to transport the same quantity of water with the same inclination. The cost of the large pipe, made of steel or wrought iron, would be considerably less than one-half the cost of the seven small pipes made of cast iron.

"The ideal conduit for high pressures is a welded steel tube. Such tubes could probably be subjected to a tensile strain of 25,000lb. with perfect safety, and would be much preferable to riveted pipe, not only on account of superior strength, but also by reason of almost perfect interior smoothness. * * * The adaptation of a superior and cheap metal, such as mild steel, for conduits, will permit the construction of hydraulic works in many parts of the world which now appear to be impracticable, owing to the cost of many of the methods still in use for the transportation of water."

Spirally-welded steel tubes meet all the conditions above described. The industry gives promise of rapid and even phenomenal development, as the cheapness and excellence of the product commands for it instant recognition as the most valuable of recent contributions to engineering materials.

AN apparatus very necessary in Germany and Holland for warning travellers of an approaching train at road crossings has been constructed by Messrs. Siemens and Halske. By an electrical arrangement a bell begins to ring violently at the crossing when the train is 1,500 yards therefrom, and continues ringing till the train has passed. The apparatus is specially intended for the light or second class railways in Germany worked by omnibus trains, where such crossings are not guarded.

MATERIALS OF ENGINEERING.—XIII.

Timber.

Timber, as a material for engineering purposes, does not possess so high a value as formerly, since the light-framed structures of wrought iron and steel have, to some extent, usurped its place. I shall therefore say all that is necessary to say in the compass of a single article, only mentioning the principal kinds of timber employed for structural purposes.

Timber in general is cut down during the winter months, when the circulation is least active. It is then seasoned either naturally or artificially, being partly or wholly cut up. When seasoned naturally, a free circulation of air is provided all around ; the logs or boards, as the case may be, being kept asunder to expose all sides to the fresh currents of air. When seasoned artificially, currents of hot air are passed through drying chambers containing the timber.

Wood, however well seasoned, will invariably alter in form whenever fresh surfaces are exposed to the air. The reason of this lies in its tubular character; this has to be taken into consideration, and allowance made for the same. The greatest shrinkage occurs in the circumferential direction of the tree; hence the presence of radial or heart shakes along the planes of the medullary rays, the alteration in size of timber of large scantling, and the shrinkage and curving of thin boards.

The quality of timber varies with relative position. In young trees the heart wood is the best ; when matured the wood is equally good throughout. In old trees the heart wood decays. The sap wood, lying just underneath the bark, is of inferior quality.

Timber is broadly divided by the engineer into two main classes, the pine woods and leaf woods ; the first embracing the coniferous or needle-leaved trees, and the second all the hard wood trees. The *pinus sylnestries* yields the Baltic deals, the Riga, Memel, and Dantzic reds, or yellow deals. The spruce fir, *abies excelsa*, yields the white deal ; the North American deals are the produce of the *pinus strobus*, *pinus variabilis*, *pinus lutea*, and *pinus rigida*. The yew, cedar, birch, and others are included in the coniferous woods.

The principal hard woods are the oak, beech, elm, greenheart, teak, African oak, American elm, mahogany, birch, and hornbeam, all more or less used in engineers' work. The appearances and characteristics of these are pretty well known, and I need not enumerate them here, but go at once to the question of the strength and testing of the various timbers.

Tables of the tensile, compression, and transverse strengths of timber have been compiled by various experimentalists, but with very great discrepancies in results. It will be necessary to note the conditions under which such experiments have been performed in order to form a just opinion of their value.

Nearly all the experiments made have been performed on test pieces of small scantling, generally selected free from defects—conditions which by no means exist in actual practice. Thus, Mr. Laslett's experiments for transverse strength were conducted on beams 2in. square and 7ft. long, with a 6ft. span ; those for tensile strength were 2in. square, with a clear length of 2ft. 6in. The specimens for compression were cubes of from 1in. to 4in., and of pieces 2in. square and upwards, of various lengths. Mr. Fincham's experiments were on beams 3in. square,'with 4ft. span. Mr. Barlow experimented on beams 2in. square and of 7ft. span. Now, between such test beams and the ordinary balks there would probably be a difference of nearly or quite 100 per cent, so that all such data must be received with caution, and large factors of safety be employed. It is noteworthy, for example, that in some of Mr. Laslett's experiments on English oak, there were twelve test pieces cut from one tree, six of which, near the heart, were of straight grain, while six from the outside had curly grain, and that the breaking weight in these varied between 390lb. to 740lb. The ultimate deflection, also, ranged from 3ft. 5in. to 7ft. Again, Dr. Anderson, summarising the results of numerous experiments by Barlow, Benan, Muschenbrock, and others, tabulates some extensive differences in ultimate tensile strength in pounds per square inch, as—beech, 22,200 to 11,500 ; fir, 18,100 to 7,000 ; oak, 19,800 to 9,000 ; teak, from 15,000 to 8,200. Similar discrepancies are found when tabulating compressive and transverse strengths. But even when pieces of larger scantling are used there is nothing like uniformity of results. Bauschinger tested pine beams measuring about 7½in. square by 98in. span, with extremely variable results. Professor Lunza experimented on beams of pine and of oak measuring from 2in. to 6in. wide and 2in. to 12in. deep, with spans varying from 4ft. to 20ft., with great variation in maximum and minimum results. For these reasons it is well, when estimating the scantlings of timber for any important works, to institute independent experiments on materials similar in quality to those which will be used, and to deduce a constant from those experiments suitable for the kind of stress to which the members of the structure will be subjected. Having ascertained the load necessary to break a beam of definite size, we can deduce therefrom a constant of strength for similar beams of other dimensions; or, having ascertained the load necessary to deflect a beam of given size to a definite extent, we deduce the constant for deflection of a similar beam of any size.

The breaking weight of a rectangular beam varies as the breadth and the square of the depth, and inversely as the length. This assumes that the length is not excessive, otherwise a twisting action will come into play. The deflection of a rectangular beam varies as the load and the cube of the length, and inversely as the breadth and the cube of the depth. The deflection of a beam should not exceed the elastic limit. But the limit of elasticity is extremely small, because timber beams take a permanent set with a moderate load long sustained ; the deflection should not exceed $\frac{1}{480}$th of the length of a beam. Dr. Anderson has summarised in a table the ultimate strength and the deflection of various timber beams as ascertained by Barlow and Tredgold. They are all reduced to the standard bar, 1in. square and 12in. between supports, the load being applied at the *middle*.

Nature of Material.	Value of strength.	Value of deflection.
Teak	820	5588
English Oak	557	3359
Canadian Oak	588	4964
Dantzic Oak	485	2757
Adriatic Oak	461	2255
Ash	675	3807
Beech	518	3133
Elm	337	1620
Pitch Pine	544	2837
Red Pine	447	4259
New England Fir	367	5072
Riga Fir	369	3079
Mar Forest Fir	381	2013
Larch	284	2437
Norway Spar	491	3374
Mahogany, Spanish	425	2906
Ditto Honduras	637	3571
Memel Deal	545	4500
Christiana Deal	686	4176

For beams differently loaded, and for cantilevers, the suitable allowance must be made ; and also for beams of other sections than the rectangular.

The preservation of timber by kyanising, and by means of Burnett's fluid, is not now much resorted to, creosoting having largely supplanted those methods. The timber to be creosoted is enclosed in a long cylinder, similar in appearance to the barrel of a horizontal boiler, and a vacuum equal to about 16lb. per square inch is produced and maintained sufficiently long to extract the sap. Then creosote, under a pressure of from 100lb. to 180lb. per square inch, is pumped in. About 10lb. of creosote per cubic foot will be impregnated. Timber sleepers and balks submerged under water will then last about 20 years. J. H.

Very Important Contracts in Italy.—A Roman correspondent says the following important contracts are pending in Italy, although the dates for their definite adjudication have not yet been fixed. The Board of the Italian Mediterranean Railway intends introducing the block system on the Turin and Trofarello line at an estimated cost of 143,822 lire, and requires also tenders for lighting 24 third-class railway carriages. The Board of the Adriatic Railway will shortly adjudicate a contract for points and crossings, estimated at 661,672 lire. Tenders are required by the Municipal Board of Venice for laying down waterworks from San Ambrogio and Castelfranco to Venice, the preliminary estimate amounting to about 1,500,000 lire.

CONSTRUCTION OF VERTICAL BOILERS.

The severe straining to which many vertical boilers, constructed with firebox and chimney tube or tubes, are subjected from expansion of the internal portions, and the serious defects which frequently result from such straining, are suggestive of some radical defect, and appear to call for alteration in their construction or proportions. The most severe strains result, of course, from overheating of the tube or tubes above the water level, which, there is little doubt, frequently occurs where the tubes are of great length, or where boilers are hard fired, and can be prevented in chimney tube boilers by protecting the tube, if it is of sufficiently large diameter, by a liner of cast iron or fireclay, as is generally advised by the inspection companies. There is, however, in all such boilers a constant, if slight, straining in every-day working, due to the firebox and tube being hotter and more expanded than the shell.

The effects of this expansive straining are shown in various ways, but generally in the form of grooving or fracture in the root of the flanging or angle iron at the lower end of the chimney tube. Its effect in multitubular boilers is sometimes peculiar, the alternations of expansion and contraction apparently causing both crown plates to be dished downwards until one of them, usually the larger one, fractures. Grooving is, however, frequently found to develop on the water side in the bend of flanging, or close to the angle iron (if so constructed) round the bottom of the firebox; or it is sometimes found round the shell just above the bottom ring seam in chimney tube boilers where the crown plates are much cambered and consequently very rigid. All the defects above described may result from or be greatly aggravated by overheating caused by deposit from the feed-water; but in either case the action is the same, and would be obviated if the boiler could be constructed so as to allow sufficient freedom for the expansive movements of the heated portions.

Vertical boilers of the ordinary type are not economical as regards evaporative results. We believe this is generally understood, but there are large numbers of such boilers in use, their adaptability for small requirements and their general handiness being their chief recommendations. They are also difficult and expensive to repair, except in a makeshift way, as a small patch even, if properly applied with rivets, necessitates, in most cases, the withdrawal of firebox and tube; and where much is required in the way of repairs the cheaper course is, as a rule, to purchase another boiler. For these reasons, as well as for avoidance of risk, the proper construction of the boilers is a matter of importance.

In Lancashire and Cornish boilers the expansion of the tubes is provided for by allowing sufficient breathing space in the end-plates. In vertical boilers, however, as ordinarily constructed, no such elasticity can be looked for at the bottom ends, and it is evident that all compensatory movement must take place in the crown plates, and in accordance with the rigidity of these parts will be the proportionate straining throughout the boiler. In the first place, the chimney tube should always be made sufficiently large to admit of a liner being inserted to protect it from the heat above water-level. This liner should never be omitted, and to ensure a proper degree of elasticity, we submit that the top end-plates of vertical boilers may in most, if not in all cases, be made flat, the required strength being obtained by a proportionate thickness of plate. In the end-plates of Lancashire boilers the best proportion of breathing space between the lowest rivets of the gusset stays and the rivets in the tube angle-irons is found to be ten inches, and this width of space in the flat end of a vertical boiler, measuring from the commencement of the bend of flange, round the periphery to the outer edge of the angle-iron round the chimney tube, would not be exceeded even in a boiler of considerable diameter. The firebox crown may be cambered to decrease lodgment of deposit thereon. The firebox should be coned, the diameter decreasing say not less than one inch for the foot in height, with a view not only to increased strength, but to allow free emission of the steam generated on the hot plates. The firebox should also be strengthened with cross tubes.

For 4ft. and upwards in diameter vertical boilers are not advisable, as economy then becomes an important factor, and a Cornish or other kind is more suitable. If, however, a vertical boiler is desired, one of the various kinds of multitubular boilers now made with horizontal tubes is no doubt preferable to the ordinary vertical. A hand-hole should be made in the shell opposite each cross tube, and there should be a sufficient number of mud-holes round the bottom to admit of cleaning in the narrow water space. In all vertical boilers the shell plates should be continued below the junction with the firebox, or the boiler should be set on three or more supports, so that ashes and moisture cannot accumulate about the bottom ring seam of the firebox. All such boilers should also be set so that the fireboxes are accessible from below after removal of the firebars. A boiler constructed in the way we have suggested would, we consider, have a chance of a much longer life than many boilers where the points referred to have been neglected.

EARTH TREMORS, ATMOSPHERIC DISTURBANCES, AND FIRE-DAMP IN MINES.*

After referring to previous researches bearing upon the subject, the author proceeds to describe an extended series of observations made at the Herin pit of the Anzin Coal Company. The microseismic movements of the earth's crust, as he calls them, in distinction to sensible tremors or earthquakes, were observed by a tromometer similar to that employed at the Douai School of Mines, consisting of a pendulum 1·50 metre (4ft. 11in.) suspended from an iron pivot fixed in a thick wall, its oscillations being read by a microscope. The wall was a very old one, of brick, 2ft. thick, running in a direction from N.E. to S.W., and completely sheltered from the sun. The most violent winds are from the S.W., and a series of observations extending over several months appears to establish the fact that the wind exercises no appreciable influence upon the apparatus, but that there are certain coincidences between seismic and barometric movements which Bertilli, of Florence, has named "baroseismic squalls." Local vibrations, such as those produced by passing vehicles, are also inappreciable, being too rapid to affect the weight or bob of a pendulum of this length, although they may cause nodes and curves in the suspension rod. A shorter pendulum, while indicating these vibrations, would fail to record microseismic movements having a period of oscillation greater than one second; and this is probably the reason why pendulums of from 1 to 4 metres length (39 to 157 inches), with a period of oscillation of from 1 to 2 seconds, are found to give the best results for this purpose.

Observations taken simultaneously at Herin and Douai during the months of October, November, and December, 1887, show a close correspondence, except on November 22nd and 23rd, when the violent seismic disturbances in the Mediterranean basin, although distinctly transmitted to the department of the Nord, appear to have escaped the Douai observers; and, generally, the Herin instrument would appear to be far more sensitive than that at Douai.

A similar concordance has been noted between the monthly averages recorded at the observations of Bologna, Florence, and Velletri.

A series of barometric observations taken at bank, at the pit bottom (558ft. deep), and in the return air-course, were found to correspond so closely as to render it immaterial which was adopted as the standard of comparison; while from a similar series of observations, at different hours of the day, as to the disengagement of fire-damp (which it was found could be estimated very closely by means of the cap or aureole on the flame of the Pieler safety-lamp), it was found that the results obtained at 6 a.m., half an hour after the miners had assembled, but before they had fairly commenced work, gave a very close average for the whole day, and was unaffected by the greater or smaller amount of coal actually got from the faces. From the percentage of fire-damp found in the return air-course, the daily amount given off was found by reducing the quantity of air actually passed through the pit to a given unit.

A diagram is given for the eleven months, February to December, 1887, showing (with certain interruptions from various causes, by which the daily observations are reduced to 180 out of a possible 230) (*a*) the intensity of the seismic movements; (*b*) the barometric readings; (*c*) the amount of fire-damp given off; and the following general deductions are offered :—

(1) Seismic disturbances and flow of fire-damp—

Concordant	81	days.
Discordant	46	„
Independent	51	„
	178	„

(2) Barometric readings and flow of fire-damp—

Concordant	75	days.
Discordant	51	„
Independent	54	„
	180	„

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* Prov. Inst. C.E., Foreign Abstracts.

But in order to eliminate such sources of error as might arise from falls of roof, &c., the value of which cannot correctly be estimated, it is considered best to take into account only the more marked variations of the curves as plotted. Taking the tromometer curve as the basis, there are 43 concordances to 17 discordances; or, inversely, if the fire-damp curve is taken, 17 concordances to 7 discordances; or in each case nearly as 5 to 2.

Taking the barometer curve as the basis, there are 11 concordances to 9 discordances; or, inversely, 14 to 15.

It would thus appear that the connection between seismic disturbance and disengagements of fire-damp is fairly demonstrated; but that the influence of barometric variations is not so well established, although the concordances outnumber the discordances; and it is interesting to remark that whenever a large increase of fire-damp has been maintained for several days above the average, including the very exceptional outburst on December 8th and 9th (of which some interesting particulars are given), there is a very remarkable coincidence between all the three curves.

The paper contains references to numerous other investigations on the same subject, and especially to an article in vol. 37 of Proceedings of the North of England Institute of Mining and Mechanical Engineers, containing the first report of the committee appointed to investigate this subject; and to one in the Zeitschrift für das Berg-, Hütten-, und Salinen-Wesen, 1887, pp. 277, 279, containing the result of Mr. Nasse's careful observations. In this case one district of a mine, which had been walled off to isolate a fire, afforded a convenient gasholder of known area and capacity; and his experiments show that a diminution of atmospheric pressure, as observed on the spot, was decidedly favourable to the disengagement of fire-damp.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

LEAKAGE IN BOILERS.

To the Editor of "The Practical Engineer."

SIR,—I am much obliged to "Chalkline" for his notice of my query in your issue of February 22nd, and am sorry I could not answer his question sooner. Of course, our feed-water is clear as crystal when put in the boiler, but the solids are not deposited in the boiler, but are held in the water and kept in circulation, so that the plates are as clean as if they were scoured. I can find nothing wrong in the flues with the exception of the bottom flue being rather small; the butt strips are thinner at the ends, and tucked under as described by your correspondent. Working pressure 90lb., shell plates $\frac{1}{2}$in., butt strips $\frac{7}{16}$in. The boiler has been examined by an inspector, who says it is the feed-water, and thinks no more of it. He was a very young Scotchman, and I do not attach much importance to his report. The boiler-maker says that, owing to the bottom flue being too small, it is liable to rapid changes of temperature during firing up. We fire by hand.—Yours, &c.,

ENGINE-MAN.

WATER TUBE BOILERS.

To the Editor of "The Practical Engineer."

SIR,—It appears probable that in the immediate future high-pressure steam will be largely and increasingly used in connection with triple and quadruple expansion engines, for driving which boilers of the water-tube type are being largely introduced. Information on the following points will no doubt be useful to the readers of your valuable paper, and particularly to the subscriber hereto :—

1. What defects (if any) commonly develop in the use of water-tube steam boilers, such as "Roots," the "Babcock and Wilcox Company's," the "Belleville," and the "Steinmuller" types, in the following or other cases :
2. Where limy feed-water is used.
3. Where muddy feed-water, or water heavily charged with sediment, is used.
4. Where intermittent and sometimes heavy demands of steam are made.
5. What trouble and expense arise by having to keep up the brick-work of which the furnaces to this class of boiler are constructed.
6. Whether they are liable to produce wet or saturated steam.
7. Whether anyone who has experienced any of the several defects they are liable to knows of any recently-discovered efficient remedies.

Yours &c., MANCHESTER ENGINEER.

QUERIES AND REPLIES.

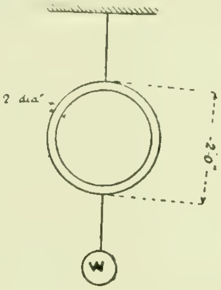
24. TEMPERATURE OF FEED WATER.—What is the highest temperature of feed water attainable in surface condensing engines with a vacuum of from 24in. to 28in.?—CROSS.

Answer.—In reply to "Cross," I beg to say that the highest temperature of feed-water he can obtain from the condenser with 24in. to 28in. vacuum will be from 98 deg. to 140 deg. Fahr.—W. A.

25. VELOCITY OF DISCHARGE.—A cylindrical tank, 40ft. high, 9ft. diameter, is full of water. A horizontal pipe 2in. diameter is connected to the bottom of this tank, and is 15ft. long. What is the velocity of discharge, and how long would the tank be in emptying itself through the horizontal pipe?—DERBYSHIRE.

Answer.—In reply to "Derbyshire," I may state that if the 2in. pipe of 15ft. long be perfectly straight, smooth inside, and even in diameter, the velocity of efflux will be 33ft. per second when the tank is full of water, but as it gradually empties the velocity and rate of discharge will gradually diminish; it will, however, empty itself in 117 minutes.—W. A.

15. STRENGTH OF RING.—Will some reader show how to find the strength of a ring made of 2in. diameter wrought iron, and 2ft. outside diameter, which has a weight suspended from its lowest point, and is supported by a chain fixed above, as shown in sketch? I wish to see the calculation, ultimate strength, safe load, &c. How would it resist collapse if the tensions became compressive pressures?—STYLEX.



16. SETTING CORLISS VALVES.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—ENGINEER.

17. CAN anyone inform me where a copy of "The Practical Boiler-maker," by S. Nicholls, published by the author, can be obtained? I have written to Blackpool, where the author formerly resided, but the letter has been returned.—I. W.

22. ANTIMONY.—Will any reader kindly inform me of the best way to melt ground antimony? The only means at my disposal for doing so are in a ladle over gas or over a large stove, and this is not effectual, as the powder simply cakes.—H. P. S.

23. LIGHT MIXING MILL.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—EASTERN.

26. CAVITIES IN SIEMENS CAST STEEL.—Can any reader explain the cause of the hollow cavities occasionally met with in Siemens cast-steel ingots? I mean hollowness so bad as to completely destroy the ingot.—W. P.

27. FORGING MUSHAT STEEL.—Will some practical reader kindly inform me of the best way of forging Mushat steel? I can forge ordinary cast steel, but Mushat steel seems to fall to pieces under the hammer.—STEEL BAR.

TO CORRESPONDENTS.

ENGINEER, Bradford.—If there is an intermediate receiver of sufficient capacity, the cranks should be at right angles to one another.

A. T., Wigan.—Your question is not clear. Do you mean how many cubic feet of steam will pass through 100 yards of 4in. pipes, to do work in an engine at 50lb. pressure, or do you mean how much will discharge from such a pipe by free expansion? Write again.

VULCAN, Maryport.—We published an article in our issue of February 1st, giving an exceedingly complete table showing the lap and travel of a slide valve suitable for given port openings. Look up the table, and you will find a column where the port opening is 1$\frac{3}{16}$, then you can get by the table the travel of the valve required, together with the lap for any required cut-off within limits. The usual allowance for lead is also given there.

S. H. T., Swansea.—We shall be pleased to receive replies to the queries you name, but prefer that you should give what information you may have through our own columns for the benefit of our other readers as well as the querists. Send a description of your improvement in compound engines, and if it is good we shall be pleased to publish it with illustrations. What kind of diagrams do you wish to draw?

MACHINERY FOUNDATIONS.—It is often of great importance to damp the vibrations set up by gas engines and other machinery, and several varieties of elastic foundations have been proposed to this end. In France indiarubber seems to have been used with considerable success, though much depends upon the quality, and it is stated that the common practice of adulterating the rubber with oxidised oil greatly reduces its value for the purpose in question, whilst at the same time this admixture cannot be detected by the ordinary tests. A layer of felt some twelve inches thick has also been used with success, but the best foundation seems to be one of concrete made with asphalt instead of cement.

MISCELLANEA.

Death of Ericssen.—The death is announced of Mr. John Ericssen, the distinguished engineer and scientist, and inventor of the screw propeller. The deceased had attained the advanced age of eighty-five years, having been born in Sweden in 1803.

Italy and the Glass Trade.—Glass manufacturers are shortly to be compelled to compete with fresh arrivals in the ranks of that industry. A company has been formed for the purpose of erecting a glass manufactory in Milan, near Parta Genova. It is stated that the capital already subscribed amounts to about £40,000. It is intended to build houses in proximity to the works for the accommodation of the workmen. Up till now Italy has been entirely dependent for her supply of glass upon other countries.

The American Railway Post.—The Railway Mail Service of the United States at the close of the fiscal year ended June 30, 1888, gave employment to 5,094 clerks. Matter was distributed on 126,310 miles of railway, and on 17,402 miles additional closed pouches were carried. There were also operated 41 inland steamboat lines, on which postal clerks were employed. The postal clerks travelled (in crews) 122,031,104 miles by railway, and 1,767,649 miles by steamboats. They distributed 6,528,772,060 pieces of ordinary mail matter, and handled 16,001,059 registered packages and cases, and 1,103,083 through registered pouches and inner registered sacks.—*Scribner's Magazine.*

A Yacht for New Guinea.—It is stated that the Government, in carrying out the decision of the late Colonial Conference, has bought and fitted a splendid steam yacht for the Government of New Guinea. This yacht is now ready to be despatched for the use of Mr. W. Macgregor, C.M.G., the Administrator, and has just undergone her trial trip. At present she lies in the West India Dock, and has been named the Merry England. In December last Parliament granted £18,500 for a ship for the colony of New Guinea, and it was then intended to expend the money on one ship, but the colonial authorities have since decided to have two ships, of which the second is to be built immediately, and to have stern wheels to adapt her for use in the shallow rivers of the country.

Interesting Experiment in an Irish Foundry.—A new system has been discovered, it is stated, of coating iron with copper. At the commencement of the present year experiments were made at Fulton's ironworks, in Kilkenny, for the purpose of testing the efficacy of the method. A piece of iron, after being raised to almost a white heat, was then thoroughly sprinkled with white coloured powder. It was next re-submitted to heat until the powder in its original form had entirely disappeared from the surface, when the iron was plunged into a quantity of melted copper, and allowed to remain there for not longer than a second. It was then removed and allowed to cool. After cooling it was observed to be completely covered with copper.

Telephoning through the Gas Pipes.—About four years ago the Board of the Consolidated Gas Company in New York hit upon an idea of avoiding the expense of laying down special tubing for the telephone service between the works and the central station, the wire being simply passed through the gas conduit, at either end of which a perforated plate was screwed bearing a glass tube. The telephonic wire runs through these tubes, and is supported at intervals by insulating rings. The new telephonic line is, of course, preserved from the action of storms, and on being examined some time ago it was found to be completely intact, although large crystals of napthaline had been formed on it.

Leeds Association of Foremen Engineers and Draughtsmen.—The usual monthly meeting was held at the Mechanics' Institute, Cookridge Street, on Thursday week, the president (Mr. J. C. Moorhouse) in the chair. A paper was read by Mr. J. A. Tempest on "Hydraulic Dock Machinery," in the course of which he described the construction and application of pressure pumps, accumulators, machinery for opening and closing dock gates and sluices, hydraulic capstans, gear for swing and lift bridges, hydraulic cranes, hydraulic motors, grain warehousing machinery, coal shipping machinery, and hydraulic lifts. Mr. Elsworth described graphically the manufacture of steel by the basic process, as carried on at the North-Eastern Steel Company's Works, Middlesbrough.

Manchester Association of Engineers.—A meeting of this association was held at the Grand Hotel on Saturday night, March 9th, Mr. S. Dixon, the president, in the chair. Mr. Frank Hazelton, assistant secretary, read the minutes of previous meetings, which were approved. A paper by Mr. Dack, Patricroft, on an improved hydraulic lift, was read by Mr. Gilbert Lewis. The chief feature of the lift described by Mr. Lewis is that in raising boats from one level to another it takes no water from the upper level, the entire quantity of water being taken from the lower level by a system of hydraulic cylinders, preferably three in number, two of which are friction cylinders. The whole weight is raised in this manner. When lowering the two friction cylinders are knocked off, and the water used in the main cylinder for lifting is returned to its source and is available for further lifts. By this system, it is claimed, greater economy is secured than by any twin system or direct system of hydraulic lift. Several illustrations of the improved lift were displayed on the walls.

The Isthmus of Corinth Canal.—The Panama undertaking is not the only canal scheme in the execution of which difficulties of a formidable character have arisen. The Isthmus of Corinth is just under four miles in width, and according to the original plan the canal was to be completed within 1888 at a cost of 30,000,000 francs. This it is now found will not be possible before 1891, and at a cost of double the sum. The managing committee has decided to defer payment of the interest of 5 per cent due to the shareholders. The committee appointed by the Government has been informed that the angles of slope should be reduced, and the sides protected by walls, to prevent any slips of earth. The manifest advantage, however, of avoiding the dangerous course round the Morea in winter makes the complete execution of the work a certainty, especially as Greek finance, owing to M. Tricoupis, has attained such an improved position.

Compressed Air Company, Birmingham.—The Compressed Air Company, Birmingham, is rapidly completing the installation of the service of mains by which it proposes to supply compressed air to users in different portions of the town. Four miles of mains, ranging from 24in. to 7in. in diameter, have already been put down, and the other three miles included in the scheme will not be laid down for some time yet. It is hoped that the company may be able to commence operations by the beginning of April. In one case an intended consumer proposes to apply the compressed air to the driving of an eighty horse-power engine for a rolling mill, and generally its application seems likely to be largely applied to the driving of motors of considerable powers. The company has very nearly surmounted the difficulty as to a proper meter. The supply will be per cubic foot, with a pressure of 45lb. per square inch, and it has been found difficult to obtain an appliance that would neither throttle the supply nor pass air without registering it. Mr. Howard Lane, however, has designed an instrument which it is hoped will efficiently do the work, andwhich has received the conditional approval of the corporation authorities.

The Durability of Steel Rails.—A commission, representing the various German railway companies, has just published a report detailing the results of observations made during six years on the durability of steel rails on German, Austrian, Hungarian, Dutch, and Belgian lines, from which it appears that the durability of a steel rail may be reckoned on an average at 35 years, presuming that the annual traffic be calculated at 343,000 tons and the minimum and maximum of wear and tear allowed be 0·007 and 0·017 millimetres. The average traffic on the German lines amounts in the year to 3,430,000 tons, and represents 28 passenger and 10 goods trains per diem. In estimating the value of the above calculation it must, however, be borne in mind that before reaching the maximum of wear and tear named the rail would probably have to be condemned on account of roughness of its surface. On the Heusinger line, where there are neither steep gradients nor sharp curves, and the brake consequently comes but little into play, the wear only amounted to one millimetre for about 10,000,000 tons.

The Cost of Steel in Great Britain and America.—We see from a report just published on the production of steel in Great Britain and the United States, 1,048 hands in the latter country produced 4,500 tons of Bessemer rails in a week, which would average 4·3 tons per man. In Great Britain, on the other hand, 600 workmen produced 1,500 tons in the same time, or only 2½ tons per man. The average wages in America were, however, fully 35 per cent higher than in Great Britain, which nearly equalised the cost of labour per ton in both cases. The difference in the actual cost of production in the two countries must then principally be attributed to the great distances from which the American works have to obtain their supplies of raw material for the manufacture of Bessemer steel, and this obstacle to the development of the rail industry in the United States would be obviated if the basic process were introduced into that country, since in many instances suitable mineral could then be found in close proximity to coal fields. There is, however, no probability of the manufacture of Thomas steel being developed in America at present, since a group of the Bessemer works has bought up all the patents referring to the product, and can consequently prevent all new works from producing it.

Caoutchouc Belting.—The employment of so-called rubber belting for machinery, or rather belting composed of cloth and caoutchouc, seems to be rapidly gaining ground in most industrial countries, since it appears that belting made of such materials presents greater homogeneity and uniformity of thickness than can be obtained with leather. Moreover, the rubber belting adheres more closely to the pulley and is not liable to stretch so much under severe tension; for instance, under a strain of 2·52 kilos. per square millimetre it would give no more than a leather belt that has to stand a strain of only 1·66 kilos. Rubber belting can also be made of dimensions that it would be impossible to obtain with leather, and its manufacture has been brought to such perfection in America that nine-fold belts have been produced in that country 52in. wide, 298ft. long, and weighing about 4,000lb. It is even stated that a monster rubber belt, 2,700ft. long, is employed in Jersey city for conveying grain from the vessels to the railways. Another advantage presented by these belts is that they have comparatively few joints. A rubber belt, for instance, of fully 60ft. in length can be manufactured with only one joint, while there would not be less than six seams in a leather belt of the same length, which would naturally be a source of weakness.

Engineering Society, King's College, London.—At a general meeting of this society, held on Tuesday, February 19th, the president in the chair, Mr. F. S. Atkinson read a paper on "Lartigue Railway Systems." The author commenced by giving a general idea of the system; he then dealt with the line at Westminster, giving a detailed account of the locomotives in use; and described the Lartigue system in Algeria, where, he stated, it had given great impetus to the Esparto grass trade. He also stated that in Russia the system had been found useful for military purposes. The author then dwelt on the advantages and disadvantages of the system, and concluded with a detailed description of the Listowel and Ballybunion railway.

Death of a Manchester Celebrity.—There died at Manchester recently Mr. Robert Hattersley, whose name has been associated with an invention of considerable value to the printing trade, viz., that of machines for the mechanical setting and distributing of type. Mr. Hattersley was a practical engineer in his early life, in the employment of Messrs. Sharp, Stewart and Co., engineers, of Manchester, when the works were under the management of Mr. Beyer. Mr. Hattersley had his attention drawn to the process of setting type by his brother, who was a typographical printer, and in consequence of the trade being practically in the primitive condition in which it was left by Caxton he devoted his ingenuity to the invention of a machine which would dispense with manual labour, and enable the work of type-setting to be carried out with much greater expedition than was practicable by hand labour. The result of many years' study and experiment was the invention of the type machines which are now known by Mr. Hattersley's name, and which have attained a considerable reputation in the printing trade. Mr. Hattersley, who was a very careful and experienced engineer, overcame the many difficulties in perfecting his machine by great exactitude of mechanism and most skilful ingenuity. He was in his 59th year, and, though his health had been failing for some time, his death was not anticipated.

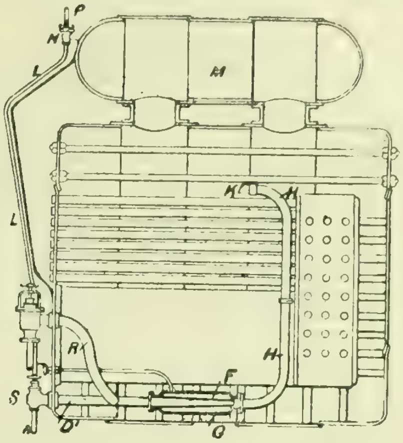
Electric Tramways in America.—The application of electricity to street railways in America is proceeding rapidly. Already nine lines are fully equipped and running, while 22 are being built, and 15 others have been contracted for. In Richmond 12 miles of track are being operated on the overhead system. The current is conveyed by a contact wire 1in. diameter, and at an electro-motive force of 450 volts. The running stock (says *Engineering*) consists of 20 closed cars, seating 22 persons each, and 20 open cars, seating 40 each, fitted with a Sprague motor. The running speed is 7½ miles an hour on the average, with a maximum of 15 miles an hour. The gradients are very severe; the worst is one of 10·1 per cent, but it is very short; another is 9·2 per cent for 100ft., while gradients of 8·5 per cent occur on curves of 40ft. radius, and gradients of 5·3 per cent on a radius of 27·5ft. In New York the Julien Company are extending their system. On the Fourth Avenue line the cars are now running three round trips, or 36 miles, without change of battery. Twelve miles are run with the expenditure of 15 electrical horse power. An electric power transmission plant was lately erected on the Big Bend river of California. Two five-horse power Sprague motors at the end of an eight-mile circuit succeeded in clearing a shoal of water 600ft. square by 10ft. average depth in the bottom of the river channel. The efficiency obtained at the point where the pumps were located was 65 per cent. The situation was such that no other form of transmission than electric could have been employed.

A New Application for Glow Lamps.—Owing to the pressure of work at the chain, cable, and anchor testing works of the River Wear Commissioners, South Dock, Sunderland, the introduction of the electric light was decided upon some time ago. At first seven 300 candle-power "Sunbeam" lamps were fitted up, the current being supplied by one of Messrs. Clark, Chapman, and Parson's turbo-generators at 65 volts pressure. These lamps, though giving a good general illumination, did not, however, prove efficient for the work of examination of chains and anchors under test, and to get the requisite amount of light for this particular work it was estimated that the pressure would have to be increased to 80 or 100 volts. This would, of course, have shortened the life of the lamps very considerably, and could not, therefore, be done. In this difficulty Mr. J. Hartness, superintendent of the test works, hit upon the device of portable lamps fixed to the peaked caps of the workmen, and connected with the overhead mains by their flexible leads. This arrangement has proved perfectly successful. The lamps are of 16-candle power only, and it was even found possible to slightly reduce the original voltage, for as the man bends over his work the light is brought quite close to it, and is found to be ample for the purpose. The flexible leads allow each man to move within a radius of about 20ft., and this distance could be increased if necessary. This is probably the first time that glow lamps have been so used in an English works, although M. Trouvé devised, some years ago, a similar arrangement for use in the Paris sewers. In this case, however, the current was produced by a primary battery carried in a knapsack on the back of the workman, and as a battery of small weight only was admissible, the light was necessarily feeble. The system now in use at Sunderland should prove useful in other works where the men move only within a confined space. The peak of the cap effectually keeps the glare of the light from the eyes of the worker, and the light flexible lead overhead does not inconvenience him.

ILLUSTRATED PATENTS.

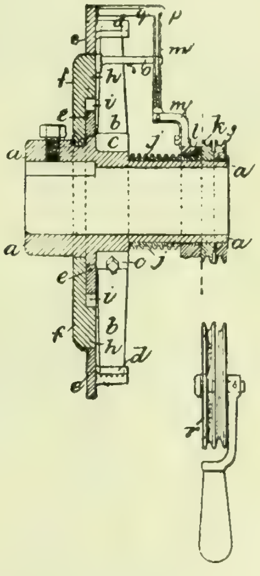
14,233. **Steam-boiler Water Circulation and Feed-water Heating**, D. Thomson, Poplar, Middlesex.

Relates to improvements in that class of apparatus in which the incoming feed water induces currents of low-lying boiler water, and, rising with such boiler water through suitable channels, issues near the water surface. The improvements principally consist in the application of a steam jet to assist in the circulation. As applied to a marine boiler, when the working pressure has been reached, a pipe L conducts steam from the reservoir M, or the superheater, to a clack-box S containing a non-return valve. The steam then passes, with or without feed water from the branch R, through the nozzles D¹ and F, and draws low-lying water through perforated lateral pipes opening into the chamber G The mixture then ascends the pipe H, heating the feed water in its passage, and issues from the valved opening at K. When steam is being raised in the boiler, and in consequence there is no steam from the boiler available for water circulation, steam is conducted from a donkey boiler for that purpose through the pipe P and valve-box N into the pipe L.—October 19, 1887. [8½d.]



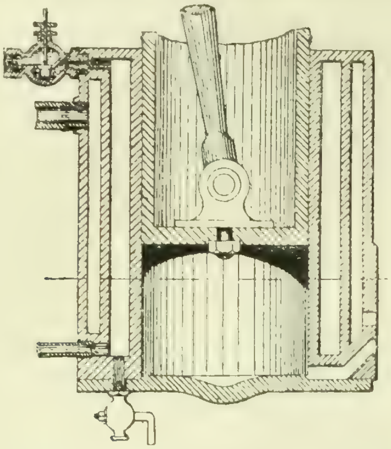
14,247. **Dynamometers**, W. Parkinson, Accrington, Lancashire. (J. Wallace, Bombay, India.)

Relates to dynamometers for estimating the power required to drive a machine. The sleeve *a* is secured to the driving shaft, and has a flange *f* which supports a loose disk *e*. The flange has two projections *h*, which enter slots *i* in the disk and act as stops. A number of radial plate-springs *b* are secured to the sleeve by set screws *c*, and are held at their outer ends by jaws *d* projecting from the disk *e*, which is thus driven by the sleeve *a*, through the springs, and has as much play as is permitted by the projections *h*. The driving pulley is loosened from the shaft and attached to the disk *e*, the driving power being thus transmitted to the machine which is being driven through the springs *b*, whose flexure thus affords a measure of the power expended. A sheet of paper *q* is held in a support *p* attached to the disk *e*, and a diagram traced upon it by a pencil held in a spring-holder *m*. The pencil holder passes between two pins *o*, projecting from the flang *f*, and thus revolves with the sleeve *a*. It is attached to a nut *l* on a screwed sleeve *j*, loosely mounted on the sleeve *a* and turned by a pulley *k*. The pulley *s* is attached to the sleeve *a*, and drives by means of a cord a double grooved pulley *r*, mounted on a suitable handle. The pulley *r* drives the pulley *k*, which actuates the screw *j*. The grooves in the pulley *r* are of slightly different diameters, and thus driving the screw *j* at a different rate to the sleeve *a*, and imparting a traversing motion to the nut. The pencil thus moves in one direction or the other, according as the pulley *s* is connected to the larger or the smaller of the grooves in the pulley *r*.—October 20, 1887. [8½d.]



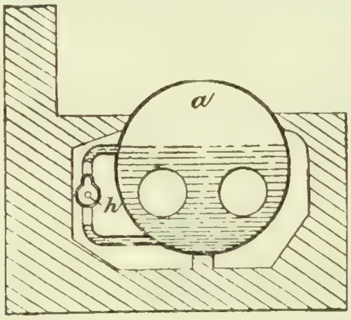
14,269. **Fluid-pressure Engines**, R. Hutchinson, Brompton, Middlesex.

Consists in a method of utilising heat radiated from the cylinders of steam, gas, or other engines in which heat is the source of power, for vaporising oil or other hydrocarbon. The cylinders are made with a double jacket, to the outer of which the exhaust from the cylinder is admitted. The oil to be vaporised is supplied to the inner jacket, the necessary fittings being added for regulating the inflow of the liquid and outflow of the vapour. The latter may, for example, be employed for driving an engine or motor.—October 20, 1887. [8½d.]



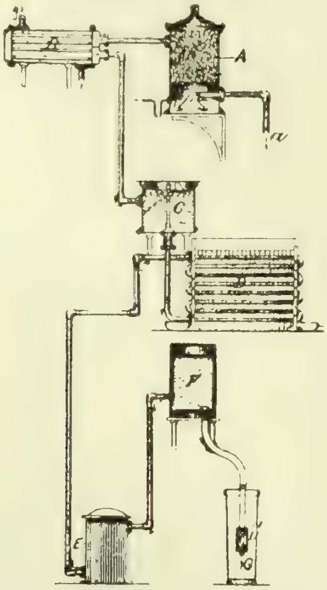
14,359. Promoting Water Circulation in Steam Boilers, C. C. S Knap, London.

For this purpose a fan, pump, injector, or similar contrivance mechanically displaces the water in an external pipe connected at both ends to the water space of the boiler. The illustration shows a centrifugal pump *h* applied to the "Lancashire" boiler *a*. The specification also describes and illustrates the application of the invention to a sectional steam generator.—October 22, 1887. [1s. 2d.]



14,440. Ice Making, L. Sterne, Westminster. (J. C. de la Vergne, New York, U.S.A.)

Transparent ice is made without stirring by employing exhaust steam from the engine after it has been filtered and condensed. The steam passes from the pipe *a* through the filter A and is condensed in the vessel B by the water previously used for liquefying the compressed ammonia gas. The water leaves at the temperature of boiling point, passes through the regulator C, and is cooled in the condenser D. It then passes through the water filter E into wooden storage tank F, from which it may be drawn as required for the ice moulds G through the valve i^1, which is opened when its stem touches the bottom of the mould. October 24, 1887. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq. *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

February 21st.

3093 Driving Gear, T. Taylor, London.
3094 Drilling Machines, T. Taylor, London.
3098 Hardening Steel, R. H. Brandon, Paris.*
3113 Gauges, A. F. Tavernier and E. Casper, London.
3124 Pumps, C. J. Appleby, London.
3125 Filters, W. Mather, London.
3127 Chains, A. G. D. Craushay, London.
3136 Screw-down Valves, J. Larmanjat, London.
3137 Water Gas, W. C. Owston, London.
3141 Breech-loading Guns, H. H. Lake, London. (Die Actien-Gesellschaft Grusonwerk, Germany.)*
3142 Tool Handles, A. J. Boult, Middlesex. (A. Hartmann, Germany.)*

February 22nd.

3150 Heating Apparatus, J. A. Groom, London.
3151 Tubes, C. H. Smith, Bradford.
3161 Testing the Strength of Paper, W. Sinclair, Glasgow.
3173 Duplex Engines, G. Thomson, Birmingham.
3176 Valve, R. G. Schmitz, Manchester.*
3185 Rolling Mills, J. F. Miller and F. Finlayson, Glasgow.
3187 Motor, P. M. Justice, Middlesex. (W. P. Gibson, United States.)
3224 Brake, G. H. Foster and J. Tuckett, Middlesex.

February 23rd.

3228 Corrugating Machines, J. Bigwood, T. C. Bigwood, and H. M. Bigwood Birmingham.
3244 Valve Seatings of Pumps, J. E. Rogers, Tipton.
3246 Vacuum Motors, E. G. Wastfield, Stoke-on-Trent.
3255 Looms, T. Taylor and T. Dawson, Manchester.
3263 Electrical Dynamos, G. Richards, Manchester.
3267 Tool Holders, J. Hope, Liverpool.
3284 Motive-power Engines, C. Cole and J. W. Booth, London,
3293 Liquid Meter, H. C. Ahrbecker, London.
3298 Crushing Ores, T. R. Jordan, London.

February 25th.

3317 Gas Furnaces, W. Simms and E. Houghton, Manchester.
3321 Ring Throstle Frames, J. Dickinson, Manchester.
3324 Arc Lamps, F. T. Schmidt, Bradford.
3325 Heating Feed-water, W. C. Lockwood, Sheffield.
3326 Testing Machine, R. H. Smith, Birmingham.
3327 Signalling, W. Ballard, Worcester.
3331 Engines and Motors, M. J. Adams, Yorkshire.
3332 Ventilating, A. Shaw and J. Parkinson, Yorkshire.
3334 Carding Machine, G. Ebenauer, London.
3335 Ring-spinning Machines, G. Ebenauer, London.
3340 Lamp Reflectors, G. L. L. Eldon, London.
3343 Pulley Blocks, T. Deer, Liverpool.
3350 Electricity, Sir C. S. Forbes, Bart., London.*
3361 Rotatory Motors, E. O. Tompkins, Westminster.
3366 Gas Lamps, F. H. Wenham, London.
3380 Sheaves, W. Blair, London.

February 26th.

3401 Dynamo-electric Machines, E. A. Sperry, London.*
3405 Lifts and Hoists, H. G. Warren, Kent.
3406 Punching and Shearing Machines, N. Bird, Workington.
3412 Fire Extinguishers, J. M. Miller, London.*
3416 Carding Engines, J. Moorhouse, London.
3418 Valves, J. J. Rose, London.
3419 Coupling Railroad Cars, T. C. Chappell, London.*
3436 Steam Traps, E. E. Gold, London.*
3444 Cartridge-loading Mechanism, G. M. Peters, London.*
3456 Electric Circuit Couplers, S. C. C. Currie, London.*
3469 Rotary Engines, L. C. Huson and The Huson Motor Co., Limited, London
3471 Portable Railways, A. Koppel, London.*

February 27th.

3475 Expansion Gear, H. Kühne, London. (W. R. Proell, Germany.)
3489 Traction Engines, F. J. Burrell, Norfolk.
3496 Miners' Safety Lamps, E. Kaye, Leeds.
3507 Screw-down Valves, R. Bradley, Manchester.
3524 Furnace Fire Bars, T. Bradley and W. Bradley, London.

February 28th.

3544 Looms, J. Cowburn and C. Peck, Manchester.
3546 Facing Tools, A. Anderson, Glasgow.
3547 Gas Furnaces, J. Bromilow, Gateshead-on-Tyne.
3552 Plaited Packing, L. G. Cresswell, Manchester.
3557 Valve Gear, J. E. Rogers, Tipton.
3560 Lubricator, E. Chappell, Manchester.
3567 Engine Packing, J. Moseley and B. Blundstone, Manchester.
3570 Rotary Blowers, J. C. R. Okes, London.
3571 Consuming Smoke, J. Kippax, London.
3581 Grinding Rolls, J. H. R. Ritson and W. Jenkins, London.
3583 Steam Generators, R. Marshall, London.
3606 Corrugated Tubes, S. Ziani de Ferranti, London.

March 1st.

3613 Compound Engines, A. B. Drautz, London.
3618 Belting Composition, A. Huxley, Birmingham.
3620 Slotting Machinery, Z. Coltman, Loughborough.
3638 Automatic Feed Apparatus, J. Barr, Glasgow.
3640 Governors and Valve Gear, R. M. Harison, Glasgow. (F. A. Gardner and Co., United States.)*
3648 Ball Valves, J. Jackson, London.
3649 Pipe Joints, H. S. Smallman, Birmingham.
3650 Union Joints, F. W. Plumstead, F. Kingston, and H. C. Pearch Pentonville.
3654 Screw Fans, R. D. Hughes, London.
3657 Air Nozzle, W. A. Granger, London.
3684 Coupling Shafting, E. J. P. Ranet, Middlesex.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE
PRACTICAL ENGINEER,
MARCH 22ND, 1889.

HEAT REGENERATORS.

ALTHOUGH the successful application of the regenerator and of the regenerative principle to practical engineering is generally associated with the name of the late Sir C. W. Siemens, yet it should not be forgotten that we owe the invention in its primitive form to two men—the late Rev. Dr. Stirling, a Scottish clergyman, and Captain John Ericsson, the famous Swedish engineer and inventor, who has just died in New York, at the great age of eighty-six years. The invention was simultaneously originated by them, and both sought to utilise it in the production of efficient forms of hot-air engines. Both succeeded in constructing workable engines in which air alone was used and steam entirely dispensed with, and many engineers predicted a complete change in the modes of obtaining motive power. Professor Macquorn Rankine and Mr. John Bourne were especially confident in this direction.

Although Ericsson's name is more popularly associated with his later work, the design of the American monitors, and with his earlier work, the invention of the locomotive engine, the Novelty, which competed at the Rainhill trials, yet at this time it may be appropriate and interesting to discuss the development and difficulties of the regenerator during the more than fifty years which have passed since its first conception.

The original idea was exceedingly simple, and the expectations formed of its applicability to heat engines were probably erroneous. The theory of heat engines was at that time very imperfect, and in the light of modern knowledge we can now see how closely akin to perpetual motion were the beliefs entertained regarding its possibilities. It was thought that when air was expanded by heat, and caused to do work upon an engine piston, that all the heat remained in the air at the end of the stroke, as at the beginning. It therefore followed, that if this heat could be abstracted by some contrivance from the discharge air, and imparted to the entering cold air, an almost indefinitely great increase in economy would be the result. The regenerator was an attempt to accomplish this purpose.

The Ericsson hot-air engine consisted fundamentally of two cylinders, one for compressing air, and the other for expanding the compressed air after it was heated by a furnace—a compressing cylinder and a power cylinder, in fact.

The compressing pump or cylinder took in air from the atmosphere at each stroke, and compressed it into a receiver at a pressure of about 30lb. per square inch; from thence it passed to a regenerator, containing a very large metallic surface, through passages into the working cylinder, the bottom of which was heated by a furnace, and then it did work upon the piston by its expansion by heat.

In this engine the power was obtained by increasing the volume of air, when compressed, by heat, not by increasing its pressure. When the piston got to the end of its stroke the pressure had fallen nearly to atmosphere, and then the hot exhaust was passed through the regenerator before being expelled into the outer air. The plates were thus heated, and the entering cool air coming from the compressed air reservoir was heated thereby before reaching the furnace-heated part of the cylinder bottom. So far as the regenerator was concerned, the principle of Stirling's engine was very similar, but in that engine the air was not expanded without increase of pressure by the heat, but was heated at constant volume, and, therefore, the pressure, instead of the volume, was increased. Both engines worked well in practice for a short time, and Stirling's even gave a fair amount of power in proportion to its bulk, but both had fatal practical defects, arising in part from the burning out of the heated metal cylinder bottoms, and in part from the difficulty of keeping the regenerator interstices clear from obstruction caused by dust and oil.

Many inventors have since laboured at the problem, but in vain. Over fifty years of effort have failed in applying the principle successfully to engines, although engineers so distinguished as the late Sir C. W. Siemens and Professor Fleming Jenkin devoted many years to experiment with such inventions.

Siemens entirely failed in applying it to engines, but when he turned his efforts to furnaces he succeeded admirably, and regenerative furnaces are now much occupied in almost all metallurgical operations for steel and iron production. Many other industries, too, profit by the regenerator, of which perhaps glass-making and gas manufacture are the chief. The regenerative gas lamp of the Siemens and Wenham type, now so commonly seen, is its latest application.

Now, it is well to note the comparative conditions of its failure and success, particularly as we have lately observed that some of our engineering contemporaries favour fresh attempts to apply it to engines. Those attempts are, in our opinion, doomed to failure from a commercial engineering standpoint, as no fresh combinations have yet arisen to avoid the difficulties which conquered inventors in the past. The conditions necessary in the interior of an engine were, and still are, entirely opposed to those requisite for successful regeneration. There the minimum clearance space is required. In regenerators large clearance spaces are necessary in order to provide sufficient surfaces for the absorption and transmission of heat. Again, wherever high temperatures are used, non-metallic substances, such as fireclay, form the most efficient regenerator surfaces, and such substances have long been known to be entirely inadmissible within an engine.

The late Professor Fleming Jenkin very clearly pointed out this fact, as the result of a long series of his experiments extending over some years. He found that fireclay subjected to heat in the interior of a cylinder, together with changes in pressure, rapidly split up into minute fragments by the gases getting forced into the pores, and then the sudden change of pressure upon opening the exhaust valve caused them to expand again and rupture the material. Many other air-engine inventors have encountered the same difficulty. In furnace work, on the other hand, the pressure of gases surrounding the material, if it changes at all, changes but slightly, so no tendency to disintegrate arises except from the inevitable unequal expansion due to heating and cooling. The fracture of fireclay within an engine cylinder causes dust and grit, which invariably grind and score both piston and cylinder. Metal, on the other hand, deteriorates rapidly by oxidation, so that in attempting regeneration within an air-engine cylinder we are met by the necessity of reconciling entirely contradictory conditions.

In conclusion, we may state our opinion that, however admirably adapted for furnace work, regenerators are at present entirely unsuited for engines, and that the work of 50 years has not brought us within measurable distance of any such successful application. We would accordingly dissuade engineers from being tempted into experimenting with engines of the so-called thermo-motor type. They are thoroughly impracticable, and will remain so if fireclay or porcelain is used in the interior of their cylinders.

Mr. George Westinghouse, jun., is having an instruction car built at Altoona for the purpose of showing American railroad men the practical working of all the Westinghouse railway appliances. The car will be fitted with working models of the improved air brake, steam heating apparatus, and other specialties. A 15 H.P. boiler and a Westinghouse engine and dynamo will be included in the fittings.

BOILER EXPLOSIONS.

Board of Trade Reports.

Since our last reference to these publications a number of reports have been issued. These reports are in the main very similar to those to which we have referred on previous occasions, but, as it will doubtless be of convenience to many of our readers to have a complete record of the Reports of Preliminary Inquiries that are issued from time to time under the Boiler Explosions Act, we will take up the list from the point at which we left off in our issue of December 7th last, although many of the reports which have been issued since that date deal with casualties of an exceedingly trivial nature, and can only be characterised as boiler explosions in virtue of a legal definition.

Report No. 292 refers to the fracture of the cast-iron valve chest cover on board the steamship Emma, of Sunderland, while lying in the roadstead of that port on September 3rd last. As the vessel was subsequently lost in a voyage a few days after the casualty, no accurate particulars as to its cause appear to have been gleaned. The explosion is stated to have resulted in the blowing away of a portion of the cover of the chest of the auxiliary starting valve, but no one was injured.

Report No. 293 deals with the bulging of the furnace tube of the boiler on board the steam yacht Buccaneer, while on a voyage from Torquay to Liverpool. No person was injured, and the dimensions of the fracture which constituted the explosion are not stated, but from the description and the fact that the engineman was drawing the fires at the time it occurred, it would appear to have been little more than a crack two or three inches in length. The case is of interest mainly from the fact that it was pregnant with possibilities of serious disaster. From the evidence elicited by the Board of Trade Surveyor, there can be little doubt the bulging was the result of overheating, arising from the density of the water in the boiler. Those on board either neglected the use of the salinometer or failed to read it correctly, for the boiler was allowed to become charged with a saturated solution of salt, which formed a deposit ⅜in. thick on the furnace crown and led to its overheating.

Report No. 294 refers to the explosion of the boiler of a traction engine at Rothienorman, Aberdeenshire, on November 3rd, and resulted in the death of the attendant. The engine was used for threshing and general haulage purposes, and the explosion, which occurred on the public road, arose from the collapse of the left-hand side of the firebox, in consequence of the failure of sixteen of the stud stays uniting the firebox to the outer casing. The report attributes the failure of the stays to their defective condition, coupled with excessive pressure in consequence of the safety valves being unduly loaded. The safety valves were loaded with spring balances, and the nominal working load appears to have ranged from 80lb. to 100lb., according to the class of work upon which the engine was engaged. The valves were, however, not fitted with stop ferrules, and there was nothing to prevent them being screwed down hard and fast, and thus rendered quite inoperative. Although there was no direct evidence that the valves had been tampered with at the time of the explosion, still, from all the circumstances, it would appear very probable that the nominal working pressure was considerably exceeded. The folly of equipping traction engine boilers, or indeed boilers of any kind, with safety valves which can be rendered useless by a few turns of a thumb nut, has been so frequently pointed out in our columns that a repetition of the warning becomes almost nauseous, and we should hardly deem it necessary to reprint it did we not know from experience that stop ferrules on spring balance safety valves are the exception rather than the rule. It should be stated that the boiler was not under the care of any boiler inspector or insurance society.

Report No. 295 refers to the failure of a small vertical multitubular boiler at Deptford, on October 28th. The boiler was of the ordinary vertical type, except that, instead of a single centre uptake connecting the crown of the firebox to the crown of the shell, there were ten small smoke tubes, 2¾in. in diameter. These tubes were ferruled at the lower or firebox end, but simply expanded in the tube plate at the top, and the failure was caused by the upper tube plate slipping off the tube ends at the ordinary working pressure, when the rush of steam so severely scalded the brother of the owner that he died a few days afterwards. The upper ends of the tubes had become wasted by corrosion until they were reduced in some places to the thickness of paper, and had thus completely lost their hold upon the plate. The report states that the boiler had been in the possession of the owner about seven years, but no examination had been made during that time to ascertain its condition.

THE CENTRAL SUBWAY RAILWAY FOR LONDON.

As every year brings into greater prominence the need for better means of rapid transit within what may be termed the inner circle of London, and intensifies the congestion of the surface traffic, it is not surprising that plans are forthcoming to overcome the difficulty. The latest suggestion, and one which is even now only awaiting the consent of Parliament to become an established fact, is that of an electric railroad laid in the middle of existing thoroughfares, but beneath the street surface ; indeed, the street surface forms the upper part of the superstructure of the covered railway.

In the design proposed the material of the street is removed to a depth of about fourteen feet, and a solid basis of concrete two feet in thickness brings up the surface of road to within twelve feet of the street. Along the line of kerbs strong longitudinal walls spring from the concrete base and serve to support the ends of steel girders which extend over the railway. Between the girders and over them the floor of the street is formed by steel buckled plates, asphalt, and concrete, on which latter is laid the street pavement. The steel girders are supported at intervals by pillars, between which are fixed panels of "terflax," a tough, non-resonant material composed of steel wire embedded in compressed vegetable fibre, and prepared by some chemical process to resemble horn. By these means the covered way is subdivided into as many separate ways as there are tracks of railway, and as the traffic in each one of these subdivisions is always in one direction only, it is plainly seen that great facilities are afforded to the proper and effectual ventilation of the line. The kerb walls form the boundary of the cellars or vaults of occupiers along the line of route, and will leave such vaults intact. These walls form also one wall of the longitudinal galleries which extend along both sides of the railway. In these galleries will be placed all the gas, water, steam, hydraulic, and pneumatic pipes and tubes at present existing in the streets passed through and all future pipes or tubes.

The buckled plates of the subway roof afford facilities for all the telegraph, telephone, or other wires that can ever be required, and when it is considered that no future tearing up of the streets for the purpose of laying or repairing pipes will be required, it is not difficult to understand the benefits claimed for the scheme, quite apart from its intrinsic value as a means of rapid transit.

As it is most desirable that the construction of the railroad shall not interfere with present street traffic, it is intended to open the streets only in narrow longitudinal sections, and to provide by night a good road surface, as was done in the shallow work of the Metropolitan Railway, all excavating being effected from below, and no spoil appearing on the street surface.

The motive power to be provided is entirely electrical. Indeed the use of steam locomotives is wholly out of the question. The three causes of vibration in a steam railway are—first, the repeated increments and decrements of atmospheric pressure which occur in all covered ways or tunnels from the pulsations of the exhaust ; secondly, the vertical non-balance of the locomotive itself, due to the horizontal counterbalancing which throws the engine out of balance vertically, and gives rise to severe vertical vibration, as bridgemen know well ; and, thirdly, rail joints, especially when the rail length and wheel bases of the vehicles are about equal. The first two, and the main causes of vibration are completely eliminated in an electric motor, which has no exhaust, and is perfectly balanced in every direction by reason of its symmetrical construction ; and the third cause is eliminated by supporting the rails on stiff longitudinal sleepers of steel, bedded in the concrete base or floor, so preserving an even and continuous rail surface.

The carriages intended to be used are carried very low, and entered from the ordinary rail level with ease. In this way is secured ample height of carriage and steady running, the wheels being 42in. in diameter. The carriages, like the subway partitions, will be largely constructed of the material "terflax," and will thus be very strong and safe. They will be electrically lighted. Entrance to the various stations on the route will be by doors, opening from the footpaths through ordinary buildings to staircases within such buildings ; and a great advantage of this *shallow* subway railway is the very small amount of stair-climbing which passengers will be required to perform. It is now clearly perceived that this great depth has been an obstacle to the success of the underground lines of London, as well as the noxious vapours of sulphur and the oxides of carbon.

As the design of the subway embodies no excavating below the line of thrust of even quite shallow foundations, no fear need be felt as to their endangerment by the line, and as vibration is eliminated the line is unlikely to be a nuisance ; and as it will avoid all future street breaking up, it is said to be largely supported by the intelligent occupiers who will be affected by it, though the invariable Colonel Sibthorpes of 60 years ago are still alive and protest against all innovations. The portion applied for in the bill now pending is that from St. James's Street, Piccadilly, to Holborn Circus, by way of Shaftesbury Avenue ; and it is estimated that the line can be completed and at work within twelve months from commencement. By the arrangements contemplated a service of trains will run in either direction at intervals of two minutes.

CORROSION AND PITTING IN MARINE BOILERS.*

The question of boiler corrosion and pitting is one that has had the writer's professional attention and consideration for some few years ; and although he is somewhat conversant with the many theories and practical explanations so ably propounded in papers read before the various scientific institutions of this country, yet it appeared to him that the chemistry of corrosion as investigated by himself would be of interest to this institution.

It was not his intention to propound any startling theories, but to lay before the members the simple and plain facts he has observed, and the deductions he has drawn therefrom.

On examination of corroding boilers, those parts seriously affected are generally found devoid of the usual hard, protective, "sulphate of lime" scale, and in exceptional cases the whole of the boiler is perfectly free from this scale, and the various parts covered with a red, or even a black coating of a soft matter, frequently slimy in character. Much of this matter is found on the upper portions of the boiler in the form of a froth, while the rest is deposited on the tubes, combustion chambers, or settles to the bottom of the boiler like mud.

Attention is particularly drawn to the chemical composition of this deposit ; the following analyses may be taken as fair averages of the many samples the writer has examined and analysed :—

	Deposited at bottom of Boiler. Per cent.		From top of Boiler. Per cent.
Ferric oxide	65·00	...	72·9
Calcic sulphate................................	9·02	..	1·58
Calcic oxide	·75	...	1·38
Magnesic oxide................................	10·12	...	8·14
Zinc oxide................................	·75	...	1·35
Sand, &c.	1·70	...	1·2
Oily organic acid, combined with the ferric, calcic, and magnesic oxides...	10·66	...	10·75
Free uncombined oil	2·00	...	1·25
Water	—	...	1·45
Total	100·00		100·00

In some cases this oily combined acid has amounted to 20 and even 25 per cent.

On examining these deposits one is struck with the curious fact that they contain a very large percentage of magnesic oxide in an insoluble form, and also with the fact that they contain a very considerable amount of oily organic acid, and that this organic acid is in combination with the ferric, calcic, and magnesic oxides. The presence of this insoluble magnesic oxide compound at first sight appears unaccountable, and causes us to speculate as to where it comes from, because sea water only contains magnesia as either sulphate or chloride, both of which salts, especially the chloride, are exceedingly soluble, and are not, as sulphate or chloride, capable of forming an insoluble deposit. Indeed, in one gallon of sea water only the 98·7 grains of calcic sulphate and the 2·8 grains of calcic carbonate are capable of forming permanent insoluble deposits on boiling and evaporating. All the other constituents are very soluble, and simple boiling and evaporation, to the extent carried on in a steam boiler, would only make the solution stronger without causing their deposition in an insoluble form—that is, supposing no other influences acted on them at the same time. It may be asked, might not the river waters with which the boilers are filled when in port furnish this magnesia ? But river waters do not contain magnesia salts as a rule, but are surface waters containing principally calcic sulphate ; therefore this magnesic oxide of the deposits must be derived from the chloride and sulphate of the sea water.

There is also another fact noticeable in the analyses of these deposits, and that is the very considerable percentage of "oily organic acid" present in combination with the ferric, calcic, and magnesic oxides, and this organic acid is derived from the mineral oil used as "cylinder oil" in the cylinders. It is generally stated that these oils are hydrocarbons, therefore not capable of saponification, and that they do not affect metallic surfaces. This is correct as applied to these oils in their natural state; then alkalies do not affect them or form soaps, nor is copper or other metals tarnished or corroded, even after being immersed in them for a considerable or indefinite length of time; but it is incorrect as applied to these oils when exposed to the influences and conditions existing in the high-pressure cylinder of an engine working at such a pressure that the temperature is higher than the "vaporising point" of the "cylinder oil" which may be in use. All these oils are capable of oxidation, otherwise they would be incombustible; and placed under sufficiently favourable conditions for oxidation, such as very extended surfaces exposed to the action of steam of sufficiently high pressure, and therefore temperature, to reduce a portion of the oil to a vaporous state—and these are the conditions existing in engine cylinders, particularly in the high-pressure cylinder of a triple engine—under these conditions these oils will become in part decomposed and broken up, producing compounds different from the original oil put into the cylinder. These compounds pass forward with the steam, and gradually work their way through the condenser into the boiler, and these compounds so introduced into the boiler are capable of combining with bases such as ferric oxide, calcic oxide, or magnesic oxide, as is proved by the constituents of the deposits already mentioned.

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*J. B. Dodds. North-East Coast Institution of Engineers and Shipbuilders.

Oil merchants and manufacturers will state that their particular oils have a "vaporising point" of over 600 deg. Fahr.; it has even been seriously contended that the "vaporising point," or that point when vapours become apparent, is at a higher temperature than is the flash point. The writer has examined very many of the standard cylinder oils, and can say that the majority of them, as supplied to ships, vaporise or show vapour when heated to under rather than over 280 deg. Fahr., and flash at under rather than over 450 deg. Fahr.

Seeing that 160lb. pressure is not now considered an extraordinary pressure, and that the temperature of the steam at this pressure is 363 deg. Fahr., it is not difficult to imagine that much vapour is given off from such oils when used at such temperature; and as this giving off of vapour indicates the decomposition or change of the oil, the amount of such decomposition may be estimated therefrom.

Having pointed out these two peculiarities, let us take into consideration what it is that takes place in a steam boiler supposing the surfaces of the metal to be unprotected by scale or by artificial means. The salts of the sea water, especially the magnesic chloride, cause the water to act chemically on the exposed metallic surfaces. This chemical action takes place at *all* temperatures, and in water of all specific gravities, but is greater at a high temperature than at a low one, and also greater the higher the specific gravity or more degrees the water indicates on the salinometer. The result of this chemical action is the oxidation of the exposed surfaces of the iron, but more especially of the steel. This oxidation or chemical action at the same time produces electricity, as chemical action always does. When this oxidation takes place in a cold solution, the electric tension exhibited is slight, even though the chemical action be considerable. Though this tension does appear slight so far as instruments show it, yet in fact the amount of electricity produced is proportionate to the amount of chemical action; but as both the metal and the water are conductors and remaining in contact, the greater part of the opposite electricities produced recombine and neutralise each other as fast as they are separated. But if this chemical action or oxidation takes place at a high temperature, as in a steam boiler, this recombination does not take place to the same extent, and the salts of the sea water become electrolysed or decomposed by the electricity, their bases combining with the "oily organic acid" to produce the deposits found in the corroding boiler. As these bases of the sea water combine, and are neutralised by these "oily organic acids," there is liberated an equivalent amount of the acid of the sea water salt, which helps to still further increase the corrosion.

These reactions take a considerable amount of time to state, but in fact they all take place nearly instantaneously, and this, the writer considers, is the reason why corrosion is attributed to electric action, whereas really the electric action in a steam boiler is due to the chemical action of the water on the metal of the boiler.

A voltaic couple, which may consist of say a plate of zinc and a plate of copper, immersed in a bath of dilute sulphuric acid, the two plates being connected outside the liquid by a wire, chemical action is set up, and electricity produced in exact proportion to that action. The chemical action causes the electricity, not the electricity the chemical action. The same state of things exists in a steam boiler; there is corrosion or oxidation of the iron or steel exposed surfaces by the sea water, instead of the corrosion of the zinc plate by the dilute sulphuric acid, the sea water acting in its degree as the exciting liquid to produce chemical action, and so electricity.

There are two ways of stopping this corrosion, one by rendering the water non-exciting, and the other by taking advantage of a law or fact observed in electricity, which is—that when two elements or metals of dissimilar characters are immersed in a liquid capable of chemically acting on one or both of them, and are at the same time connected together by means of a metallic connection, that element or metal which is most acted on by the exciting medium becomes the positive or corroded element, while the other becomes the negative or inactive element, and so escapes all corrosion so long as they are in metallic contact.

When it is wished to stay corrosion by taking advantage of this electrical fact, the usual method is to employ metallic zinc, being careful to bring it into intimate metallic contact with the metal of the boiler. This will, if sufficient zinc be used, have a beneficial effect; still too much is generally expected from the zinc. Engineers expect the effect of these zinc plates—say four of them weighing in all about 56lb., and placed in different parts of the boiler, which will weigh about 30 tons—to influence the whole and every part of the boiler, and to continue to influence it for a period of time. Even if these plates were most elaborately connected in strict metallic contact with the metal of the boiler in its different parts, it is too much to expect from such a quantity of zinc, there being too great a disproportion between the weight of 30 tons and 56lb.; therefore the area of its influence must be circumscribed, more especially after being in use a few days, when its surface becomes coated and protected against a great proportion of the corrosion it ought to undergo to enable it to keep its place as the most readily acted on metal, and absorb to itself the chemical action or corrosion which would otherwise attack the iron or steel of the boiler. This idea that the areas of influence of the protective plates are circumscribed to some extent accounts for the fact that a boiler shows signs of corrosion sometimes in one place and then in another; in other words, it shows these signs over areas where the protection influence of the zinc has either been destroyed, or too much diminished to be effective.

56lb. of zinc represents ·083 per cent of the weight of a 30-ton boiler. If from four to five times this amount were used in the first instance, and supplemented from time to time as it was corroded and rendered ineffective, it would be found that corrosion would be stayed, though there would be considerably more than a proportionate quantity of zinc consumed in a given time than when the smaller quantity was employed; the reason for this larger consumption of zinc being that though zinc in proper metallic contact absorbs all corrosion to itself, it does not destroy or prevent the chemical action or the resulting electricity being formed in the boiler—it rather increases it. As has already been stated, the action of the zinc is simply that, being the most readily acted on metal, it becomes the positive or corroded element instead of the iron, as would be the case were the zinc not present and in metallic contact. This being the case, it may be unnecessary to point out the advisability of the zinc used being good and as pure as possible. Any foreign metals the zinc may contain will injure its efficiency as a protector to the metal of the boiler, as part of its power will be wasted in becoming positive to them instead of to the boiler.

(*To be continued.*)

Engineering Society, King's College, London.—At a general meeting of this society, held on March 5th, the vice-president in the chair, Mr. Lauder read a paper on "Lighthouses." He began by giving a short history of the lighthouse, mentioning the methods employed for warning mariners in the middle ages, and stated that as the commerce of this country increased new methods became necessary, and led to the erection of lighthouses. Mr. Emerson's buoy finder was then described. The use of the electric light was discussed, quoting from "The Story of Lighthouses," by Professor Tyndall, which appeared in the *Nineteenth Century*. An account was given of the erection of the four Eddystone lighthouses, and how each successive builder profited by the experience of his predecessor, until Smeaton, rising above the prejudice of his age, perceived the right principles for the construction of his lighthouse, and determined the principles upon which all rock lighthouses have since been constructed. The author described St. Catherine's lighthouse in detail, the light given being of 3,000,000 candle power. After a vote of thanks to Mr. Lauder for his paper, the meeting was adjourned.

HYDRAULIC MACHINERY EMPLOYED IN THE TRANSMISSION AND CONCENTRATION OF POWER.—IV.

In our last article we tabulated the thickness necessary for cast-iron and steel cylinders for test pressures of varying intensity. A few remarks may be here appropriately introduced on certain points in the design and construction of high-pressure hydraulic cylinders of these materials, non-attention to which will frequently result in failure and disappointment.

In the first place, the internal corners at the bottom should be struck to a large radius, as shown by fig. 6; and, if the cylinder be cast with a solid bottom, the interior of the bottom should be struck to a radius not exceeding the diameter of the cylinder in length. A good practical rule is to make the corners one-fourth the internal diameter of the cylinder in radius, and the bottom three-fourths the internal diameter of the cylinder in radius. If these proportions be adopted, the thickness of the bottom of the cylinder will be sufficient if made equal to that of the walls, as illustrated by fig. 6. In the case of long cylinders, in which it is necessary to carry the core bar through the bottom in order to provide a support for its end, the same proportions may be adopted by simply inserting the necessary plug for stopping the hole left by the core bar.

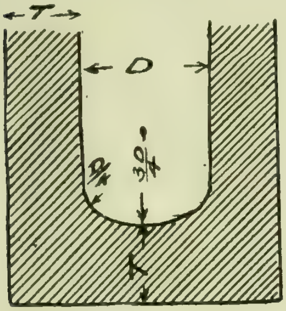


Fig. 6.

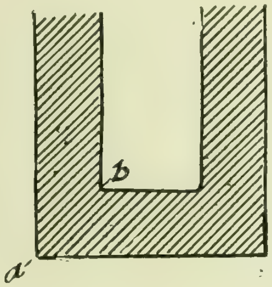


Fig. 7.

The necessity of a large rounding of the corners arises from the fact that if they be left nearly square (see *b*, fig. 7), the crystals of the casting arrange themselves during cooling in such a manner as to invite fracture along the line *a b* (fig. 8), and unless the cylinder be constructed of a thickness unnecessarily great for the pressure to which it is subjected, deterioration gradually goes on along the line *a b*, until sooner or later failure takes place, as illustrated by fig. 8; and a conical piece A breaks away from the end of the cylinder.

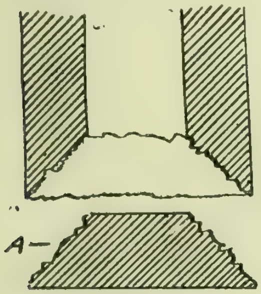


Fig. 8.

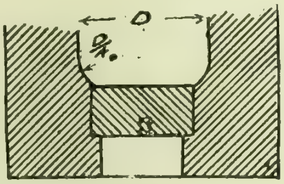


Fig. 9.

Fig. 9 illustrates a properly-designed cylinder and similar to fig. 6, but with a plug inserted by driving in from the inside. This method is found amply sufficient for cylinders of diameters ranging to 10in. or 12in. inside, or even more. For larger cylinders, the method illustrated by fig. 10 may be adopted, in which the plug is made tight by means of a U leather and back plate.

The sources of weakness to which attention was drawn in our first article should also be carefully avoided, and it is also in general advisable to construct high-pressure hydraulic cylinders in the form of plain cylinders, as the castings are less likely to suffer from unequal contraction, and the risk of unsoundness due to "drawing" at the junction of ribs, arms, lugs, flanges, &c., is avoided; also the cylinder is then more readily replaced, and at less cost, if found defective. Very considerable deviation from this rule may, however, be made without incurring undue risk, if proper skill be possessed and employed by the designer and founder.

In the second place, supposing the cylinder skilfully designed and of adequate proportions, the two great essentials required to ensure soundness in the casting are, firstly, the metal shall be of close texture, otherwise, though amply strong enough to resist the stresses due to internal hydraulic pressure, the casting will fail from its permeability, and under intense pressure the water will ooze through the metal. Also, from the examination of cast-iron cylinders, which have been ruptured in ordinary work, although apparently of adequate strength to resist the pressure to which they have been subjected, the writer has been led to consider it probable that a partial permeation of the metal by the water may result in a higher intensity of stress on the internal layers of a cylinder than would be due to the pressure of the water within the cylinder; and hence a cylinder may be erroneously considered to have failed from deficient thickness of metal, when the failure has really resulted from porosity in the casting.

Secondly, it is necessary that a "head" of ample dimensions should be cast on the end of the cylinder which is uppermost in the mould (usually the bottom of the cylinder in actual work). This head should not only be of sufficient *depth* to produce adequate fluid pressure on the casting, but also of sufficient *bulk*, in order that it may remain fluid longer than the body of the cylinder, and thus maintain a pressure on the metal during the whole period of solidification. Hence, to be effective, the head should take the form illustrated by fig. 11 or 12, and not that illustrated by fig. 13, which is ineffective and irrational, though not unfrequently adopted.

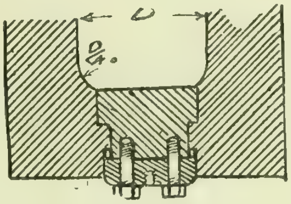


Fig. 10.

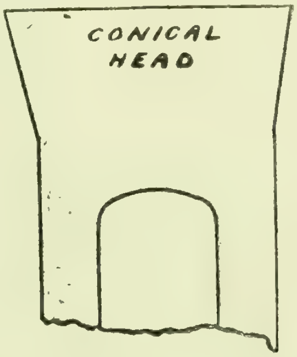


Fig. 11.

If due attention be paid to the points here briefly discussed, the thicknesses given in the tables of our last article will be found amply sufficient for the test pressures there stated.

Having thus cleared the ground by defining the meaning to be assigned to tests and working pressure and stress, and their proper relative and absolute values for the various materials employed in the construction of hydraulic machinery, we are now at liberty to discuss the proper proportions and design of the details and component parts of such machinery, and will commence with the subject of

Ram, Piston, and Plunger Packings.

The packing by means of which the rams, pistons, or plungers of hydraulic machinery are enabled to slide to and fro at the same time that the passage of fluid past the sliding surfaces is prevented, may be divided into two classes, viz., firstly, that in which the packing is self-acting—that is, maintained in water-tight contact with the sliding surface by the simple action of the hydraulic pressure itself; and secondly, that in which the tightness of the packing is dependent on mechanical compression by means of glands or junk rings, as in the case of stuffing boxes, &c.

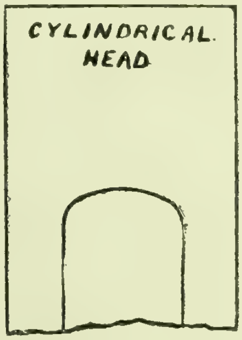


Fig. 12.

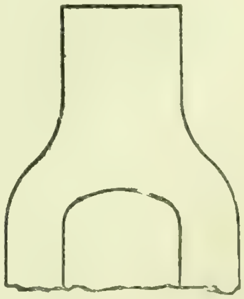
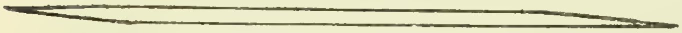


Fig. 13.

Of the first, or self-acting class of packing, the simplest is the spiral leather packing, figs. 14, 15, 16, and 17. This is a very excellent packing for small plungers and pistons. It consists simply of a strip of supple leather $\frac{3}{16}$in. or $\frac{1}{4}$in. wide, and of sufficient length to lap round the plunger three, four, or five times (fig. 14.)

Fig. 15 represents the plunger without the packing, fig. 16 the packing in course of being wound on, and fig. 17 the plunger packed and ready for use. The operation of packing a plunger in this manner is apparently very simple, but yet requires a certain amount of skill and practice to perform it with speed and neatness. The strip of leather must first have one end cut with a sharp knife to an acute angle (see fig. 14.) It must then be tried in the groove of the plunger (fig. 15), and shaved if necessary down to the proper thickness to just fill the groove up to the required working diameter which will fit the pump barrel tightly. It is then lapped round the plunger and the free end chamfered off to a gradual taper and length to just fill the length of the groove (fig. 16.) The free end is then hammered into the unfilled portion of the groove with the handle of a screwdriver or file (fig. 17), and the plunger is ready for use.

Fig. 14.



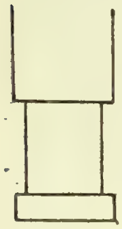


Fig. 15.

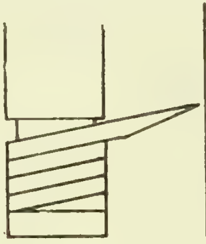


Fig. 16.

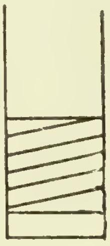


Fig. 17.

This description of packing is only suitable for small plungers not exceeding 1in. or 1½in. in diameter, but is a very simple, cheap, and durable packing for such small work, and is perfectly reliable and water-tight at even the highest pressures. We defer the consideration of leather packing of more complex types, their construction, friction, &c., to our next article.

THE LÉGÉ TORPEDO.

For some time past Mr. A. Légé has given his attention to the production of a torpedo, based broadly upon the principle of a flying kite. The weapon therefore belongs to the class known as towing torpedoes, and so far there is a similarity between it and the Harvey torpedo, but beyond the actuating principle the resemblance does not extend. The Légé torpedo is fish-shaped, and the one recently exhibited at the inventor's works, 31, Kirby Street, Hatton Garden, London, is 7ft. long by 11in. *maximum* diameter, and carries a charge of 50lb. of guncotton, dynamite, or other high explosive. The torpedo itself weighs 80lb. without the charge, and is designed for either attack in the open or for river or harbour defence. It is made of delta metal, that being the material used in constructing Whitehead torpedoes, for which purpose it is well suited on account of its strength and capability of resisting the corrosive action of sea water.

Outside the fish-shaped body are two blades or fins, one on either side, a tailpiece and a rudder, the fins and tailpiece being actuated by the expansion and contraction of an elastic metallic air chamber placed inside the torpedo and exposed to the pressure of the water. The torpedo is loaded with cork, so that its specific gravity when charged is a little greater than that of water. When placed in water it gradually sinks to the bottom, and the pressure of the water, acting on the elastic air chamber, causes the fins and tailpiece to assume an angle which directs the torpedo quickly towards the surface when the tow-line is hauled upon. On nearing the surface the water pressure decreases, and with it the angle of the fins, so that the torpedo is then towed at a level a little below the surface. The charge is fired by hugging contact, the firing pin projecting from the nose of the torpedo. A key locks the firing pin until the torpedo is placed in the water, when it is withdrawn by a line. The firing apparatus is also locked from the inside by a spring bolt connected with the tow-line, but remains unlocked while the weapon is being towed, or while there is a pull upon the tow-line. In operation the torpedo is to be dropped into the water, and a long length of tow-line paid out from a launch, which is to proceed to the far side of the enemy's ship.

The torpedo is then towed so as to hug the ship, and on catching against the torpedo net, with which it is assumed the ship will be protected, it is stated that the torpedo will overbalance, dive under it, and come up nose forwards against the bottom of the ship and explode. It is claimed that should a torpedo miss its aim or get adrift it will not be dangerous, owing to the internal locking arrangements. It is proposed to tow several of these torpedoes in a group, radiating fan-like from the launch, the rudder of each being first set to keep it on its own proper course, a long line of attack being thus formed. For the defence of harbours or the mouths of rivers an arrangement is proposed for keeping a series of these torpedoes slowly moving on an endless chain under water, so as to catch any vessel that may attempt to enter. The weight of a Légé torpedo is very small as compared with that of a Whitehead torpedo of similar power. A 4ft. 6in. Légé weapon weighs 35lb. plus a 30lb. charge, while a Whitehead torpedo carrying a 35lb. charge is stated to weigh 6cwt. and to measure 15ft. in length. It also carries in its hull expensive machinery, which the Légé does not, so that the cost of the latter is very considerably less. It is intended shortly to carry out a series of experiments with the Légé torpedo in order to demonstrate its practicability, which, however, Mr. Légé states he has already proved by smaller torpedoes.

JAMES WATT AND THE STEAM ENGINE.

On Saturday evening, March 9th, at Firth College, Sheffield, before a large and appreciative audience, Professor Ripper delivered a popular lecture, entitled "James Watt and the Steam Engine." He said that in these days it was difficult to realise the debt we owed the inventors of the steam engine, and especially James Watt, to whom the honour belongs of having first rendered that engine commercially successful, and of having clearly set forth the principles underlying its successful construction. Before the time of the steam engine, mining was carried on under great difficulties, and in many cases mines had to be abandoned owing to the difficulty of keeping them free from water. The atmospheric engine of Newcomen failed owing to excessive consumption of fuel. It remained for Watt to discover the remedy for this defect, namely, the use of a separate vessel, or condenser, in which to condense the steam instead of injecting cold water into the cylinder itself, as Newcomen did; and out of this apparently simple device had grown the modern steam engine, and with it the unexampled commercial prosperity of modern times. In explaining the relation between heat and work, the lecturer said the heat from a little piece of coal the size of a cube one-eighth of an inch each way, was capable, if all converted into work, of raising one-third of a ton one foot high; but this was no more wonderful than that a train, weighing perhaps 150 tons, should be rushed at more than racehorse speed from one end of England to the other in 10 hours, for the expenditure of about one ton of coal per hour; or that a steamer should travel from Liverpool to New York, a distance of 3,000 miles, in less than six days, for the expenditure of less than one ton of coal per 1,000 horse power per hour. After giving an outline of the life and inventions of Watt, illustrated by some excellent diagrams shown by limelight, the lecturer traced the progress of the steam engine since Watt's time. Progress had been made chiefly in two directions, first in increase of steam pressures, and secondly in improved methods of expansive working. Boiler pressures had rapidly increased since the introduction of steel plates. In 1830, the pressures in marine boilers were from 2lb. to 3lb. per square inch. At present pressures were as high as from 150lb. to 200lb. per square inch, the shell of the boilers being made of steel plates 1⅜in. to 1¼in. thick. The next great step had been the adoption of the compound engine with two, three, or four cylinders, in which the steam was successively expanded before being exhausted into the condenser. The advantages of a compound engine over the single-cylinder engine were most conclusive when the coal bill of each class was compared. The average coal consumption for triple-expansion marine engines was 1·4lb. to 1·45lb. per indicated horse power per hour. In an investigation instituted by the Corporation of Birmingham, it was found on indicating six non-condensing steam engines, taken indiscriminately, that the average consumption of coal was no less than 18lbs. per indicated horse power per hour. The wasteful character of the small type of commercial steam engine was fast leading to its being superseded by the gas engine, of which there were over 12,000 of the "Otto" type alone at work in this country.

DISCHARGE FROM RECIPROCATING PUMPS.

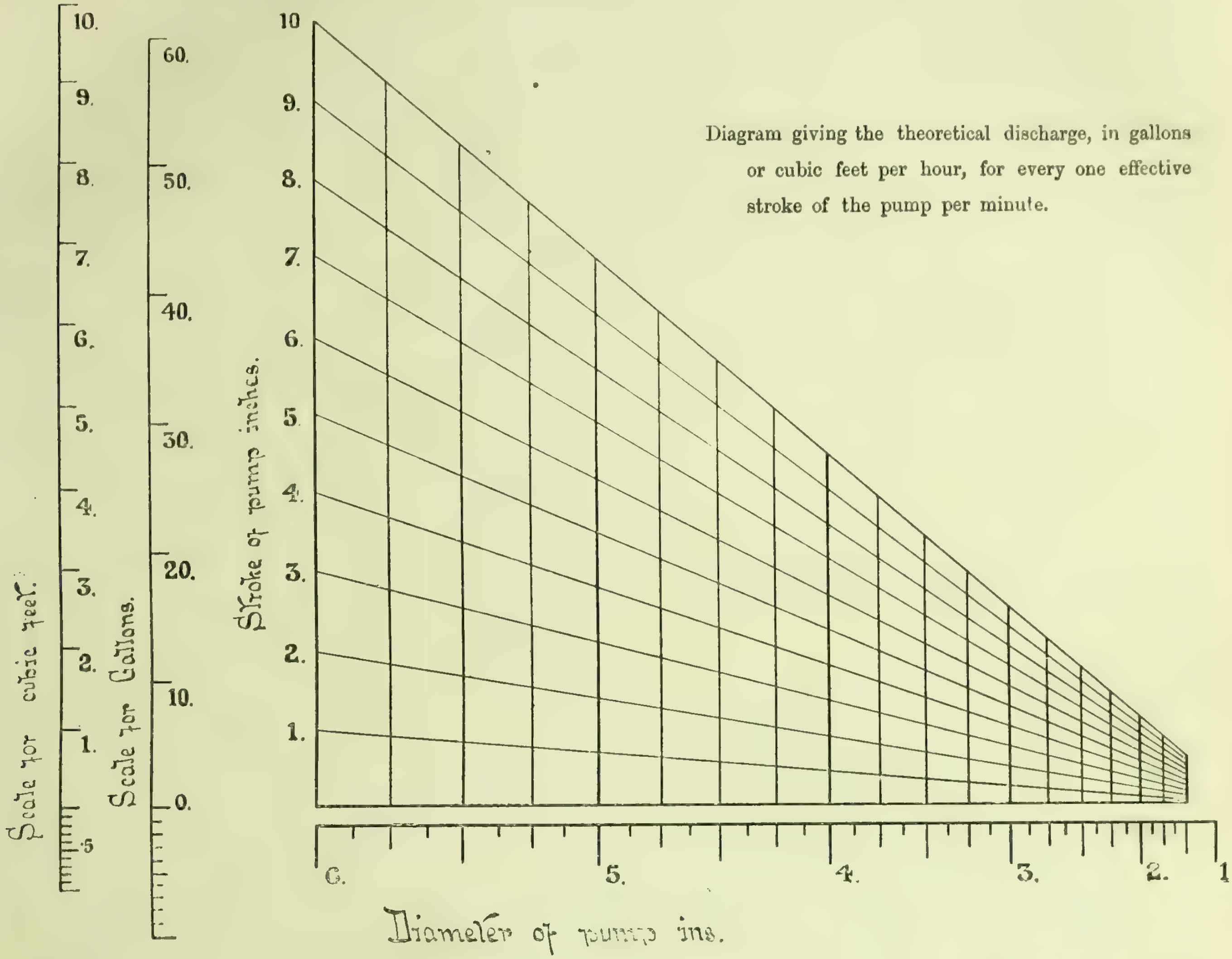


Diagram giving the theoretical discharge, in gallons or cubic feet per hour, for every one effective stroke of the pump per minute.

The accompanying diagram of discharge from reciprocating pumps, giving the theoretical quantity the pump will discharge per hour for every one effective stroke per minute, either in gallons or cubic feet, is one which will be found very useful in many cases, where calculations concerning the required size of pumps or the time occupied in filling ballast or other tanks, &c., have to be made; for with the aid of this diagram it is only necessary to ascertain the number of effective strokes the pump makes per minute to obtain the quantity of water it will pump per hour.

For example, suppose we have a double-acting pump, 5in. diameter by 8in. stroke, making 160 strokes per minute, required the quantity of water it will pump per hour.

With a pair of dividers measure from the base of the diagram at the point marked 5in. on the scale of diameters the height of the ordinate up to the line marked 8in. on the scale for stroke of pump to the left of the diagram; transfer this distance to the scales of gallons and cubic feet, and read off 34 and 5·4 as the quantity of water the pump will deliver per hour for every one effective stroke per minute in gallons and cubic feet respectively.

Then gallons per hour $= 34 \times 160 = 5440$.

For $5^2 \times \cdot7854 \times 8 = 157{\cdot}08$ cubic inches per stroke,

and $157{\cdot}08 \times 160 = 25132{\cdot}8$ cubic inches per minute;

and $25132{\cdot}8 \times 60 = 1507968$ cubic inches per hour, which, divided by 277·25, the number of cubic inches in the gallon,

$$\frac{1507968}{277{\cdot}25} = 5440 \text{ gallons per hour;}$$

or, dividing by 1728, the number of cubic inches in a cubic foot,

$$\frac{1507968}{1728} = 5{\cdot}4 \text{ cubic feet per hour.}$$

This diagram may also be used inversely, as in the following case: A pump is required to deliver 5,440 gallons per hour, to be worked by an engine which makes 160 strokes per minute. In this case the length of stroke must first be decided, and should be made such that the mean speed of the plunger does not exceed 120ft. per minute; or taking it at 110, then

$$\text{Length of stroke} = \frac{110}{160} = \cdot68\text{ft.} = \text{say 8in.}$$

Next divide the gallons per hour by the strokes per minute, which, assuming the pump to be a double-acting one, in this case $= \frac{5440}{160} = 34$ gallons per hour for every one stroke per minute; then take this value on the scale for gallons (see diagram), and run along the line corresponding with 8in. stroke until the other leg of the compass touches the base line, and read off the required diameter 5in. It may here be remarked that this gives the theoretical diameter for the pump; in practice it is usual to increase it by about 20 per cent, which can, however, be allowed for when using this diagram by adding 20 per cent to the gallons per hour at the start.

This diagram will also be found useful to find the time in which a pump will empty a tank. For the solution of this question we have the formula—

$$\text{Time in hours} = \frac{\text{Cubic feet of water in tank}}{\text{Cubic feet pumped out in an hour}}.$$

Suppose, then, we have a tank, say of 2,628 cubic feet capacity, filled with water, and we require to know how many hours it will take a pump, say 5½in. diameter by 9in. stroke, making 120 effective strokes per minute, to empty it.

At the point on the scale of diameters, at the base of the diagram marked 5½in., take with a pair of dividers the height of the ordinate up to the line corresponding with 9in. stroke, which by the scale for cubic feet equals 7·3, which multiplied by 120 equals 876 cubic feet per hour; therefore,

$$\text{Time in hours} = \frac{2628}{876} = 3.$$

Also this diagram will be found useful in cases where one larger pump, making a given number of strokes per minute, is to be substituted for two or more smaller pumps making different strokes per minute, to pump the same quantity of water per hour, and many other cases.

NOTES.—If the quantity of water is given in lbs. $\div 10 =$ gallons, or $62{\cdot}5 =$ cubic feet; if in tons $\times 224 =$ gallons or $35{\cdot}84 =$ cubic feet fresh water, or $35 =$ sea water—

$$\text{Gallons} \times {\cdot}16 = \text{cubic feet.}$$

A rule which the author has found very useful in practice for the quantity of water that a pump will deliver in gallons per hour is

$$G = D^2\ S\ N \times {\cdot}1698$$

In which $G =$ the gallons per hour.
$D =$ the diameter of the pump in inches.
$S =$ the stroke of the pump in inches.
$N =$ number of effective strokes per minute.

or approximately $G = D^2\ S\ N \times {\cdot}17$

whence $D = \sqrt{\dfrac{G}{S\ N \times {\cdot}17}}$

and $N = \dfrac{G}{D^2\ S \times {\cdot}17}$

$S = \dfrac{G}{D^2\ N \times {\cdot}17}$

In practice, the constant ·17 varies from ·10, giving 60 per cent efficiency to ·16, giving 95 per cent efficiency.

ERICSSON, THE INVENTOR OF THE MONITORS AND HOT-AIR ENGINE.

THE *Newcastle Daily Chronicle* gives an interesting account of the life of the great engineer who designed the first system of ironclad ships, and who invented a type of hot-air engine.

Mr. John Ericsson, the famous engineer, who invented the caloric engine, has just died at New York, at the advanced age of 86. The designer of the vessel that destroyed the chances of the Confederates becoming a naval power was a native of Sweden, where, in conjunction with his elder brother Niel, he early gave evidence of ability. There was much in the genius of these sons of the same family that told their kinship, but the younger attained the greater celebrity. John Ericsson really revolutionised the naval warfare of modern times. The Merrimac, originally a United States war vessel, had been seized by the Confederates and re-named the Virginia. In the beginning of March, 1862, this ship proceeded to attack the Federal squadron in Hampton Roads. It was the first ironclad ever seen in a naval engagement, and to its prowess the wooden ships of the Federals fell an easy prey. What might have been the result had it been left unchecked may be imagined. But, alive to the necessities of the situation, Congress, on the 3rd of August, 1861, voted supplies for the construction of armoured harbour defence vessels. On the 7th, competitive designs were asked for, and shortly afterwards the ingenious Swede was at work on the vessel that was to bring victory to the Union.

In 1829 John Ericsson competed for the prize offered by the Manchester and Liverpool Railway for the best locomotive. The prize was awarded to George Stephenson's Rocket. But it was universally acknowledged that Ericsson's invention was Stephenson's sharpest competitor. It has been said of some poets that they lisped in numbers, and from boyhood Ericsson's mechanical genius was conspicuous. At the age of twelve he was appointed a cadet in the Swedish corps of engineers, and in the following year was put in charge of a section of the Gotha ship canal. Failure to secure supreme success in the locomotive competition at Rainhill, in 1829, had not the slightest effect upon his indomitable spirit. His brain teemed with projects, much as the brain of a novelist or a poet teems with visions and plots. Pumping engines, fire engines, caloric engines, were in rapid succession produced by this intrepid foreigner, who might have been utilised by England in much the same way that Prussia has utilised Moltke. But when were the Lords of the Admiralty ever fortunate enough to detect or honour genius? Between 1834 and 1836 Ericsson invented his famous screw propeller. At once comprehending its fitness for ships of war, he had a vessel constructed to exhibit his propeller in action, and invited the Lords of the Admiralty to its trial. The experiment was in every respect successful, but my Lords were unconvinced. The surveyor of the navy advised his masters that, though a vessel might be propelled by the invention, it could not be steered! The fallacy of this suggestion was demonstrated before the year was over by a screw steamer that had no difficulty in doing what the surveyor pronounced impossible. It may be hoped Captain Beaufort's letter, informing Ericsson of the utter disappointment of the Admiralty with his propeller, is still extant, and will in due course find a place in some biography of the inventor. Sir William Symonds, principal designer of Her Majesty's ships, had a perfect horror of novelties, hated steam power, and pronounced iron ships "monstrous." It was not, in those circumstances, wonderful that Ericsson left England for America. Fortunately neither France nor Russia got hold of this daring and fertile genius.

Captain R. F. Stockton, of the United States Navy, detecting the utility of his invention, had two iron vessels constructed for the Republic by the firm that afterwards built the Alabama. Subsequently Ericsson built the Princeton screw steamer for the United States Government. With screw steamers to-day everywhere, it is difficult to understand the prejudice which for years kept the principle from being adopted. Prepossessions die hard, but a day arrives when they are compelled to succumb to common sense. The Princeton was the first steamship ever built with the propelling machinery out of reach of shot. When the inventor was again required, there was little difficulty in recognising his genius. For a sum of £52,000, Mr. Ericsson undertook to construct, within a hundred days, an armoured shot-proof harbour defence vessel, drawing ten feet of water and steaming nine knots per hour. The original Monitor was completed in four months, and arrived in Hampton Roads just in time to prevent the Merrimac from completing the destruction of the Federal fleet in Hampton Roads. With the advent of this craft the career of the Confederate ironclad closed. Just as all the features of the locomotive of to-day are found in its earliest type, so all the features of the present monitors exist in the original ship. Ericsson's invention, which practically destroyed the chances of the Confederacy establishing itself, was a flat-bottomed vessel, armoured on the sides and on the deck—the deck being almost on a level with the water. The revolving arrangements of the turrets recalled the turnstiles on which heavy locomotives are pivoted. Ericsson's Monitor combined the maximum of invulnerability with the maximum of offensive power. To the Swede belongs the honour of being the first to bring the system of iron turret ships into operation. It was not, however, in one, but many ways that his genius displayed itself. In the great exhibition of 1851, the American section was rendered conspicuous by Captain Ericsson's inventions, and throughout his entire career his faculties never slumbered. The late Lord Brougham enjoyed the advantage of reading an elaborate account of his own death. But if the famous Swede had any interest in such accounts, he has had that advantage twice. One of the most important and most accurate of British biographical dictionaries announced that he died in 1853. Subsequently that statement was corrected as premature, and his death said to have taken place in 1869. As a matter of fact, he has lived for twenty years beyond even this extended term. Many of the world's great engineers have been distinguished for their longevity. Watt died in his eighty-third year, and Murdoch—the right-hand man of the famous Soho firm—in brilliancy and fertility of genius much akin to Ericsson, reached eighty-five. Ericsson's was a life of unremitting industry, and his length of days is another proof that not work, but worry, kills. To the last the great engineer was occupied with his inventions, his only regret in leaving the world being that he left them uncompleted. To his chief assistant he gave his final instructions as to the sun motor, on which he had long worked, exacting a promise that it should be carried to its accomplishment.

ANOTHER RUSSIAN RAILWAY SCHEME.—Among the many important railway enterprises which are just now being started in Russia, it appears that the Government of that country contemplates constructing a line from Odessa to Wosnessensk. At the present time the port of Odessa is only connected by one railway with the interior, which is utterly insufficient to meet the requirements of shippers during the autumn season. By means of the new line the distance between Odessa and Moscow would be shortened by about 160 versts, and the route to the Donetz coal district would be curtailed to the extent of 315 versts, which would reduce the cost of carriage on coal by at least 4 copecs per pood, and obviate the calamitous coal panics which have taken place in Odessa of late.

WATER-GAS AS A STEAM BOILER FUEL.

(Concluded from page 183.)

The results of the tests are given in the following table :—

TABLE III.

Gas.	Weight of water evaporated.	Temperature of water at start.	Temperature of room in which experiments were made.	Pressure of gas at meter in inches of water.	Time required to heat the water to its boiling point.	Time required to heat and to completely evaporate the four pounds of water.	Number of cubic feet of gas burned.	Amount of water that would be evaporated from and at 212 deg. F. by the amount of gas burned.	
								Actual.	Per 1000 cub. ft. of gas.
	Lbs.	Deg. F.	Deg. F.	Ins.	Mins.	Mins.	Cu. Ft.	Lbs.	Lbs.
Uncarburetted..	4	56	61	4	12	79½	36·1	4 64	128·5
,,	4	59	62	4	11¾	79½	34·8	4·64	133·3
Carburetted....	4	56	61	5½	8½	69	19·4	4·64	239·2
,,	4	59	62	5½	10	73¼	18·2	4·64	254·9
,,	4	68	66	4½	8¼	63	19 8	4·60	232·3

From Table III. we obtain an average evaporation, per 1,000 cubic feet of uncarburetted gas, of 130·9 pounds of water from the temperature of 212 deg. and at atmospheric pressure, and for the carburetted gas an average of 242·1 pounds. That is, the experiments tend to show that the ratio of the calorific power of the uncarburetted to that of the carburetted gas by volume is

$$\frac{130 \cdot 9}{242 \cdot 1} = 0 \cdot 54.$$

The volume of one pound of air at 62 deg. Fahr. is 13·14 cubic feet; hence the calorific power of the gases per cubic foot on the basis of Table II. should be :—

$$\text{Uncarburetted, } \frac{7373 \times \cdot 505}{13 \cdot 14} = 283 \cdot 3 \text{ heat units ;}$$

$$\text{Carburetted, } \frac{13{,}317 \times \cdot 632}{13 \cdot 14} = 640 \cdot 5 \text{ heat units.}$$

The calorific powers calculated from the analyses of the gases are therefore in the ratio of

$$\frac{283 \cdot 3}{640 \cdot 5} = 0 \cdot 44,$$

a figure that is lower than that given by experiment. It is very probable, however, that the efficiency of combustion in the practical tests of the two gases was not precisely the same, and we may therefore conclude that the calorific effects, as calculated from the analysis, are in about the same ratio as would be obtained under maximum efficiency in actually burning the gases. One pound of good Lackawanna coal has a calorific power of 13,000 heat units.* The number of cubic feet of gas required to produce the same heating effect as is produced in burning one ton of coal will therefore be :—

$$\text{Uncarburetted gas, } \frac{13{,}000 \times 2{,}000}{283 \cdot 3} = 91{,}780.$$

$$\text{Carburetted gas, } \frac{13{,}000 \times 2{,}000}{640 \cdot 5} = 40{,}590.$$

The efficiency of a boiler will be about the same when burning gas for fuel as when coal is used. If, therefore, we disregard the difference in the cost of attendance, in favour of using gaseous fuel, 40,590 cubic feet of carburetted, or 91,780 cubic feet of uncarburetted gas, must be sold for the same price as one (short) ton of coal, in order to successfully compete with the latter for use under steam boilers.

We will estimate the probable excess of cost involved in firing with coal above that of gas firing. In burning natural gas it has been found that one man is able to attend to boilers aggregating 1,500 H.P., whereas, if coal is used, 200 H.P. will be a fair figure. It therefore requires, in the case of large plants, only about $\frac{2}{15}$ as much labour to fire with gas as is involved in firing with coal. If the wages of firemen are 2·50 dols. per day of twelve hours, the cost of firing one ton of coal in boilers that require 4lb. of coal per boiler H.P. per hour will be

$$\frac{2 \cdot 5 \times 2{,}000}{12 \times 200 \times 4} \text{ dollars} = 52 \cdot 1 \text{ cents.}$$

The cost of firing with gas would be $\frac{2}{15}$ of this amount, so that the extra cost of firing with coal would equal $\frac{13}{15} \times 52 \cdot 1 = 45$ cents. To make a liberal allowance in favour of the gaseous fuel, we will assume that the extra labour of firing each ton of coal costs 50 cents.

Table IV. contains the prices at which the gas must be sold per 1,000 cubic feet in order to be as cheap as coal for boiler use; first, disregarding the difference in the cost of attendance, and secondly assuming that the extra cost of firing with coal is 50 cents per ton.

TABLE IV.

Cost of coal delivered to boiler room per ton of 2,000lb.	Price of gas per 1,000 cubic feet.			
	Not including difference in cost of attendance.		Including difference in cost of attendance.	
	Carburetted.	Uncarburetted.	Carburetted.	Uncarburetted.
$	cts.	cts.	cts.	cts.
6·00	14 8	6·5	16·0	7·1
5·00	12·3	5·4	13·6	6 0
4·00	9·9	4·4	11·1	4·9
3·00	7·4	3·3	8·6	3·8
2·00	4·9	2 2	6 2	2·7
1·00	2·5	1 1	3·7	1·6

CONCLUSIONS.

(*a*) As the cost of manufacturing the uncarburetted water-gas by the present processes, not including interest on capital invested, is from 10 to 20 cents per 1,000 cubic feet,* it does not appear possible to employ it economically for a boiler fuel until considerable reduction in cost of production shall have been made.

(*b*) For culinary purposes, where a small amount of heat is required, and it is of special advantage to have this heat under ready control, fuel-gas could in all probability be sold at a price that would make it a more desirable fuel than coal. For house-warming purposes, however, that are not of too limited a nature, it is not probable that gas could be sold cheap enough to displace coal; for the efficiency of a good steam-heating plant is about 50 per cent, and if the heating efficiency of the gas be taken at 80 per cent on account of any advantage that it might have in applying the heat more directly to the air in the room, the price at which it would have to be sold, in order to be as cheap as coal, could be only three-fifths greater than the figures given in Table III.

(*c*) It would also appear from Table III. that a carburetted gas might possibly be made that would cost less, for an equal heating effect, than an uncarburetted gas; in other words, that water-gas might be made a medium for burning liquid petroleum fuels.

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* J. C. Hoadley's Report on Trials of a Warm-blast Apparatus. Trans. Am. Soc. of Mech. Eng., 1885.

* Mr. McMillin, in the article previously cited, recommends the use of a mixed fuel-gas that could be manufactured and stored in the holder, for 7·88 cents, 9·72 cents, and 11·75 cents per 1,000ft., with coal at $2, $3, and $4 per net ton respectively, and furnished to the consumer for 25 cents per 1,000 cubic feet. This fuel-gas, according to his calculations, would develop, on combustion, 323 heat units per 1,000 cubic feet, or it would possess about one-seventh more heating effect per cubic foot than the water-gas which has been made the subject of discussion in the present paper.

A GIGANTIC RAILWAY PROJECT.—The Government of Western Australia has come to terms with the promoters of a gigantic railway project. A line is to be constructed from Eucla to Perth, a distance of 800 miles, which, when completed, will bring into railway communion Perth, Adelaide, Melbourne, Sydney, and Brisbane. It is expected that the work will occupy ten years. The contractors have agreed to construct the railway on the understanding that for every mile completed they shall receive from the Government the gift of 20,000 acres of land. Should they keep their promises the contractors will become the owners of an estate of 16,000,000 acres, equal in size to one-fourth the territory of Victoria.

NEW DRAWBAR HOOK FOR RAILWAY WAGONS.

FIG. 1.

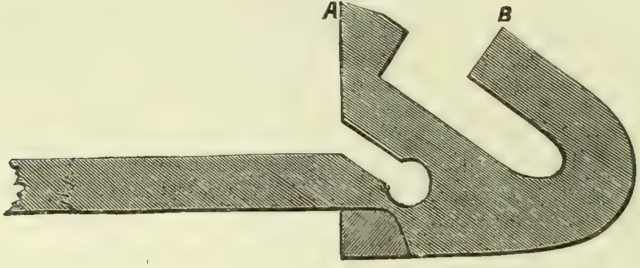


FIG. 2.

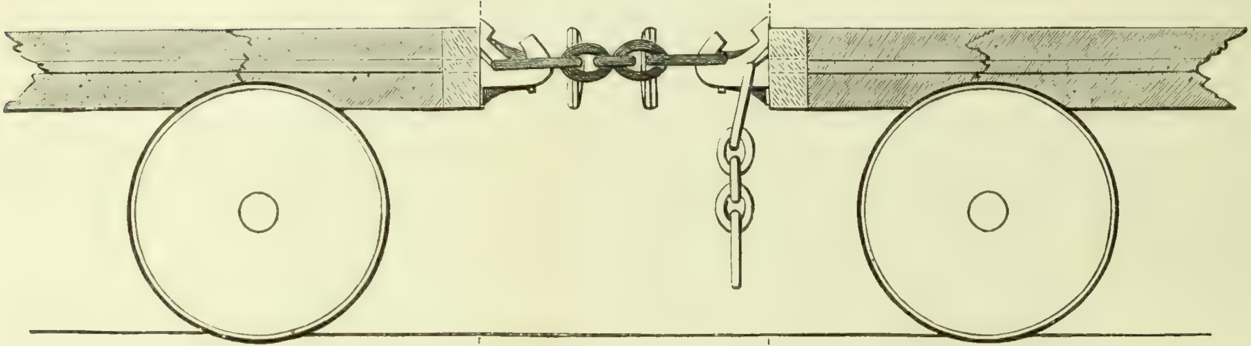
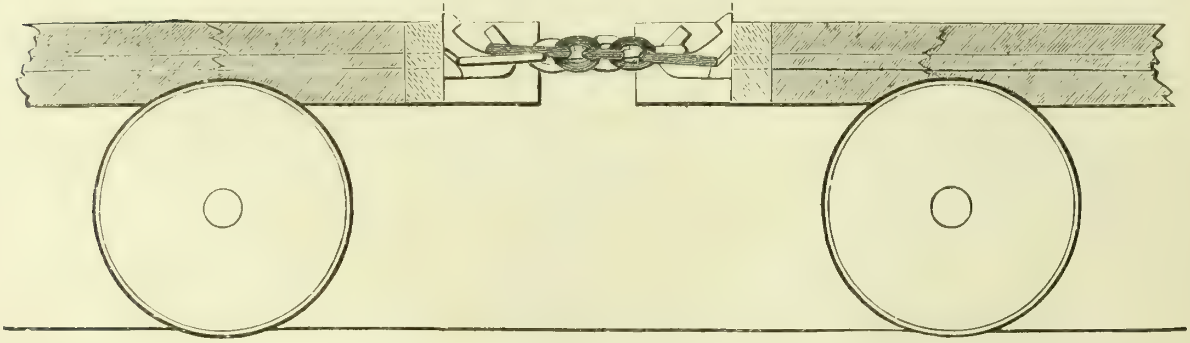


FIG. 3.



THE principal railways in Britain have now for a considerable time used the shunting-pole for coupling and uncoupling, with great safety to their employés as compared with the dangerous practice of getting between the wagons. Occasionally, however, from various causes shunters are obliged to get between the vehicles, and the new drawbar hook we illustrate above has been designed by Mr. Hosken, of Gosberton, to overcome this difficulty, by so arranging matters that the wagons may be coupled or uncoupled by the pole under all circumstances.

Fig. 1 shows a diagrammatic view of the hook, from which it will be seen that the novelty consists in the arrangement, and especially in the configuration, of the portion between A and B, which causes the coupling to slide easily into position, if thrown over by the pole in any position between A and B. The incline allows of easy connecting and disconnecting, while the portion at right angles to the incline prevents the link being forced out by sudden stoppage in answer to signals. Fig. 2 shows the hook applied to spring-buffer wagons—one of the couplings is hanging loose; and fig. 3 shows it as applied to ordinary block buffers, both couplings in position.

We are informed that this hook has now been in use for some time on many wagons, with most satisfactory results, and that shunters find it more convenient than the ordinary type.

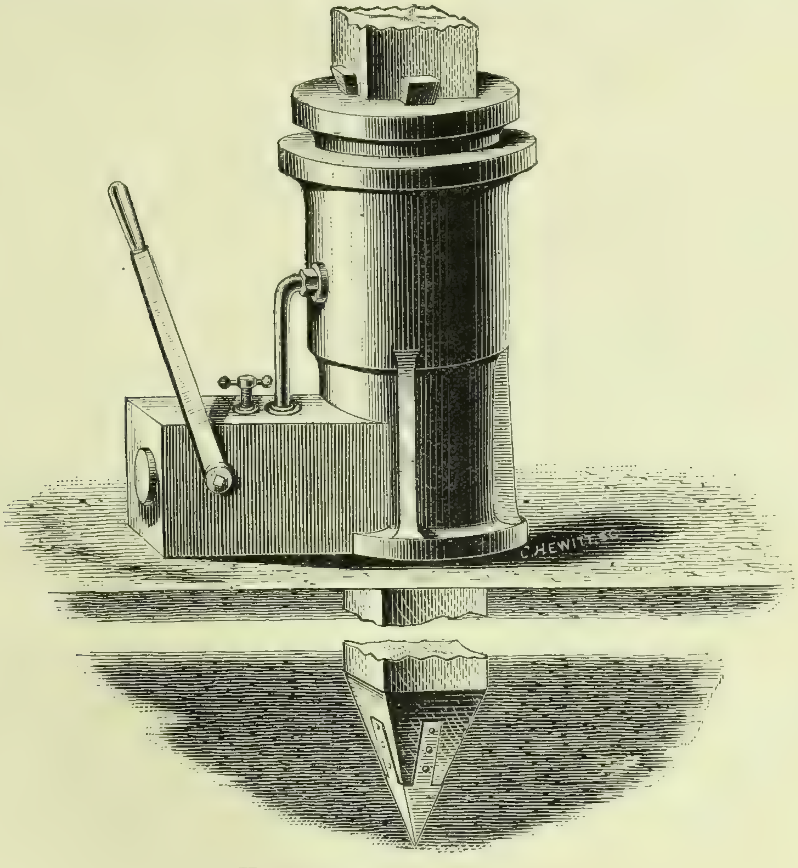
THE THURLOW CAST-STEEL GUN.

AFTER the disastrous failure of the Bessemer steel gun, there were some natural misgivings as to the results of the test of the open-hearth cast-steel gun made by the Standard Steel Casting Co., of Thurlow, Pa. But the Annapolis trial of February 7th has dispelled this doubt as far as ten full-service rounds within 20 minutes could prove the efficiency of this new weapon.

The original casting was made at the works at Thurlow ten months ago, with 13 tons of open-hearth steel used in the cast. It was rough-turned and bored out at Thurlow, and turned, rifled, and polished at the Washington Navy Yard. The walls at the breech are $7\frac{1}{4}$in. thick, and at the muzzle $2\frac{1}{2}$in. thick. The total length of the gun is $193\frac{3}{4}$in. The tensile strength of the metal is 20,000lb., the elongation 21 per cent, the reduction 19 per cent, and the elastic limit 40,000lb. With a charge of 48¼lb. of brown prismatic powder, a conical shell weighing 100lb. has a muzzle velocity of 2,000ft. per second.

The two preliminary 36lb. charges, and the ten 48lb. service charges, with a 100lb. projectile in each case, were fired within 33 minutes. The star-gauge tests for expansion have not yet been made public.

The one thing established is that a cast-steel gun can be made to stand the Government test of 10 service rounds—a gun that costs only 5,300 dols.—and has a calculated range of nine miles. Mr. Baldt, the manager of the Standard Steel Casting Company, claims that they can make a better gun still; and that, even if the present gun is for any reason rejected by the Government, this fact will not deter them from making another and better gun. Mr. Baldt says that this gun was not tempered, and when it was cast it took up every bit of steel they could scrape up about their works. Experiments made with three test pieces taken from this gun showed that by oil-tempering the elastic limit was increased from 40,000lb. to 77,000lb., and the tensile strength from 80,000lb. to 109,000lb. This gun had 21 per cent of elongation, but when oil-tempered this was reduced to 9 per cent. The metal can also be increased in density by giving it a greater casting-head. Existing facilities are ample at the works of the company to turn out ten such guns per week if called for.



Hydraulic Pile Extractor.

HYDRAULIC PILE EXTRACTOR.

The extraction of piles which have served their purpose and require removal for some reason is not by any means an easy matter, and several methods have been designed with the intention of facilitating the operation. Mr. G. C. Marks, engineer, of Birmingham, has invented a hydraulic pile extractor, manufactured by Messrs. Youngs, engineers, Ryland Street, Birmingham, which we illustrate here. It consists, as will be observed, of a ring-shaped hydraulic ram, working in an annular space in a cylinder, arranged of sufficient diameter to allow of it being placed over the end of the pile to be taken out.

The operation is very simple. The pile is first secured to the interior of the ram by wedges; then the pump is pumped up till the ram moves through its full range; the wedges are then taken out and the ram dropped to the bottom of the stroke, wedged again, and then pumped up. This operation is repeated, securing the pile in position at each stage, when necessary, until it is got clear out. The illustration shows the arrangement very clearly, with annular ram, cistern, and force pump.

In yielding soil the base must be suitably supported to give a firm enough hold to start the pile. Special hydraulic tools are very commonly used, and this one seems to us most convenient and handy.

THE CONSTRUCTION OF GASHOLDER TANKS.*

A paper was read on this subject by Mr. M. C. Hunt, M.Inst.C.E., in which he said that the early history of the means employed for storing and delivering gas belonged to the domains of chemistry and physics, rather than that of engineering. The first gasholder was invented by Lavoisier, in 1782, and was called by him a gasometer. It consisted of a square vessel inverted in a square tank, filled with water, and provided with two pipes for inlet and outlet. The vessel, or holder, was suspended by a chain which passed over the curved end of a balanced lever, and was counterbalanced by ordinary weights placed in a scale. It was said that this form of gasholder was first adopted on a working scale about the year 1815, and at that time larger tanks were made of wood, after the manner of brewers' vats. Passing over the various attempts that were made, the real interest in this subject commenced a few years later than the date already given, when brick tanks began to be constructed. They were at first of very small dimensions, but they rapidly assumed greater proportions. At present the largest tanks made either with bricks or concrete had a depth of between 50ft. and 60ft., with an extreme diameter of 250ft.

The principal point in constructing a gasholder tank was to know as much as possible of the nature of the ground in which it was intended to construct it. Of all subsoils, perhaps the best for tank construction was London clay, because this could be worked into a basin impermeable to water; it afforded a solid foundation for the tank walls, when undisturbed by water; and its angle of repose being slight, the pressure it exerted upon the back of the walls was inconsiderable. Perhaps the most troublesome ground in which to construct a tank was sandy loam, the loam making it very difficult indeed to drain sufficiently to get a dry bottom for the foundations. Occasionally the engineer had chalk or sand to deal with; then the task was comparatively easy;

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* The Institution of Civil Engineers, Birmingham Students

and even when he had to deal with hard rock the great cost of excavating was largely compensated for by the tolerable certainty of a satisfactory issue. It was, therefore, apparent that the cost of constructing gasholder tanks bore an intimate relation to the ground in which they were constructed. For small gasholders, where excavation was likely to prove a difficult undertaking, cast or wrought iron tanks, especially the former, were used. In either case it was usual to form the bottom with cast-iron plates having inside flanges laid upon a concrete foundation, made perfectly level by floating, or having a small space between it and the plates, to be filled in and made solid by grouting. It was, of course, essential that the concrete should rest on solid ground, otherwise the structure would come to grief. He quoted several instances where this had occurred. Tanks with cast-iron sides were invariably strengthened by wrought-iron bands, which held the structure together by sustaining the bursting pressure of water within the tank. Wrought-iron side-plates, although more liable to corrosion than cast-iron ones, were frequently preferred to the latter, because there was always a certain amount of danger attending the use of bands, from the giving way of a cottar or some other fastening. In America, tanks of wrought iron and steel were largely used, while he had seen one in Belgium formed of channel iron rolled to a very wide section. The lengths were bent to the required circle, placed one on top of the other, and their flanges riveted together. This plan afforded great strength and stiffness, and appeared specially suitable for tanks of large diameter. Wrought-iron annular tanks were used occasionally where the excavation proved unsuitable for building. This kind of tank consisted of an annular water space or trough resting upon a suitable foundation, the centre of the tank being left unexcavated, and made water-tight by a covering of clay puddle, or by other approved means.

Returning to the consideration of excavated tanks, constructed of brick or similar material, he might observe that these were divided into two principal classes, viz., one in which the tank was made impervious to water by a continuous envelope or basin of clay puddle, and the other, in which the same object was secured, by an interior coating of cement rendering. In the first of these the water passed through the more or less porous wall of the tank, and its pressure was consequently exerted directly against the puddle and earth backings, while in the other the impervious coating of cement caused the wall itself to be opposed to the full bursting pressure of the water.

Until recently bricks and stones had been exclusively used for the construction of tanks, but concrete was now largely used. Concrete for this purpose was usually composed of one part of Portland cement to six or seven parts of gravel or ballast, which should be free from clay. A proportion of broken fire-brick and clinkers was mixed with it.

In deciding upon the thickness of the wall, the fact had to be taken into account that, although during construction, and until the tank was filled with water, the wall had to perform the function of a retaining wall by sustaining the whole weight of the earth behind it, yet the rule for determining the thickness of a retaining wall could not apply, because of its curvature. This afforded an immense advantage in point of strength, although to what extent precisely could not be calculated. All experience, however, showed that with a reliable foundation and a tolerably wide base, the wall need not be of much greater thickness than would ensure its keeping in shape until properly and firmly set. It was a common practice, as an additional precaution, to interpose courses set all round in Portland cement, at intervals of a few feet in the height. In a general way the thickness of tank walls at the bottom might be stated to vary from 18in. to about 6ft., according to depth and diameter, this being reduced by set-off to one half, or less, at the top.

The diameter of the tank and the thickness of the wall necessarily determined the area of excavation. The method usually followed was to form a circular trench of the full width required at the bottom, allowing for the footings of the wall. In setting out this trench, sufficient space should be left for timbering; each frame of timber occupied about 8in. or 9in. on either side. The timbering required to be watched, and made secure against the slightest movement, for this, if allowed to extend, might result in disaster at any moment.

As a preliminary to digging the trench, it was necessary to get rid of the water. With this object a clear start should be made with the sump in which the pumps were to be placed. This should be situated as near as convenient to the site of the tank, and carried down at least two or three feet lower than the lowest part of the required excavation. Too much importance could not be attached to this. Water not unfrequently occurred in great abundance, and pumping then became a serious item of cost. In the construction of a large tank in the Old Kent Road works of the South Metropolitan Gas Company, the quantity which had to be pumped up each 24 hours was stated to be 2,160,000 gallons, while nearly 3,000,000 gallons per 24 hours were raised during the construction of two large tanks at Windsor Street Works, Birmingham. The building of the last tank he had superintended himself, and had much trouble to contend with. One of the tanks was 200ft. diameter and 37ft. deep, and was probably the largest out of London.

Some difficulty was experienced in gaining the necessary depth, although the drainage was assisted by cutting a gap between the trench and the sump, through which was led to the latter all water that found its way into the trench from the back of the runners. The displacement of the soil, however, by this water was a serious matter, for the timber, which sank repeatedly, had to be constantly looked after, and at the outset some trouble was caused from the bottom of the sump being in running sand, a great deal of which was drawn up by the pumps until stopped by pouring underneath the suction a kind of filter-bed made of straw securely timbered over and wedged down.

A striking contrast to this was the tank constructed for the Liverpool United Gaslight Co., by Mr. Wm. King, M.Inst.C.E., It was wholly in the porous sandstone, and no pumping was needed.

Other varieties of tanks were alluded to, and in conclusion the author gave a table, which we reproduce, giving the comparative costs of gas tanks in different parts of this country.

Description and Locality of Tank.	Diameter.		Depth.		Cost of Tank.	Cost per 1000 Cubic Feet Capacity.
Brick and puddle tanks—	Ft.	In.	Ft.	In.	£	£
Birmingham	82	0	20	9	1,902	17·3
Do.	97	0	20	9	2,250	14·7
Do.	102	0	24	9	3,882	19·2
Do.	102	0	24	9	3,420	16·9
Do.	142	0	24	9	5,850	15·3
Do.	185	0	41	0	18,190	16·5
*Do.	200	0	37	0	16,800*	14·4*
*Do.	200	0	37	0	20,800*	17·8*
†Salford	154	0	40	0	11,700	15·7
Fulham	233	0	32	0	10,000	7·3
Kennington Lane	218	0	44	6	21,446	12·9
Beckton	195	0	37	6	15,000	13·4
Leicester	172	0	37	0	15,200	16·5
‡Brick tank, Bolton	142	6	32	0	7,066	14·0
Concrete and puddle tank, Nine Elms, London	200	0	45	0	17,600	12·4
Concrete and rendered tank, Old Kent Road, London	218	0	55	6	20,300‖	9·8

* Inclusive in each case of £1,200 for timber framing to the gasholder crown.

† Puddle found on site. No pumping.

‡ No puddle; a cavity between two walls filled with hydraulic mortar.

‖ Inclusive of £1,800 for timber framing, valves, &c.

THE INSTITUTION OF CIVIL ENGINEERS.

At the sixteenth ordinary meeting of the session 1888-89, held on Tuesday, the 12th of March, Sir George B. Bruce, (the president) being in the chair, the paper read was on "Indian Railways; the Broad and the Narrow Gauge Systems Contrasted," by Mr. Francis John Waring, M.Inst.C.E.

The subject of the relative advantages of the broad and the narrow gauge for the State railways of India had been discussed at the institution sixteen years ago; and the object of the author in the present paper was to compare the cost of constructing and of working railways on the gauges of 5ft. 6in. and 1 metre. It was pointed out that the reasons formerly advanced by the advocates for maintaining uniformity of gauge, which were then ignored by those in favour of the narrow gauge, were shortly afterwards found to be so cogent in the cases of the Indus Valley and of the Punjab Northern Railways as to out-balance any anticipated economy to be effected by adopting the metre gauge for those lines. The author based his comparison on the statistics of the construction and working of Indian railways, as contained in the Administration Reports of the Director-General of Indian Railways, with the object of testing by the results of experience the soundness of the views then expressed on both sides of the question. Commencing with a length of 20¼ miles of the Great Indian Peninsula Railway, opened on the 18th of April, 1853, the railway system of India had expanded to 13,390¼ miles on the 31st of March, 1887, when an additional length of 3,205¾ miles was in progress or had been sanctioned for construction. The gauge of all the earlier lines constructed by guaranteed companies was 5ft. 6in., the first departure being in the case of the Nalbáti Railway, opened in 1863. This remained the sole exception from the standard till the Rajputana-Malwa Metre-Gauge State Railway was opened in 1873, at which time 5,576¼ miles of railway of the 5ft. 6in. gauge were in existence. Since then 2,411½ miles of line of that gauge had been opened for traffic, and 1,741¼ miles, or 54 per cent of the whole mileage now sanctioned or being constructed, were to be of the same gauge. The length of metre gauge lines open on the 31st of March, 1887, was 5,117 miles. The total capital outlay, including expenditure on the connected steamboat services, amounted on the 31st December, 1886, to £170,498,911, at the conventional rate of 2s. per rupee. The gross receipts in 1886 were £18,704,536, and the net revenue was £9,773,553, being at the rate of £5 14s. 8d. per cent. The total number of passengers was 88,436,318; the receipts from coaching traffic were £5,793,152; the aggregate weight of goods was 19,576,365 tons; the receipts being £12,385,914. The capital outlay upon construction per mile of railway open had varied, in the case of lines of 5ft. 6in. gauge, from Rs. 210,686 on the East Indian to Rs. 35,929 on the Pátri Railway. Upon the metre gauge lines the highest expenditure had been Rs. 87,230 on the Northern Bengal Railway, the lowest Rs. 17,271 on the Jodhpore Railway. For railways having the same gauge these large variations could only be accounted for by differences of the class of railway, and the presence or the absence of difficulties and costly works in their construction. Comparing the mileage cost of lines of the 5ft. 6in. gauge with that of lines of the metre gauge, the author attributed much of the economy effected in the construction of the narrow gauge lines to some inferiority in the class of railway made, possibly conjoined to the comparative absence of engineering difficulties in making them. In support of this view the author pointed out that the broad-gauge lines, which might be described as the main arterial communications throughout India, were to a large extent laid out for a double line of way, so far as regarded earthworks, and in many cases culverts and bridges, excepting the girders; in fact, 11·3 per cent of the open lines had been doubled; but of the metre-gauge lines only 1¼ mile of double way had been laid, and so far as he knew no preparation had been made for doubling any portion of the remainder. The former lines were laid with rails of from 60lb. to 84lb. per yard, in many cases of steel; they were well ballasted and fenced; ample station accommodation was provided, and in many respects their finish was equal to that of English railways: but the latter, which were mostly feeders to the broad-gauge lines, were laid with rails of not more than 41¼lb. per yard, less station accommodation was provided, and on some of the less important lines ballasting and fencing had been omitted. Some of the leading dimensions affecting the railways, as prescribed in the Government Regulations for Railways of both gauges, were stated.

The principal difficulties upon Indian railways had been the crossings of the great rivers. Upon the broad-gauge lines, forming the main trunk communications of the country, the heavy expenditure entailed by bridging these rivers had to be faced; whereas upon the subsidiary narrow-gauge railways any exceptional quantity of bridging upon a proposed line would, it was thought, lead to the undertaking being abandoned. To such an extent had this apparently been the case that, out of forty of the largest railway bridges, no less than thirty-five occurred on the broad-gauge lines, increasing their average mileage cost, from this item alone, by nearly Rs. 11,000, while the corresponding increased cost on the metre-gauge railways was only Rs. 1,416 per mile. The actual cost of a large bridge did not, in many cases, represent the total expenditure involved; for, where the rivers overflowed their banks annually during the rainy season, heavy approach embankments, and numerous smaller bridges to provide a passage for the inundation waters, were necessary. On these grounds the author was of opinion that the broad-gauge lines generally were of a superior type to those of the metre gauge, and that the difficulties encountered in constructing them contributed to swell their cost to a degree which did not occur in the case of the latter. The Administration Reports for 1886-87 contained detailed information connected with the working statistics during 1886 of eight broad-gauge railways aggregating in length 7,648 miles, and of twelve metre-gauge railways aggregating 4,421 miles. From this information a table had been compiled, showing the mean, maximum, and minimum values of the most important items for both systems of railway, together with the differences between these mean values and the gauge of the lines on which the higher mean value occurred. The remainder of the paper referred concisely to the results shown by this table. It appeared that notwithstanding the higher outlay of capital per mile on the broad-gauge than on the metre-gauge lines, the average net returns were higher upon the broad-gauge railway. This was due not only to the total earnings per mile being higher, but also to the fact that the working expenses did not increase in the same proportion per mile per week and per train-mile. The cost per 1,000 gross ton-miles moved was more than 50 per cent higher upon railways of the metre gauge, upon which the percentage of working expenses was 12½ per cent higher than upon the broad gauge. The coaching receipts per train-mile were in favour of lines of the broad gauge to the extent of nearly 10 per cent; but the percentage of freight to dead weight was 2·13 per cent in favour of the metre-gauge railways. A similar examination into the statistics of the goods traffic showed greatly-increased economy in the working of the broad-gauge lines. The proportion of paying freight upon the capacity hauled was in their favour, while the proportion of freight weight to dead weight was practically the same upon railways of both gauges. With respect to the percentages of earnings from various sources to the total earnings, the railways of 5ft. 6in. gauge had secured a larger proportion of goods traffic, on which the profits seemed to be higher than on passenger traffic. The cost of maintenence per mile of line, per mile of track, and per train-mile was higher upon the 5ft. 6in. gauge, yet the excess was not even approximately in proportion to the excess in weight of the traffic passing over each mile and to the increased weight of the trains, and the balance of economy was largely on the side of the broad-gauge railways. The author argued that the type of permanent way adopted for the metre-gauge lines was not so suitable as that adopted for the heavier traffic on the lines of 5ft. 6in. gauge; and that an increase in the weight of the rails, in the scantlings of the sleepers, and in the amount of ballast used on lines of the narrow gauge, would be attended with beneficial results. The author then discussed the cost and particulars of locomotive expenses, and showed that the averarge expenses per 1,000 gross ton-miles were nearly 28 per cent in favour of the broad-gauge lines. On the other hand, carriage and wagon expenses were less on metre-gauge lines, as were also to some extent traffic expenses per train-mile. Finally, the average amount of general charges per train-mile was much higher upon railways of the metre gauge than upon those of the 5ft. 6in. gauge.

MANCHESTER GEOLOGICAL SOCIETY.

EARTHQUAKES—ROBURITE—GOAF PACKING—NEW FORM OF SAFETY LAMP.

AT the last meeting of the Manchester Geological Society, held in the afternoon of the 12th inst., some important matter was brought forward. Mr. John Knowles, M.Inst.C.E., the President, stated that at the time of the recent earthquake in the Manchester district, which was fully reported in the daily papers, he found that the firemen in several of the collieries belonging to his firm had, in their regular reports, made remarks upon the disturbance, which they attributed at the time to large falls in the roads, but on examination they found nothing different; in one case, the workmen of a whole district left work, as they thought some accident had occurred.

Mr. Henry Bramall, M.I.C.E., called attention to a newly-discovered danger in the use of roburite as an explosive. Many of the shot-lighters who were firing this explosive had become incapacitated from work owing to the effects of the fumes resulting from the explosion, and not from the handling of the explosive, which it is well known communicates poison to the system by absorption through the skin.

Dr. Berry, of Pendlebury, who had examined and attended some 10 or 12 cases, described the symptoms and effects of the fumes, and stated that the evidence was positive of poisoning from the inhaling of carbonic oxide gas.

Mr. Herbert Fletcher described the system of goaf packing in use at Ladyshore Colliery, a large proportion of the packing material being conveyed into the working places and airways, and even taken from the surface for the purpose of stowing the goaf in the thick seams. Mr. Hollingworth, F.G.S., exhibited and described Mr. Clifford's new patent safety lamp for mines. The Phœnix lamp is of quite a novel construction, and is the invention of Mr. Wm. Clifford, mining engineer, Sheffield, the inventor of the well-known Clifford lamp. It is impossible to fully describe the lamp without a diagram, but we hope to give full details in a future issue. The chief peculiarities of its construction are that the usual movable gauze is replaced by a fixed gauze of a flat construction placed at the back of the lamp, and that a cylindrical glass, slightly curved at the top, which surrounds the flame, enables the light to be thrown upwards as well as horizontally—a great advantage for examining the roof of the working. The air enters through a well-shielded opening in the back of the lamp, and then through the gauze into the lower part of the lamp, whilst the products of combustion pass through a trumpet-shaped tube at the top of the glass, through the gauze, and out through another well-shielded opening at the back of the lamp. The lamp in consequence is not affected by currents, and is guaranteed to stand an explosive mixture moving at the extreme velocity of 75ft. per minute without passing the flame.

The parts of the lamp are convenient for cleaning and examination, and as the gauze is a fixture it cannot be accidentally left out in putting the lamp together, as has been known to be the case with bonneted lamps, and an unsafe lamp sent into the workings.

Another novel feature is the method of hooking the lamp bottom to the other part of the lamp, instead of screwing them together, as is usual.

The lamp gives a good light, and weighs only about 2½lb., in stamped brass or crucible steel. It can be sold at 6s. 6d. per lamp. It was very favourably received at the meeting.

NOTE ON CAST-STEEL WATER-JACKETS.*

The use of water-cooled breast-jackets or cinder-tap blocks is a great convenience in lead-smelting, even when siliceous slags are made. If the charges are at all basic it is almost imperative. Jackets of riveted wrought iron or steel are expensive; those of cast iron are liable to crack; those of bronze are costly and not durable, being easily penetrated by tapping-bars or destroyed by streams of matte impinging against them. To overcome these objections I introduced at the Hanauer works, in April, 1866, cast jackets of steel, which have been in constant use since that time and are to-day as good as new.

These jackets were made for us by the Chester Steel-casting Company, of Chester, Pa., at a cost of ten cents per pound at the works of that company. The metal is ⅝in. thick, and the jackets were cored and tapped for 1½in. bushings, affording two large holes for the removal of dirt and incrustations. The same holes are used for feed and discharge water through ¾in. pipe.

I hope the successful introduction here of cast jackets of steel will lead to their more extended use in all branches of metallurgy where water-cooled surfaces are severely taxed and where the size and thickness of the castings are not unfavourable to the production of a sound article, impervious to water and of high tensile strength.

RAIL SECTIONS.†

The subject of the wear of rails seems to have attracted an unusual amount of interest in the last six months, and in the hope of doing my share to direct opinions in what seems to me the right direction, I will attempt to discuss briefly the several ways in which the shape of the rail-section may affect the life of rails. In a paper presented at the Boston meeting of the Institute (Trans. XV., 594), I outlined the principal causes in the various steps of manufacture which might affect detrimentally the service of steel rails, showing that, in my opinion, the result might be algebraically represented by an equation composed of a number of variable factors, and that it was not possible to ensure a good rail by fixing any single one of these. In the present paper, on the other hand, I shall seek to prove that the design of the rail-section, independent of the material used, may make a poorly-wearing rail.

The designing of many rail-sections by engineers who are far from being experts in the metallurgy of steel has led to the general acceptance of erroneous principles as the rules for such designs. Until very recently, it has been assumed that the more metal was put in the head, to wear away, the longer the rail would wear; and it has been the practice, in adopting heavier sections, to put all the additional weight on top of the rail-head of a very much lighter section. Careful investigation on a number of railroads has shown that of the rails weighing 65lb. per yard and over the greater part have to be removed after comparatively trifling abrasion, solely because they are no longer fit for a smooth track. This is evidence of error in the principles of the design of the section.

It is generally admitted that, as a rule, rail-sections designed since 1879, for rails of 65lb. and over, have not given entire satisfaction. There are several reasons which may account for this; first, a constant increase, during this period, of wheel loads on engines and cars, together with generally higher speeds; secondly, new methods in manufacture, cheapening the cost of production and possibly producing an inferior article; thirdly, mechanical conditions in the rail itself, due to the shape of the rail-section.

1. The first cause is undoubtedly a real one. I think there is evidence that the elastic limit of much of the rail steel now in use is actually often exceeded by the strains of practice, causing a flow of metal, which is then abraded by the wheel flanges; and the result is a kinking or a battering of the rail, which condemns it for a good track. Granting the existence of this cause, there are two ways of ameliorating the result; one is to increase the bearing surface of wheels on rails; the other, to raise the elastic limit of the metal, which subject I shall take up later on.

2. With regard to the second cause, it is held by many that the enormous production, low cost, and "improvements" induced by competition have involved inferior quality of product. Many well-informed men are content to rest on the simple assertion that the old John Brown steel gave remarkable satisfaction, because it was made of a good iron and did not contain more than ·08 per cent of phosphorus, any analysis showing more being grossly inaccurate. If they are satisfied that this is the solution of the problem of making a really good rail, why do they not try their ·08 per cent of phosphorus? Low phosphorus steel can be made to-day with more certainty and at less cost than ever before. The only question is, whether the elimination of phosphorus is going to be worth what it costs. The fact that as many Bessemer charges are now blown in one hour as were formerly blown in a day is pointed at as evidence that the same care cannot be given to the operation; but I think men really conversant with the turning out of a large product will maintain that almost absolute regularity in the iron is necessary to keep things running with the clock-work regularity required for such a rate of production. Indeed, large product and general smoothness in mill operation are, to my mind, an indication of a uniform product, so far as metal in the rail itself is concerned, and seem to me, therefore, not objectionable on that score. With the rapid rolling, however, particularly the rapid blooming or breaking down of large ingots, I find fault, as I have explained at some length in my former paper, already cited.

3. That mechanical conditions in the rail itself, due to the general design of the rail section, can have any important effect on the service value of rails hasnot been generally admitted, so I wish to lay particular stress upon this cause and attract to it the recognition it deserves. Speaking in general terms, that form of rail is, in my opinion, faulty, which has a deep massive head, a wide, thin base and a thin web, connected to the head and base by small fillets only. The objection to this form and the advantages which might be obtained by different proportions may be concisely enumerated as follows:—

a. Such a form necessitates rolling at a higher temperature, and, what is of chief importance, finishing at a higher temperature than permits the securing of a well-forged, compact rail.

b. This type of section probably encourages the use of a higher percentage of manganese to reduce the number of second-quality rails; and this production of second-quality rails, as well as the additional manganese, figure in the cost of the rails to the consumer.

c. Rails with heads out of proportion to the rest of the section require a great deal more cold-straightening, because it is impossible to know how much bending or cambering such a rail needs in its hot state in order that it shall cool straight. This is certainly a very important consideration.

d. The same sort of disproportion must produce corresponding disproportions in the rate of cooling, causing internal strains which are only partly dispersed or effaced by the small connecting fillets.

e. A section having these internal strains exaggerates the effect of any impurity which may chance to have segregated in the ingot, while a section not liable to these strains would safely admit of a generally higher carbon steel as well as a considerable latitude in composition.

f. It is not economical to provide for an abrasion of some ⅝ of an inch, or even more, from the top of the rail, if it is found that rails have failed long before this amount has been abraded. Instead of providing more height to wear away, we can do better by providing more breadth of bearing-surface, and metal of a higher resistance within the elastic limit.

g. Inasmuch as the funnel-shaped cavity, dispersed blowholes, and possible impurities exist in the ingot in the axis of its length, it follows that these defects will exist (especially in rails made from the upper part of the ingot) on an axial line which passes through the rail-section. It follows that if the rail section has 50 to 55 per cent of its metal in the head, the poorest metal is enclosed in the head, where it receives the least amount of forging; whereas, if the amount of metal in the head does not exceed 40 to 45 per cent, this poor metal occurs in the thoroughly worked web portions.

The foregoing objections seem to be so formidable and convincing that I am glad to see a general tendency among all the later investigators to come to the same conclusions. It seemed to me that rail-sections should be made to certain definite proportions, regardless of the weight per pound. It is often said that the larger sections will admit the use of a higher carbon steel; but this assertion requires the proviso that the heavier section shall be similarly proportioned. One seventy-four-pound section which I have in mind could not be safely made of as high a carbon steel as the sixty-two-pound section from which it has been schemed.

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* By R. H. Terhune, Am. Inst. Mining Engineers.

† By Frederic A. Delano, Trans. of Am. Inst. of Mining Engineers.

While I am deeply interested in the recently published researches of Mr. D. J. Whittemore, chief engineer of the Chicago, Milwaukee, and St. Paul R.R., and agree entirely with him in his conclusions that wheels should be cylindrical and the bearing surface should be increased, it seems to me that a rail-head of twelve inches radius is flat enough. Since there is a lateral play of fully half an inch for the average car wheel on an average track (not to mention a 4ft. 9in. gauge) both the wheel treads and the rail-heads must wear to a curve. On the other hand, if the rail-head begins with a slight top-curve, it would take no longer than with the flat-topped rail to assume the curve of the average wheel. This is a subject, however, which deserves more attention than I am able to give it in the present paper. Mr. Whittemore has ably argued the need of more bearing-surface, which, after all, can only be obtained by widening the rail-head; and I am glad to quote him here as authority for the need of wider heads for our rails. The reasons for making the head shallow, as well as wide, have been recited. For the same reasons the web and flanges should be heavy, with liberal connecting fillets.

The problem is to increase the life of rails without greatly enhancing the cost. It might be possible to make a sixty-pound rail of steel worth $75 per ton give as good service as an eighty-five-pound rail made of $30 steel; but the discovery would not prove remunerative.

With regard to internal fillets and flat fishing angles, I have held the extreme view that the fillets should be liberal and the angles of enough slope (certainly not less than 15 degrees), to allow really colder rolling than is anywhere the practice in this country.

The specifications, which I append as a conclusion to these brief remarks, may be of interest to some, as being different in several particulars from any other rail specifications. They were drawn up originally fifteen months ago, and have not been changed in any important particular since that time.

Proposed Specifications for Steel Rails.

1. The steel used in the rails shall be made by the Bessemer or by the Open-hearth process, and shall not contain more than $\frac{12}{100}$ths of one per cent of phosphorus, as determined by an analysis made from a boring into the centre of metal of the rail-section of any rail.

2. The ingots shall be poured with care, and the moulds filled at one pouring, without undue spattering of the sides. No sand or water shall be thrown upon the ingots after pouring; but, on the contrary, coke or charcoal dust shall be used. In no case shall rails made from a chilled heat or a bled ingot be accepted as first-quality rails.

3. Cold moulds, or moulds in such a shape as to require more than a hand-sledge to free them from the ingot, shall not be used.

4. It is preferable that ingots, when taken from the pit, should be kept erect, and so heated; but if this is not the practice of the rolling mill company, the ingot shall not be laid on its side until it is certain that the central part has solidified.

5. Blooming-rolls of 40in. from centre to centre shall not be driven at a speed exceeding thirty revolutions per minute, and larger or smaller rolls shall not be driven at a speed exceeding this in linear velocity. (The linear velocity of an ingot going through the first or 13in. pass of a pair of 40in. rolls, driven at a speed of thirty revolutions per minute, would be about 205ft. per minute.)

6. No metal shall be cut from that end of the bloom which corresponds to the "butt" end of the ingot.

7. From that part of the bloom which corresponds to the top part of the ingot an amount shall be cut equalling in pounds the area of the mean cross-section of the ingot in inches, or as much more as is necessary to secure a sound pipe, free bloom.

8. The number of the charge shall be stamped distinctly on each rail, and the place and date of manufacture rolled on.

9. The section of the rail rolled shall conform to the template, and a variation of more than a scant thirty-second of an inch over or under the template height shall not be allowed, and the rail must be made close enough to template to fit properly in the splice.

10. The weight of the rails per yard shall be kept as close to the standard weight per yard as can be after complying with the conditions of clause 9.

11. The rails shall be drilled for the bolts of the splice bar, or, if necessary, notched in the flange, in accordance with the templates and diagrams furnished by the railroad company.

12. The rails shall be cut at right-angles to their length, and be at 60 deg. to 75 deg. F., within ¼in. of the standard length of 30ft. No shorter length rails shall be accepted by the railroad company, except under special provisions of this contract for such acceptance.

13. Rails shall be perfectly straightened in both surface and line, and without any twists, waves, or kinks. Particular attention shall be given to having the rails free from "camber," in which the ends droop, and also free from any flaws, cracks, or excessive roughness.

14. The rails shall be finished at such a temperature that it will not be necessary to allow more than 4in. for contraction on every 30ft. rail sawed immediately after coming from the finishing-pass in the rolls.

15. One rail end, which must correspond to what has been the ingot top, shall be tested for each heat or charge by a drop weight of one gross ton, falling 10ft. on the rail head, midway between the supports, 3ft. apart. The bearings are to be of iron or steel, fastened firmly to oak framing constructed of oak timbers bolted together into a solid floor, and this supported on masonry foundations not less than 4ft. deep. The guides are to be smooth, straight, and parallel. Should one rail end be broken by the above test, two similar rail ends must succeed in enduring the shock, or else cause the rejection of all rails in that same heat. It is expressly desired that the rail steel shall contain as high a percentage of carbon as the maker is willing to put in, and still produce a rail which shall endure this drop test.

16. The representative of the railroad company shall at all times be allowed, on request, to see the *bona fide* analyses and carbon determinations, as made by the rolling mill company, of the steel used in making these rails.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

Sir,—I really cannot share the sanguine belief of your correspondent, "Manchester Engineer," in the future of water-tube boilers for application to high-pressure triple-expansion engines, at least in Lancashire, as it seems to me that the difficulties of such boilers, when using hard water, must necessarily be very great as compared with those of the ordinary Lancashire type. All we engineers who have practically to do with boilers using bad water know, to our cost, the constant care required in cleaning out and scaling, and view with dismay the job of scaling the tubes of such new boilers.

I have myself no personal experience with water-tube boilers, but would very much like to know how the interiors of the tubes are scaled. I suppose that, as steam is formed within them, the solid scale-forming matters must be deposited in the tubes, and require frequent removal, and would like to know from some one with practical experience in Lancashire the nature of the deposit, its hardness and closeness of adherance to the metal.

Does it form as hard as the scale on the flues with limy water, or does any peculiarity of the circulation make it softer than usual? Again, surely the numerous joints forming the junctions of the tube ends with the water cases must give trouble from leakage. The few riveted seams of flue boilers give trouble enough under many circumstances, and I cannot see how so many joints, as in say the Roots and Babcock and Wilcox, can fail to give at least more trouble.

I have also heard it said, whether true or not, that the tubes sometimes boil dry by ejecting water from them when rapidly generating steam, and then are in great danger of burning out or bursting. Altogether, we Lancashire engineers have a strong prejudice, it may be, in favour of double-flue boilers, and much prefer to add our tube surface, in the shape of Green's economiser, where no actual boiling takes place, but we should certainly like to hear what could be said for the later form if someone can tell us, as the result of his personal observation and practical experience with them.—Yours, &c.,

Savery.

LEAKAGE IN STEAM BOILER.

To the Editor of "The Practical Engineer."

Sir,—It is a very easy matter to say the deposit in feed-water is the cause of the leakage complained of, and it is quite as easy to say the bottom flue is too small, but I do not think either of the charges are justified in the case under consideration. If the water contains a sufficient quantity of solid matter to cause trouble, I should certainly have expected the trouble to have been in the furnaces long before longitudinal shell seams would leak; and if due to an imperfect circulation, the ring seams on shell bottom would be the first to fail. Although the feed appears to contain carbonates of lime or magnesia, and the bottom flue is a little less than usually found, I do not think either has caused the leakage. Do the furnace seams bind against the shell side? if so, that might cause it.

I am sorry to introduce the boiler-maker, but if the machine has not been sufficiently powerful to close the rivets well in, much would depend on the caulkers, and if the strips or joints on one side were caulked by a good man, and those on the other by a poor man, or perhaps a careless apprentice, there might be sufficient difference in the work to cause trouble and no trouble. In small shops it sometimes happens that one man caulks all one side, and another man the other, and as I said before, if not made tight at first, it may take many caulkings to make it tight now, but I believe it can be made good by a good man. An old, experienced inspector would, no doubt, give an opinion after examination, and I should suggest to "Engine-man" that an *old inspector* be asked for when the boiler is next examined.—Yours, &c.,

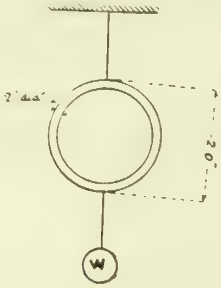
Chalkline.

QUERIES AND REPLIES.

17. **Can** anyone inform me where a copy of "The Practical Boiler-maker," by S. Nicholls, published by the author, can be obtained? I have written to Blackpool, where the author formerly resided, but the letter has been returned.—I. W.

Answer.—In answer to query from "I. W.," asking where a copy of "The Practical Boiler-maker," by S. Nicholls, can be obtained, I have a copy of this work, got some two years ago from Mr. Nicholls, and his address at that time was 168, Victoria Street, Bradford, Manchester. Probably your correspondent by applying there might get what he requires.—William Carrick.

15. **Strength of Ring.**—Will some reader show how to find the strength of a ring made of 2in. diameter wrought iron, and 2ft. outside diameter, which has a weight suspended from its lowest point, and is supported by a chain



fixed above, as shown in sketch? I wish to see the calculation, ultimate strength, safe load, &c. How would it resist collapse if the tensions became compressive pressures?—Stylex.

Answer.—After an unsuccessful attempt to find any formulæ dealing with the strength of rings such as desired by "Stylex," the writer offers the following method, usually adopted by him in such cases, as giving an approximate solution, but cannot say how near it would agree with actual experiments.

Consider the ring as a beam of circular section, fixed at both ends, loaded at the centre, and having a length equal to the mean diameter of the ring, the equation for which would be $6Wl = c\,k(4{\cdot}7r^3)$; when W equals the ultimate breaking load of the beam in pounds.

l = length of beam in inches—say 22in.
c = variable number, according to method of supporting and loading beam —say 8.
k = ultimate stress per square inch of material—say 50,000.
$4{\cdot}7r^3$ = modulus of circular section for transverse strength.

Transposing the above equation, we get $W = \frac{c\,k(4{\cdot}7r^3)}{6l}$, and substituting the respective values, $W = \frac{8 \times 50000 \times 4{\cdot}7 \times 1^3}{6 \times 22} = 14242$lb.

If w, the safe load, is steady, it may equal ⅕W; if w is liable to change from o to the maximum, either in tension or compression, take $\frac{1}{10}$W; should, however, w vary from an extreme tensional load to the same amount in compression, $\frac{1}{20}$W should be taken as the safe load. This is equivalent to a working stress per square inch of section of 10,000lb., 5,000lb., and 2,250lb. respectively.

Orion.

16. **Setting Corliss Valves.**—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—Engineer.

22. **Antimony.**—Will any reader kindly inform me of the best way to melt ground antimony? The only means at my disposal for doing so are in a ladle over gas or over a large stove, and this is not effectual, as the powder simply cakes.—H. P. S.

23. **Light Mixing Mill.**—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—Eastern.

26. **Cavities in Siemens Cast Steel.**—Can any reader explain the cause of the hollow cavities occasionally met with in Siemens cast-steel ingots? I mean hollowness so bad as to completely destroy the ingot.—W. P.

27. **Forging Mushat Steel.**—Will some practical reader kindly inform me of the best way of forging Mushat steel? I can forge ordinary cast steel, but Mushat steel seems to fall to pieces under the hammer.—Steel Bar.

28. **Yacht Engines.**—What is the greatest I.H.P. I would get out of compound engines $\frac{9\frac{1}{2}\text{in.} \times 16\text{in.}}{10\text{in.}}$ and boiler (horizontal) 6ft. 3in. by 5ft. 6in., and what should the areas of ports, and separate parts, and diameter of steam pipe be, so as to get the greatest power of them?—S. J. M.

29. **Cementing Rubber to Metal.**—Can any reader give me information as to the best cement for fastening a rubber stamp to metal. The cement must stand frequent pressure upon the rubber without being loosened.—J. A. L

30. **Metallic Piston-rod Packing.**—Who are the makers of Cruikshank's metallic piston-rod packing, and what is their address? Also where is the United States Metallic Packing Co.'s packing to be had?—J. W.

TO CORRESPONDENTS.

R. M. L., Gainsboro'.—We think that it would be very unwise on your part to go abroad, as you seem to propose, on the mere chance of obtaining employment. The best engineering positions abroad are settled in this country by firms who have foreign connections, and who send out men of tried experience to take charge of work constructed here and requiring to be fitted up and put in operation there. You should try and get sent out in that way if you are determined. In our own opinion, England is on the whole the best country in the world for practical engineers, and also offers the best chances of possible advancement. Thanks for appreciative remarks.

Engineer, Bradford.—In the sketch you send you have divided the crank circle, not the stroke, into eight parts. A right angle is equal to one-fourth of the circle, and, therefore, cranks which are separated by a quarter circle are at right angles to each other.

Beta, Staffordshire.—We propose describing the usual methods of preserving timber in an article very shortly, in which you will get all the information for which you ask.

J. A. L., Manchester.—In what way does the strap run round the ⅜in. diameter shaft? Does it drive it, or is it to be fixed permanently round the shaft?

Engineer, Southport.—You can obtain graphite powder from any good ironmonger or drysalter. It is quite cheap.

J. B., Peterboro'.—We are thinking of publishing specifications of machinery and boilers of steam-launch of which working drawings have appeared. They are a convenience to many of our readers.

Hydraulic, Middlesboro'.—The dimensions given in our articles upon "Hydraulic Machinery," &c., are the results of a very extended practical experience, and may be relied upon if the metal is cast properly and is of good quality.

Buffalo complains that he ordered Vol. I. of *The Practical Engineer* from his bookseller, who reported that he could not obtain it, the reason being that "we had only one in stock, which was soiled." These kind of complaints are only too common. The answer is altogether incorrect, the fact being that we still have a few *clean* copies of Vol. I. on hand, and if our correspondent will send the cost of same (6s. 6d.) direct to our Manchester office, we will send it him direct, carriage paid. He should, however, be able, after this explanation, to obtain the volume through the ordinary trade channels, if he so prefers. In any case, we should be glad to hear who gave the above erroneous reply to his previous order, so that we may take the delinquent to task.

Horizontal Engine.—The throw of an eccentric is half the travel of the valve driven by it, just the same as in the case of a crank radius and piston stroke. Your eccentric would, therefore, have ¼in. throw.

Graphic.—We fear you will find it difficult to get full detail working drawings for a modern triple-expansion marine engine of the power you mention. Many drawings have been published, but we fear not sufficiently complete for your purpose. Your best and most economical way is to employ a draughtsman who has had experience in such work.

Pinion, N. Wales.—It is not absolutely necessary for the firm who wish to manufacture your patent article to have a formal license. Letters between yourself and them are quite sufficient, but must of course be duly stamped to be binding in law. You will probably find it more satisfactory to work upon letters than a formal agreement, at first, in any case.

Subscriber, Macclesfield.—Do you wish to supply a jet blower with steam from a ½in. pipe, or do you wish to supply an engine? If the steam freely expands from a ½in. pipe, the case is very different from the supply of a machine or engine.

MISCELLANEA.

The Forth Telegraph Cables.—Telegraphic communication in the Forth district has been somewhat interrupted of late by the breakdown of the submarine cable which crosses the Forth between Burntisland and Granton. This has necessitated a visit from the Government cable steamer Monarch, which is now in the Forth, and is engaged in repairing the old and laying a new cable.

On Wednesday week, Mr. Charles H. Beloe, M.Inst.C.E., delivered a lecture at the School of Military Engineering, at Chatham, to the officers of the Royal Engineers, on the purification of water and sewage by the magnetic spongy carbon process, introduced by the International Water and Sewage Purification Company Limited, of London. The lecture was illustrated by diagrams and samples of the materials used and of the results obtained by this process, which has recently attracted much attention in the sanitary world.

At the last meeting of the American Society of Mechanical Engineers, Professor R. H. Thurston predicted the early attainment in the steam engine of a horse power with the expenditure of 12lb. of steam per hour. In the light of the accomplishment of some of our modern plants, the speedy realisation of this prophecy seems not improbable. The quadruple-expansion engine at Warren is said to be running on a consumption of less than 13lb. of steam per indicated horse power per hour, and its builders have undertaken the contract for a triple-expansion engine for the Narragansett Electric Light Co., of Providence, R.I., on a guarantee of 12½lb.

Phonograph and Telephone Experiments.—Some remarkable experiments with the phonograph were shown recently by Mr. W. J. Hammer, in a lecture on "Edison and his Inventions," delivered before the Franklin Institute, the most striking being those in connection with the telephone and phonograph, consisting in the recording and transmitting of telephone conversation, music, &c. The first experiment undertaken was the recording on a phonograph, in Philadelphia, of music and talking transmitted over the long-distance telephone line from New York, and reproducing the same to the audience. Another experiment consisted in recording music and talking by the Philadelphia phonograph, which had been talked into the long-distance telephone by a phonograph in New York. The most important test consisted in reproducing to the audience, by means of the Edison motograph receiver, or loud-speaking telephone, and the Edison carbon transmitter, the music and talking registered on the Philadelphia phonograph, which had been sent over the long-distance telephone line from New York (a distance of 103 miles) by the New York phonograph talking into a carbon transmitter. This remarkable experiment employed two phonographs, two carbon transmitters, and two motograph receivers, acting in juxtaposition with 103 miles of telephone wire, six miles of which was underground.

Petroleum Solidified for Use as Fuel.—It is stated that Dr. Kauffmann, a Russian experimenter, has succeeded in solidifying petroleum, to be used as fuel by heating it and mixing it with from 1 to 3 per cent of soap. The latter dissolves the oil, and the liquid, in cooling, forms a compact mass, having the appearance of cement and the consistence of tallow. The product is difficult to inflame, but when lighted burns slowly and without smoke, developing a high temperature, and leaving only 2 per cent of a hard black residuum.

The Vacuum Brake on Tramcars.—The directors of the Bradford and Shelf (Yorkshire) Tramway Co. met the members of the Hackney Carriage and Street Cleansing Committee of the Bradford Corporation for the purpose of submitting to the criticism of the committee the vacuum brake, which the company has fitted to one of its tramcars, and intends to apply in due course to all the other cars belonging to it. The vacuum brake has been so applied to this car and engine that if the engine and car break loose its effect is the immediate stoppage of the car, no matter how steep the incline on which it is travelling may be. Further, if the engine becomes unmanageable from any cause, the conductor can bring both the car and engine to a standstill. Many experiments have been tried with the new brake by the company, and it has been found to be completely satisfactory in its working. The action of the brake was tried whilst the members of the Hackney Carriage Committee and the directors of the company were seated in the car, and when the engine was loosened from the car, both up and down Manchester Road, the car was brought to an easy and almost immediate standstill. This is the first application of the vacuum brake to tramcars which has been made, and the Bradford and Shelf Tramway Company is to be congratulated upon having led the way in regard to this important and somewnat costly addition to the means of ensuring public safety.

Engineering Society, King's College, London.—At a general meeting of this society, held on February 26th, the President in the chair, Mr. V. J. Bouton, A.K.C., hon. member of the society, read two papers—the first on "Modern Pumping Machinery," and the second on "Winding Machinery." The first paper gave descriptions of pumps constructed for various purposes by Messrs. Bradley and Co., Messrs. Pearn and Co., the Pulsometer Engineering Co., Messrs. Fielding and Platt, and other well-known makers. The chief features of some of the pumps described are as follows: Hodge's pump, made for the Lake Superior mines, has two cylinders, 14in. by 24in. The engine also drives a winding drum to raise the skips. Bradley and Co.'s engine, with steam cylinders, 16in. by 36in., and 6in. pumps, works at 200 yards below the surface of the ground. Bernay's pump is worked by a peculiar toggle gear, giving two double strokes of the piston for every revolution of the crank. In Pearn's horizontal pump the valve cylinder is removed from the steam cylinder. Messrs. Hathorn, Davey and Co.'s hydraulic pump is at work at Marple Waterworks, where it pumps water from a central reservoir to a higher one, by means of the head of water between the central reservoir and a lower one. The second paper contains descriptions of Corliss engines used for winding purposes in Belgian collieries; Messrs. Hathorn, Davey and Co.'s engines for a Chinese mine, with cylinders 28in. by 54in., and Cornish double-beat valves; the winding engines at Silksworth Colliery, Durham; Mr. Leavitt's compound engines at Calumet and Hecla mines, with cylinders 40in. and 70in. by 72in.; and Hurd's patent wire rope gear, which saves six-sevenths of the cost of horses. These papers will be found in the *Colliery Manager* for July and October, 1888, having been originally written for that journal. After a vote of thanks to Mr. Bouton for his paper, the meeting was adjourned.

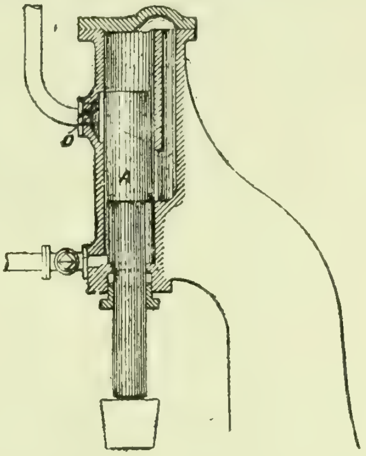
A Wear-built Torpedo Boat.—A final and very successful trial has been concluded at Portsmouth of a torpedo boat, built and engined by Messrs. Doxford and Son, of the Pallion Works, Sunderland, in which liquid fuel is used for generating steam instead of coal. The oil, which consists of creosote, the refuse of the chemical works, is stored in tanks in the double bottom, and the tanks are capable of storing about 14 tons. It is pumped into air chambers in the stokehold, whence it is projected into the furnace by means of 31 burners (though at the trial only 28 were used) in the form of spray. The boat was under way at full power for about two hours, during which the following *data* were obtained: Steam in boiler, 158·6lb.; vacuum, 23in.; and revolutions, 312. The mean pressures and indicated horse-power of the cylinders were not calculated, but the collective horse-power developed was about 900. Five runs were made during the trial upon the measured mile in Stokes Bay, the mean speed being 19 knots. The whole question resolves itself into one of cost. The oil consumed was purchased at 2½d. per gallon, or in round numbers at about £2 per ton, whereas the Admiralty contract for coal is at 14s. per ton. But whereas a pound of coal will evaporate 10lb. of water, oil will evaporate about 15lb. This still leaves an important superiority in favour of coal at existing prices in England. On the other hand, however, there are several advantages accruing from the consumption of oil. There is no dust, and little or no smoke. Trimming is also dispensed with; the potential energy, weight for weight, stored on board is one-half greater; and the supply of steam, since it is free from the inequalities of stoking, is likely to be more constant.

New Asbestos Mines in California.—It is stated that one of the largest and probably the most important of all the asbestos mines in the world is found in California, in a district in which the only minerals that had hitherto been supposed to exist were a few beds of borax, soda, and salt. The newly-discovered asbestos mine is situated near Oro-Grande, and contains an abundance of the mineral of a quality unrivalled for purity. The vein that has been struck is from 7in. to 8in. thick, and 450 metres in length, and is expected to extend even to 1,200 metres further. It is entirely free from foreign substances such as hornblende and tremolite, and shows a long, silky fibre of a beautiful, pearly hue, which has a resistance equal to that of flax, and produces a very fine thread. Besides the fine fibrous asbestos, which composes the core of the vein, large masses of so-called rock cork are found on the edges, which is easily cut, and is, in fact, as light as ordinary cork. The remainder of the bed consists of the ordinary asbestos, which is used at present for making steam packing. Vast quantites of late are also found in the neighbourhood, which, when mixed with the asbestos, will serve to make firebricks and crucibles. Should the projected railway between Los Angelos and Salt Lake City be carried out, there is no doubt that the mineral wealth of the district in question will prove the most important factor in the development of its commerce.

ILLUSTRATED PATENTS.

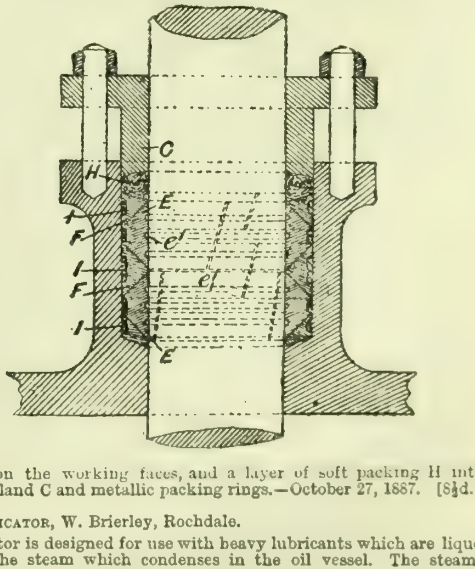
14,608. Fluid-pressure Hammers, A. Davy, jun., Sheffield.

Relates to valveless power-hammers, either of the direct-acting or tilt-hammer type, and driven by steam or compressed air. The piston A is in length about equal to half the length of the stroke, and the effective area of the upper end is considerably in excess of the lower. Slightly above the middle of the stroke, and slightly below the middle, are respectively exhaust and equilibrium ports, in the form of elongated narrow slits D, C. These are so placed that either one or other is always covered by the piston. Steam is admitted constantly below the piston, and is distributed by the resulting automatic movement. The piston rod may either carry the tup directly or may act on the beam of a tilt-hammer.—Oct. 26, 1887. [8½d.]



14,629. Stuffing-box Packing, A. Webster, Wavertree, Lancashire.

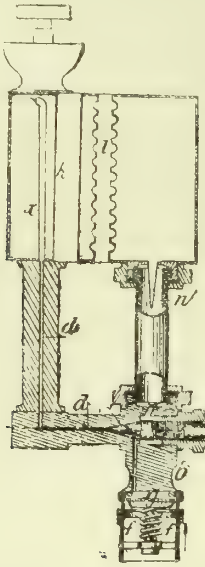
Segmental wedge rings E, F are employed, and secured together by circumferential coils of twine, &c., arranged in grooves I. Lubricating grooves e^1 may be also formed on the working faces, and a layer of soft packing H interposed between the gland C and metallic packing rings.—October 27, 1887. [8½d.]



14,669. Lubricator, W. Brierley, Rochdale.

The lubricator is designed for use with beavy lubricants which are liquefied by the heat of the steam which condenses in the oil vessel. The steam enters through the pipe *f*, containing the valve *g*, and passes thence into the chamber *b* which contains the regulating valve *o*. From the chamber *b* the steam is con.

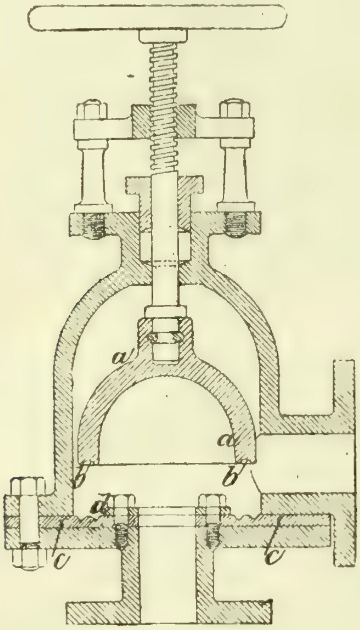
veyed through the pipes d, x to the oil reservoir, in which it condenses. The oil reservoir is fitted with pipes k, l, through which air circulates in cases where



steam of high temperature is employed. The oil from the reservoir drops from the nozzle n in the sight tube and passes down into the chamber b and so into the steam pipe.—October 28, 1887. [6½d.]

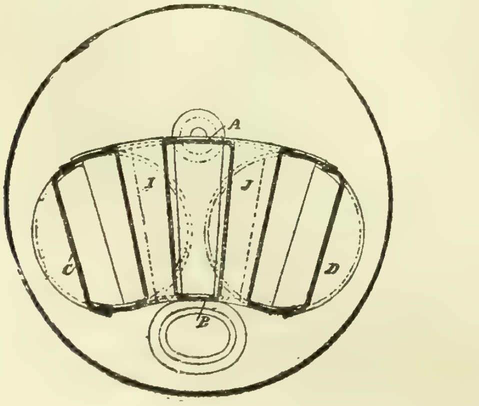
14,714. Stop Valves, J. Wescott, Wokingham, Berkshire.

The valve a is bell-shaped, and has one or more grooves b on its edge. The seating consists of indiarubber and canvas or other suitable materials faced



with wire gauze. The casing divided into two or more parts, preferably so that the seating material may be held between two of them. The edge of the valve shapes the seating, as shown at d.—October 29, 1887. [8½d.]

14,871. Steam Generators, J. W. Johnson, London (G. H. Sellers, Pennsylvania, and W. Malam, Delaware U.S.A.)



Relates to that class of boilers known as the "Galloway" type, in which a pair of furnaces usually open into a common flue or combustion chamber. The circumferential riveted seams of the combustion chamber are dispensed with by constructing the chamber of four plates A, B, C, D united by longitudinal joints. The side plates C, D are vertically corrugated at regular intervals, while the conical water tubes I, J are evenly spaced along the flue. The tubes are placed with their upper and lower flanges in the water space and flue respectively. November 1, 1887. [8½d.]

Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

March 2nd.

3691 Percussive Rock Drills, A. W. Daw and Z. W. Daw, London.
3696 Hydrocarbon Oils, W. G. Robinson, Yorkshire.
3702 Vertical Boilers, H. Coltman, J. C. Coltman, and E. E. Coltman, Loughborough.
3737 Thrashing Machines, J. Marshall, London.
3749 Siphon Lubricator, J. Belliss and E. M. Dadd, London.

March 4th.

3753 Condensing Steam, O. M. Row, Liverpool.
3757 Cleaning Iron or Steel, T. B. Saunders, Bradford.
3761 Electric Fuses, H. C. L. Holden, Woolwich.
3762 Supplying Water to Boilers, J. T. Vause, London.
3768 Reversible Motion, W. Crook and E. Entwistle, Blackburn.
3776 Starting Gear, F. F. Abbey and S. W. Endicott, Huddersfield.
3780 Rotary Steam Engines, L. C. F. Coelho, London. (Ribeiro da Costa, Brazil.)
3782 Motors, L. Bohnen and M. Kleber, London.*
3784 Breech-loading Firearms, R. C. Romanel, London.
3798 Refrigerating Engine, J. Meyer, London.
3799 Marine Engines, E. W. Toulmin, London.
3802 Compound Steam Engines, G. Harriss, London.

March 5th.

3806 Flexible Tubing, A. French, Surrey.
3807 Cut-off Gear, C. Fox, London.*
3809 Stoppers, G. M. Key, Poplar.
3812 Lubricants, T. Munro, Glasgow.
3820 Gas Motor Engines, H. Williams, Manchester.
3821 Regulating Gas, H. Williams, Manchester.
3822 Nails, A. V. Wagenen, London.*
3836 Arc Lamps, L. Hanson, Halifax.
3841 Adjustable Cranks, A. J. Boult, Middlesex. (A. Bauer, Germany.)*
3854 Air Brakes, D. W. Flickwir, J. H. Sands, and N. J. Pritchard, London.*
3855 Bending Lead Pipes, W. Watson and D. Barrie, London.
3859 Hot-air Engines, C. Wells, Middlesex.
3870 Electric Motors, H. H. Lake, London. (O. Lugo, United States.)*
3873 Ammonia Engines, J. H. Campbell, London.*
3874 Utilising Liquid Fuel, G. W. White, London.*
3882 Expansion Valves, H. Tipping, London.
3887 Brake, O. Imray, London. (P. Weilbach, Denmark.)*

March 6th.

3895 Driving Bands, J. Moseley, Manchester.
3909 Shuttle Box, R. L. Hattersley and J. Hill, Keighley.
3910 Boiler, C. J. Seaman and H. Roberts, Keighley.
3913 Carding Engines, J. M. Hetherington, Manchester.
3926 Beaming Machines, J. Dearden, London.
3928 Gas Engines, A. Histon, London.
3931 Steam Regulator, L. Luckhart, London.*
3951 Oil Motor Engines, H. P. Holt, London.
3963 Roasting Furnaces, W. Prickarts, London.*
3967 Arc Lamps, T. Robinson, London.

March 7th.

3974 Gas Regulators, W. F. Fletcher, Birmingham.*
3990 Dynamo-electric Machines, W. P. Thompson, Liverpool. (La Compagnie Continentale Edison, France.)
3991 Steam Distributors, C. Huelser, London. (T. Glauch, Germany.)
4006 Fasteners for Belts, T. Chaplin, London.
4021 Wrench, J. B. Burwell, London.
4035 Spring Balance, F. W. Cannon and H. J. Weld, London.
4046 Air Compressors, H. H. Lake, London. (Whitehead and Co., Hungary.)*

March 8th.

4050 Mowing Machines, A. McGregor, Manchester.*
4053 Hardening Steel, C. J. L. Leffler, Sheffield.
4057 Worm Gearing, W. Sisson, London.
4067 Tripping Gear, R. Middleton, Leeds.
4092 Furnaces, C. Hill, London.
4100 Brake, W. Panter, J. C. Tait, and T. W. Carlton, London.*
4102 Chain Gearing, W. Blakely, London.
4106 Steam Generators, J. Donaldson, London.
4112 Duplex Pumps, C. E. Owens, London.
4115 Non-return Air Valve, J. B. Dunlop, London.

March 9th

4156 Windmills, N. P. Hess and C. Westergard, London.*
4168 Gas-retort Ascension Pipes, W. Parlby, Westminster.
4170 Gas Generators, J. W. Spencer, London.
4184 Fastening Railway-rail Joints, N. Rowen and A. Evans, London.*
4185 Valve Gear, R. Bruce, Glasgow.
4193 Moulding Pulleys, H. Laissle, London.
4196 Ratchet Braces, T. Bass, London.
4199 Boiler Feeding, J. Fraser, London.
4201 Circular Looms, T. Lepage, London.
4204 Reverse-threaded Screw and Nut, R. E. Bradford, Millwall.*
4205 Release Nut, R. E. Bradford, Millwall.*

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Editorial Notices.

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We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

MARCH 29TH, 1889.

MINERS' SAFETY LAMPS.

SINCE the time of Sir Humphry Davy and George Stephenson almost innumerable inventors have been engaged in attempts to produce a miners' lamp which combines in the highest degree the requirements of safety, simplicity, and efficient illumination. Some success has attended their efforts, but mining engineers yet hope for greater perfection, and accordingly have not desisted from work and experiment in many directions. The conditions of safety are much more fully understood now than they were but a few years ago, and the dangers to be combated have been investigated and formulated in a very full and complete manner.

The danger of explosion is not by any means the most formidable in ordinary miners' work, though it is certainly the most dramatic and fearful, if we may use the expression, as, when explosion occurs, large numbers of lives are lost at one blow; but the greatest cause of loss of life constantly acting, although generally in detail, is the fall of roof and sides. It is accordingly of the utmost importance to the miner that he should have plenty of light to enable him to observe at a glance the condition of the roof and sides when he is at work. On the other hand, it is of great importance that the flame should be efficiently and thoroughly protected in such a manner as to put it practically beyond the chance of exploding an atmosphere surrounding it should it accidentally be immersed in an explosive mixture. It is not very difficult to make a lamp which gives a fair illuminating power and is reasonably safe in an explosive still atmosphere, but it is very difficult to get a good light and secure safety in a strong current which may at any moment become explosive. The conditions of efficient illumination and complete isolation of the lamp flame are to some extent antagonistic.

As the subject is a most important one, we think that it may interest our readers to briefly consider the actions going on within a safety lamp under circumstances likely to arise and cause possible danger. The experiments conducted at Aldwarke Main Colliery, and the more recent experiments of the Royal Commissioners on Accidents in Mines, as well as the experiments of M. Marsaut, in France, have greatly increased the available knowledge on this subject, and engineers now know much more definitely than they did a few years ago the nature of the dangers to be overcome. An ordinary Davy lamp is most dangerous in a current of explosive mixture; the mixture impinges upon one side of the gauze, ignites within the lamp, and speedily extinguishes the wick flame; it, however, continues to burn, and, if it be rich in inflammable gas, rapidly causes the gauze to become incandescent. It is then in a condition to cause explosion. The temperatures produced by flames of explosive mixture burning within or from the surface of gauze are exceedingly high, ranging from 1,600 deg. F. to 3,600 deg. F., with the varying proportions of firedamp present; and if the mixture chances to be the strongest possible, a sufficient quantity passing within a gauze is quite capable of entirely melting it, whether it be iron or copper.

The nature of the mixture flame is quite different from that of the wick flame, and temperatures impossible to the latter are easily attained with the former. In a wick flame the gases within the flame mainly combine with the oxygen of the air at a surface of junction between the flame and the air; but in a mixture flame the oxygen necessary for combustion has been intimately mixed with the gas to be burned, and consequently the combustion takes place uniformly throughout its whole mass. In a still explosive atmosphere this flame flickers feebly above the wick after the extinction of the wick flame, and looks harmless enough; but in a current where the supply is continuous and abundant it burns with great fierceness, and with a peculiar roar easily recognised if once heard. This flame is the great cause of danger in an explosive atmosphere, and the difficulties in properly shielding, while at the same time properly supplying the lamp with air, are due to its existence. A lamp must be shielded from a current, possibly explosive, in order to prevent its continued burning within the gauze, and consequent heating of the gauze and passing flame. It must also be supplied with sufficient air under ordinary circumstances in order to give sufficient light The object of the inventor is to supply sufficient air under ordinary circumstances, and yet prevent a copious supply of explosive mixture reaching the lamp in such a current.

The peculiarities of the various types of lamps arise from the arrangements made to allow freedom for ordinary access of air, and prevent the prejudicial action of currents; and their resisting power to currents of high velocity is, to some extent, the test of relative safety. It is now generally recognised that the gauze of safety lamps should be thoroughly shielded, and lamps in which this is not done are highly dangerous in currents even of low velocity. The principal danger of passing flame arises from the incandescence of the gauze, as already described, but there is another danger which has undoubtedly occasioned accidents. We refer to the explosion of a mass of mixture within a lamp, and the consequent forcing through of the flame while the gauze is quite cool. This may happen if a sudden rush of explosive mixture fills a portion of the interior of the lamp before it reaches the wick flame, and it consequently lights with explosion. Lamps vary much in this respect, but there are circumstances in which the Mueseler readily fires through, which may occur in practice. M. Marsaut found, in a long series of experiments, that a lamp of this kind, with the flame somewhat low, pushed up into an atmosphere containing an excess of inflammable gas, and then pulled down rapidly into pure air, generally gave quite a sharp internal explosion, which often passed through and ignited externally.

The Belgian Mueseler often fired through in this way, as well as the Clanny and others, but the English Mueseler fired very seldom. The explosion became more violent when the lamps were inclined even a little, as then a larger volume of mixture could fill a portion within the gauze without reaching the flame, and when it did reach the flame a stronger explosion was caused. This danger is a very real one, as it may occur at any time when testing for gas by putting the lamp up to the roof and withdrawing it. Under these circumstances a small unshielded Davy is undoubtedly the safest, as neither in Marsaut's, nor yet in the Commissioners' experiments, was an explosion caused by putting up and withdrawing such a lamp in this way.

The mixture flame may cause danger also in lamps of the Clanny type, such as the Marsaut or Mueseler, by burning in such a way as to crack the glass, and that without passing flame by explosion, or by heating the gauze. The difficulties have been carefully considered in several lamps, and those of the Marsaut type seem, as yet, to be best appreciated in actual work as fulfilling most completely the necessary conditions of safety, simplicity, and good illuminating power. We shall be much interested, however, in new developments, and shall carefully describe in our columns new lamps of whatever type. The Mueseler has advantages, but seems more liable to sharp internal explosions than others. The Stephenson type has hitherto failed in illuminating power and on other practical points, but we described in our last week's issue a lamp of this kind which seems, so far as one can tell without extended practical use, to overcome these difficulties.

In conclusion, we would point out that there is still much room for improvement in many matters. A perfect lamp should be so arranged that in an explosive mixture the wick flame would suffer immediate extinction, quickly followed by that of the mixture flame, either in still atmosphere or a current of any probable velocity. Explosion within the lamp should be almost impossible, or, if possible, should be so gentle that it could not pass the gauze; at the same time the light given should be ample and free to illuminate the roof as well as the sides. It should be simple and easily cleaned and put together, and also stand rough usage without serious deterioration. Present lamps are good advances upon past ones in these respects, and no doubt future ones will be still more satisfactory.

STATE OF THE SKILLED LABOUR MARKET.

The following memorandum has been prepared by the Labour Correspondent to the Board of Trade :—

The general state of the skilled labour market, as indicated by the reports of the principal trade unions, continues to be highly satisfactory, and in most trades employment is still improving or remains steady, while rates of remuneration are still on the ascending scale. This is, again, especially true of the shipbuilding and engineering trades, which in their turn throw a large number of subsidiary industries into a state of contagious activity. Important, therefore, as are those leading trades in themselves, they are but the producers of the finished article, the raw material for which is supplied by other departments of labour which at first sight would appear to have little connection with either shipbuilding or engineering. The coal and metal trades in all their branches are the first to be put in motion by orders for new shipping, and gradually the demand for material spreads until thousands of workers are called into a state of activity who are not at all generally supposed to be dependent upon the trades which conduct the final processes of manufacture. Never, except in the wonderfully busy period comprised within the years 1881-82-83, has the shipbuilding trade been so active as it is at present, and the number of men fully employed in it is now very nearly equal to the figures of that time. The great society which represents the iron shipbuilders has now a membership of 27,500, and of these only 1·8 per cent are returned as out of work. Taking the societies of all the principal branches of the engineering trades connected more or less directly with shipbuilding, we have a total of 80,803 members, and of these the proportion of unemployed is not more than 2·5 per cent. For the season of the year this figure is unusually low, and is certainly in marked contrast to the return for the corresponding month of last year, when the percentage was about seven for these branches. So great, in fact, has been the demand for men in these trades, on the north-east coast especially, that in some departments a positive scarcity of hands has been experienced.

Bad as the weather has been during February, the building trades already begin to show signs of improvement, and with the advance of spring will doubtless develop considerable activity. The change for the better in those departments of labour is as yet very slight, being indicated in figures only by a decrease in the proportion of unemployed from 6·7 to 6·4 during the month. Small as this is, however, it is an extremely hopeful sign for the building trades.

The coal and general iron trades may be bracketed together as well employed, and the number of men engaged therein who cannot find work at present is infinitesimally small. The cabinet-making trade is but moderate, although there are indications of improvement, and fewer men are on the books of the trade societies of this industry.

In the provinces the printing trade is not to be described as better than moderate, but in London the opening of the Parliamentary session has caused a considerable change for the better. The textile trades remain very quiet, and the numbers out of work form from 4 to 5 per cent of the whole.

Altogether 17 trade societies have reported on the state of their respective labour markets. Of these four may be classed as "very good," six as "good," and seven as "moderate." A total membership of 174,519 is accounted for, of whom 4,831 are out of work, as against 5,363 for the previous month. The proportion now is 2·8 per cent not employed, as against 3·1 a month ago. If the various sections of the coal and general iron trade could have been included in these returns, the percentage of unemployed would be very much less than even this low figure.

EXCESSIVE STEAMING IN LANCASHIRE SHEDS.

Excessive "steaming" and oversizing in the cotton-weaving sheds of Lancashire are doomed. That has been made certain by the conference held at Westminster on Thursday week between trade representatives of the operatives and their members in Parliament, at which the questions were carefully discussed, and a resolution was unanimously adopted in favour of early legislation for the abolition of a system which, it has been proved to demonstration, sows the certain seeds of disease and death among workpeople for the sake of maintaining what is little more than a huge fabric of trade deceit. The agitation has naturally been strongest at Blackburn, which is the chief centre of oversizing and "steaming" operations, and though there is the inevitable minority of persons who take a different view of the question, there can be no doubt that the vastly preponderating balance of opinion found expression in the decision arrived at by the conference under notice. On behalf of those cotton manufacturers—and they are said to constitute nearly a third of the whole number in Lancashire—who descend so far from the best traditions of English commerce as to load their yarn with more than its own weight of china clay, and who have then to subject their unfortunate workpeople to a continuous Turkish bath—kept up from early morning to late in the evening, and from one week's end to another, all the year round—in order that the yarn so adulterated may lend itself properly to the operation of weaving, it is urged that "the mild Hindoo" prefers to have his garments so adulterated, and that if this queer predilection on his part were not satisfied by Lancashire manufacturers it would be pandered to by less scrupulous persons elsewhere, to the grievous loss of British trade. There may be something in the plea, only it is unfortunate for the chance of its entire acceptance that it is based on a second-hand, and not altogether disinterested, version of the Hindoo's preferences, instead of being urged by himself in his own proper person. But even if it were clear beyond the shadow of a doubt that the natives of India do really prefer to be clothed in "china clay, flour, tallow, or other sizing materials," instead of honest cotton cloth, it would by no means follow that this extraordinary fashion justifies the slow murder of English working people. "Life is more than the means of living;" so the Roman philosopher declared two thousand years ago; and surely Englishmen of the present day are not going to content themselves with a lower standard of humanity than that which was recognised even by the old Pagan Romans. The case against "steaming" was really complete, and established beyond the possibility of reversal, when the late Medical Officer of Health for Blackburn reported that the main cause of the terrible winter death-rate of 34 per 1,000 of the population was "the wholesale slaughtering of the inhabitants by effusing steam into the workshops." There is only one thing more wonderful than the commercial morality which demands that Lancashire men and women should be slowly, but surely, done to death in order that Hindoos may clothe themselves in china clay, and that is the patience with which the workpeople have borne their grievance.

THE FORTH BRIDGE.

The last for the season of the Mason College free artisans' lectures was delivered on Monday week, by Professor R. H. Smith, whose subject was the Forth Bridge, the largest bridge yet constructed in the world. After describing the geographical situation of the bridge, and its advantages for railway traffic between north and south, the lecturer gave the leading dimensions, illustrating these by saying that the length of the bridge would stretch from the college to Curson Street Goods Station, that the clear space in the two larger spans equalled the distance from the college to Snow Hill Station, and that the height of the great pier above water was more than thrice the height of the college. He explained the mechanical principle of the bridge by likening each arm of the great cantilevers to a crane with jib and guy-rod; and mentioned that the same principle had been used for centuries for smaller bridges in India and Japan. He described many of the details of the construction and of the ingenious and monster machine-tools specially built to facilitate the work. The canting of one of the great pier columns, and the nine-months' struggle to get it back into position, was referred to, and the methods of sinking these columns into position, by compressed air forced into a chamber at the base where the men worked, was explained fully. At the deepest point the air pressure needed to keep the water out was three and a half times the ordinary atmospheric pressure, and even the steady and exceptionally sober Italians who were employed on this work had to be relieved in four-hour shifts. Owing to swells and waves passing the outside water surface making the water pressure variable, the water in some parts of the work was continually surging in and out of this working chamber. The electric light was used in this submarine chamber, and on one occasion this light attracted a diver who was working outside the column, so that he walked right into the chamber under the open edge of the tube, causing much astonishment among the other men working there, with whom he could hold no communication owing to his being encased in diver's helmet and dress, and whom he had to leave in silence, and without explanation of his desires, by disappearing in the water under the edge again. At the conclusion of the lecture a hearty vote of thanks was passed to the lecturer, and on his motion a vote of thanks was also passed to Mr. Benjamin Baker, the engineer to the bridge, for the excellent large diagrams lent for the lecture, and also to Messrs. Grant and Son, of Edinburgh, who had sent a series of large and beautiful carbon photographs, illustrating parts of the bridge in their various stages of erection.

THE BOILER FURNACE.

On Saturday, March 2nd, Mr. S. Boswell, of Manchester, gave a practical lecture on "The Boiler Furnace," before the Ashton-under-Lyne Association of Engineers (Mr. R. E. Burcham, chairman), at which there was a good attendance. The lecturer gave a short history of the boiler, and mentioned the dates of the introduction of several important features, for instance vertical water pipes in 1820, the flanged seam in 1850, and the Hill's bridge rail hoop in the same year, while in 1853 the Galloway boiler and cone tube, as also Dunn's vertical boiler, with corrugated firebox, were first used. Since the latter date most makers have been satisfied with improving the Lancashire boiler rather than trying to supersede it by new inventions, for out of the 3,000 patents taken out, not more than 100 had been successfully worked, which the lecturer thought showed great ignorance on the part of the inventors. He also stated that until very recently the only place the engineer considered worthy of notice was the engine and engine-room, and important questions of steam generation and fuel consumption were much neglected, as the different authorities worked upon the problem, "Given the steam, how to make the best use of it." He also pointed out the almost entire absence of good books on boilers, while books on engines might be counted by hundreds.

The different peculiarities of the external and internal furnaces were fully dealt with, showing the apparent loss by radiation from the sides of a brickwork furnace and the rapid deterioration of boilers when fired under the bottom, owing to the unequal expansion of the top and bottom of shell, while with sedimentary feed-water such a mode of firing was positively dangerous. On the other hand, the internal furnace or firebox was most satisfactory, both as regards position and form. As regards form, it was of such a shape that any deviation from the original circle might easily be detected by gauging. It was self-contained, was suitable for the accommodation of a long or short grate, allowed free access to the underside of bars, formed its own ashpit, and the bulk of the sediment in boiler could fall below the level of the fire. Taken all round, such boilers could be worked the most economically. The material was next considered. The qualities of cast iron and copper were described, and reasons given why such metals, although possessed of many good qualities, were not adopted. Wrought iron was next dealt with, and some remarks on the qualities and brands of different firms were made to show that the brands of "Best Best" and "Best Best Best" were very misleading, except in the case of established makers. Lamination, its cause and effects, were fully gone into, and it was stated that even the best brands were not free from it, while it was explained when it might be considered important as likely to cause danger. The superior quality of mild steel as now used was amply proved, and several test pieces from different brands were exhibited.

In the lecturer's opinion, for steam-boiler purposes mild steel was the most suitable material ever known; but he admitted that mild steel badly handled was no more reliable than common iron. Form and construction were considered fully, and the alteration in form of a long, unstrengthened flue, due to its buoyancy, was explained. The mistake of supposing a boiler flue required supporting because of its weight, or that it was a load on the end plates, was pointed out. Longitudinal seams were best welded, so that the circular form might be accurately maintained. With the ring seams many devices have been tried. The ordinary lap-joint seam allowed a free arching movement, but restricted expansion longitudinally. The T-seam was a most rigid seam in every direction, but excessively strong. The flanged seam was supple in a longitudinal direction, and provided for expansion and contraction, while giving strength against a collapsing pressure, but it was rigid circumferentially, which occasionally led to fractures in the root of the flange. The Bowling or Bolton hoop was now made of such a section and at such a cost that it could be dealt with, and as such a seam had all the advantages of the flanged seam, without the disadvantage of circumferential rigidity, it was to be preferred. The Hawksley-Wild flanged seam was discussed and its peculiarities pointed out. However, Mr. Boswell pointed out that nearly all the anti-collapsing seams had one defect: when a new plate was required, the front end invariably had to be cut away; while with the cone-belt furnace, which contained all the advantages of strength and flexibility, this was not required, as the flue could be drawn out through the hole in the front end plate. A full description of working and repairs was given, with some remarks from actual experience upon different kinds of boiler compositions and fusible plugs.

The usual votes of thanks (after the discussion) terminated an interesting meeting.

ALUMINIUM AND ITS MANUFACTURE BY THE DEVILLE-CASTNER PROCESS.*

Aluminium was shown to be a distinct substance in 1754 by Maygraff, and might be ranked among the noble metals, because it did not tarnish, even when exposed to damp and very impure atmospheres. Until lately it was almost a precious metal, the price ranging as high as 60s. per pound. The chemical symbol of aluminium was Al, and its atomic weight 27·4. It was very widely diffused over the earth, and its silicate formed the chief constituent of clays. It entered into the composition of a vast number of minerals, especially of felspars; the fluoride, united with that of sodium, formed cryolite. A ferruginous hydrate bauxite was probably the most convenient ore from which to extract the metal.

The method now generally adopted in preparing aluminium was discovered early in this century by the eminent French chemist, Henri Saint-Claire Deville, and consisted in reducing the double chloride of aluminium and sodium ($2NaCl.Al_2Cl_6$), by means of metallic sodium at a high temperature. As sodium to the extent of nearly three times the weight of aluminium was required in the reduction of the latter metal, it would be seen that the cheapness and abundance of the aluminium depended very much on the cost of the sodium, and the quantity in which it could be produced. Till quite recently, sodium cost 50s. a pound, and large quantities of it could not be obtained, as the processes of its manufacture were difficult and even dangerous. The improvements effected by Mr. Hamilton J. Castner in the manufacture of sodium, by which it could be made in any quantity and without risk, at about 1s. per pound, had rendered it possible to produce aluminium of about 98 per cent purity, which could be sold profitably at 20s. per pound.

The object of this paper was to describe the process of manufacture adopted by the Aluminium Co., at the works just started at Oldbury, near Birmingham.

Hydrate of alumina, in a finely divided state, was mixed on a suitable floor with lamp-black, charcoal, and common salt, moistened with water, and, after been thoroughly mixed and incorporated, was forced through dies, constructed exactly as in drain-pipe machines, and the issuing cylinders of the compound were cut off by wires into pieces of about 3in. long, which were carried to the tops of chloride furnaces, and spread out to dry thoroughly.

The next process was to expose this mixture of hydrate of alumina, carbon, and salt to a high temperature in the presence of chlorine gas, in order to obtain the vapour of the double chloride, which operation was performed in regenerative furnaces, constructed very like banks of ordinary earthenware gas retorts. These retorts were connected at their opening ends by means of earthenware pipes to gasholders containing the chlorine gas, special means being taken to regulate the pressure of the gas, and the rate at which it was allowed to flow. The fumes of double chloride passed from the opposite ends of the retorts to cast-iron condensers, and thence to brick chests or boxes. Convenient openings were made for cleaning out the passages, as the double chloride condensed very quickly; the greater portion of it liquefied, but some sublimed, and came out in the form of a yellow powder. The reaction which took place was as follows :—

$$2Al_2O_3 + 3C_2 + 4NaCl + 6Cl_2 = 2(Al_2Cl_6 2NaCl) + 6CO.$$

Previous to the year 1886 sodium was produced by reducing it from the hydrate or carbonate of soda by heating it to a very high temperature with an excess of carbon. Great care was taken to avoid fusion, which was prejudicial to the process, because, when fused, the carbon separated from the alkali, and only little sodium was obtained.

Mr. Castner, a chemical engineer, of New York, thought it might be possible to reduce the sodium and potassium compound at a much lower temperature by bringing the carbon into intimate contact with the alkalis in a molten condition. He prepared an artificial carbide of iron by coking an intimate mixture of finely-divided iron and pitch, the result being a heavy metalliferous coke, which, when ground fine and mixed with caustic soda in the fused condition, blended intimately with it, and caused the reduction of the soda at a much lower temperature than hitherto. The chemical reaction was as follows :—

$$4NaHO + FeC_2 = Na_2CO_3 + Fe + 2H_2 + CO + Na_2.$$

The sodium was made in crucibles, and five crucibles yielded 500lb. of sodium per twenty-four hours, so that the battery of four furnaces which was employed was competent to yield 2,000lb., or nearly one ton of sodium per day.

Having prepared the two principal ingredients required for the production of aluminium—namely, the double chloride of aluminium and sodium, and metallic sodium—the double chloride was broken into small pieces and mixed with cryolite (the native fluoride of aluminium and sodium, $6NaF.Al_2F_6$), and with metallic sodium cut into thin slices. The mixture was tightly enclosed in a revolving wooden box, in which it was thoroughly mixed, and then turned out on the hearth of a regenerative reverberatory furnace, over which the mixing cylinder was placed. There were two furnaces, a small one which produced 60lb. of aluminium per charge, and a large one which yielded 140lb. The reaction was as follows :—

$$2(NaCl).Al_2Cl_6 + 3Na_2 = 8NaCl + Al_2.$$

The process of reduction lasted about three hours, and required great skill and attention to the temperature of the furnace. The large furnace produced 840lb. of aluminium per day of 24 hours, and the small one 360lb. The first portion of the metal which ran out was the purest, and this formed rather more than three-fourths of the charge, while the remainder, which got entangled with the slag and had to be subsequently separated, contained a larger portion of foreign substances.

The metal was then taken to the casting-house, arranged like an ordinary brass foundry, remelted in plumbago crucibles, and cast into ingots, plates, or bars.

The author then gave a table, which we reproduce, giving the quantities of the several ingredients employed to make one ton of aluminium :—

Metallic sodium	6,360lb.
Double chloride	22,400lb.
Cryolite	8,000lb.
Coal	8 tons.

To produce 6,300lb. of sodium there were required—

Caustic soda	44,000lb.
Carbide, made from pitch, 12,000lb. Iron turnings, 1,000lb	7,000lb.
Crucible castings	2½ tons.
Coal	75 tons.

Aluminium was endowed with several remarkable properties. It was the lightest of the metals which possessed considerable tenacity and hardness. Mr. Anderson described several of its peculiarities, and said that one of the most remarkable applications of the property which aluminium possessed of lowering the melting point of metals had been made by Mr. Nordenfelt, in the production of castings of pure iron. Pure iron melted at about 1,700 deg. C., but even then the molten mass was not liquid enough to be run into moulds, but the addition of from $\frac{1}{2000}$ to $\frac{1}{700}$ part, by weight, of aluminium lowered the melting point to such an extent that it became fluid enough to run into the most minute and intricate forms. Mr. Nordenfelt had given the name of *Mitis* (flexible, ductile) to his metal. The author here exhibited several of these mitis castings, one of which was in the form of a wire brush. It was a solid casting; the back and bristles formed one piece, and yet the bristles could be bent about just like the softest iron wire. These mitis castings possessed all the properties of the best forged iron, the tensile strength ranging as high as 27 tons per square inch, with an elongation of 20 per cent. The metal could be worked and welded just like wrought iron, and could not be distinguished from it, except that it was perfectly homogeneous and free from stratification.

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* Paper read before the Society of Arts by Wm. Anderson, M.Inst.C.E.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

(Continued from page 182.)

Trial A.—This trial corresponds to the similarly lettered trials of the Atkinson and Crossley engines, and observations were made in the same manner. The exhibitors elected to work at 200 revolutions per minute, and at a brake load corresponding to 12½ H.P. effective. The actual average speed throughout the trial was 198·1 revolutions per minute. The maximum speed for any quarter of an hour was 199·8 revolutions per minute, and the minimum 192·7 revolutions per minute. The average number of explosions (the misses counted as before) was 129·0 per minute. This corresponds, practically, to three misses per minute. The mean initial pressure was 132·31lb. per square inch above the atmosphere, corresponding to a mean effective pressure of 54·15lb. per square inch, and an indicated horse power of 15·47. The brake H.P. was 12·51, the mechanical efficiency being thus 80·9 per cent, and the power used up in driving the engine itself 2·96. The engine was fitted with two flywheels, on which similar brakes were placed. The gas used in the engine was 350·2 cubic feet per hour, and for ignition 7·1 cubic feet. This corresponds to a gas consumption in the cylinder of 22·64 cubic feet per I.H.P. per hour, or 28·0 cubic feet per brake H.P. per hour. These figures become 23·10 and 28·56 cubic feet respectively if the ignition gas be also taken into account. The work done during the pumping stroke (fig. 9) was equivalent to an average mean pressure of 2·40lb. per square inch throughout the working stroke, and the corresponding I.H.P. is 0·35. The I.H.P. expended in driving the engine was 2·96. The engine ran quite cool, and used 1·89lb. of lubricant in the cylinder (both ends) in the six hours. The lubricant used was "vacuum" oil, costing about 3s. per gallon, or 4d. per pound. The cost of cylinder lubrication was, therefore, equal to that of about 2·72 cubic feet of gas per H.P. per hour, taking the gas at the same price as before.

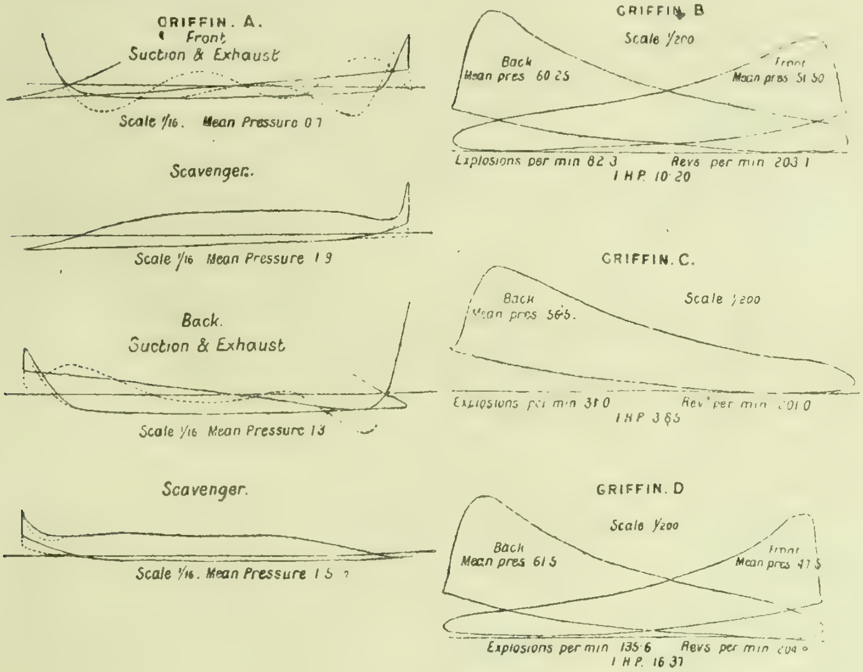


FIG. 9.

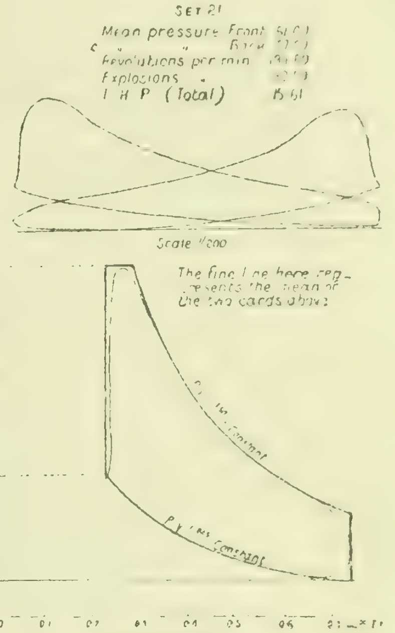


FIG. 10.

TABLE IX.—GRIFFIN TRIAL, SEPT. 27, 1888.

Constituents.	Proportion by volume.	Weight of one cubic foot. At standard pressure and temperature.	Weight in one cubic foot of gas. At standard pressure and temperature.	Proportion by weight.	Calorific value per lb. down to 100° C.	Calorific value per lb. of gas down to 100° C.	Proportional weight of O required for complete combustion of 1lb. of gas.	Weight of O required for complete combustion of 1lb. of gas.	Weight of products of combustion for 1lb. of gas. Steam.	Weight of products of combustion for 1lb. of gas. Carbonic acid.
	Per cent.	lbs.	lbs.		Thermal units.	Thermal units.		lbs.	lbs.	lbs.
CH_4	36·14	0·0447	0·01615	0·509	21510	10948	4	2·036	1·145	1·400
C_2H_4, &c.	4·04	0·1410	0·00569	0·177	20100	3558	$2\frac{4}{7}$	0·607	0·228	0·556
H	50·94	0·00559	0·00285	0·090	52200	4698	8	0·720	0·810	—
CO	4·58	0·0783	0·00359	0·114	4350	495	$\frac{4}{7}$	0·065	—	0·179
N	3·94	0·0783	0·00309	0·098	—	—	—	—	—	—
CO_2 and O	0·36	0·1060	0·00038	0·012	—	—	—	—	—	—
	100·00		0·03175	1·000		19699		3·428	2·183	2·135

Calorific value of one cubic foot = 19699 × 0·0317 = 624 thermal units.

The thermal results of this trial have been worked out upon exactly the same lines as those of the other engines, with the following results:—

The analysis of the gas used is given in Mr. Wilson's report, and its thermal value is worked out in Table IX., which shows it to have been 19,700 thermal units per pound, or 624 thermal units per cubic foot. The weight of gas used was 0·03175 pounds per cubic foot under standard conditions.

The mean pressure and volumes at the different cardinal points of the stroke marked in fig. 10 are given in the following table:—

TABLE X.

	Pressure in pounds per square inch, absolute.	Volume in cubic feet.
A	13·8	0·231
B	13·8	0·739
C	58·7	0·231
D	147·2	0·231
E	147·2	0·296
F	42·7	0·739

The mean air temperature for the day was 70 deg. F., the atmospheric pressure being 14·871b. per square inch. The temperature of the gas inside the meter was 67 deg. F., and its pressure 1·20in. of water, its total pressure being thus 14·911b. per square inch. The weight of the gas per cubic foot through the meter, under these conditions, works out to 0·03001b. per cubic foot. The corresponding weight of gas per explosion was 0·0013581b.

The mean temperature of the water as it left the jacket was 132 deg. F., and this has been assumed, as before, to be the temperature of the charge after it entered the cylinder. On this basis the ratio of air to gas by weight works out to 31·6, and by volume to 12·36. The total weight of the charge works out to 0·044261b.

The value of the index n for the compression process, worked out as before, is 1·245, and under these conditions the rise of temperature would be 206 deg. F., so that the temperature at the point C would be 799 deg. absolute. The temperature at D, corresponding to the rise of pressure at constant volume, would be 2,010 deg. absolute, taking the specific heat of the gas to be the quantity worked out in detail for the Atkinson engine. This is a point in which the different engines would vary extremely little. During the process D E (fig. 10) the calculated temperature rises to 2,580 deg. absolute, the highest limit of temperature.

The expansion process was very nearly adiabatic, the value of n being 1·350, while for the adiabatic process it would be 1·376. The calculated temperature at F is 1,866 deg. absolute. The quantity of heat apparently received during the expansion is therefore very small. It works out to only 320 foot-pounds, which is less than 7 per cent of the heat turned into work during the same operation, as against about 30 per cent in the Atkinson engine. The combustion must, therefore, have been very nearly complete when the point E was reached.

The quantity of jacket water used was 1021·71b. per hour, and the average heat carried away by it per hour was 72,790 thermal units. This amount of heat is equivalent to 7,260 foot-pounds per explosion.

The exhaust waste, calculated as before, is equivalent to 8,220 foot-pounds per explosion. With these figures the heat account comes out as follows:—

	Foot-pounds.	Percentages
Calorific value of the gas per explosion 0·001358 × 19700 × 772	20,650	100
Heat turned into work	4,350	21·1
Heat rejected in jacket water	7,260	35·2
Heat rejected in exhaust	8,220	39·8
Unaccounted for, including heat rejected in blank charge of air	820	3·9
	20,650	100·0

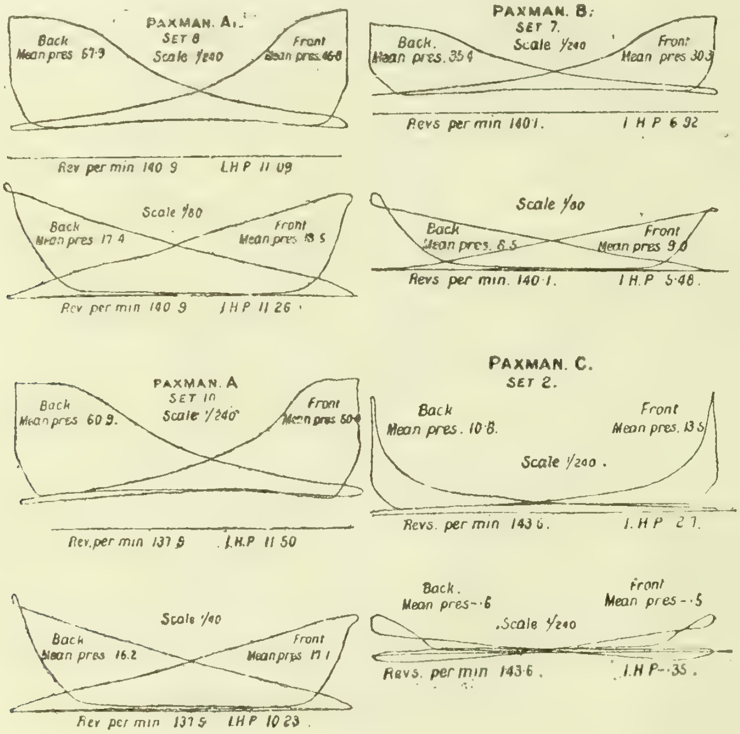


FIG. 11.

It is to be noticed that the balance unaccounted for includes in this case a quantity—the heat carried away by the "scavenger" charge of air—which did not exist in either of the two former cases.

The actual work done corresponding to the indicated H.P. of 15·47, was 3,960 foot-pounds per explosion, or 91 per cent of that due to the ideal mean process. The difference between the ideal mean diagram and an actual indicator card will be seen on reference to fig. 10. The heat actually turned into work is thus 19·2 per cent of the whole heat of combustion; 35·2 per cent of the same quantity was rejected in the jacket water; and 46·6 per cent in the exhaust, &c. The total quantity of heat used corresponds to 13,390 thermal units per indicated H.P. per hour. The efficiency of a "perfect" engine working between the same limits of temperature as the Griffin engine would be 78 per cent. The efficiency of the actual engine compared with such an engine is 24·6 per cent.

Trial B.—In this trial, which lasted three hours, the brake H.P. was 6·30, or as nearly as possible half that upon Trial A. All the other conditions were kept as nearly as possible as in Trial A. The results are given in Table VIII. The gas used in the cylinder per indicated H.P. per hour was 22·35 cubic feet, and per brake H.P. per hour 36·3 cubic feet. These quantities become 22·92 and 37·2 cubic feet respectively if the gas used for ignition be also taken into account. The expenditure of the heat of combustion (135,200 thermal units per hour) was approximately as follows:—

	Per cent.
Heat turned into work	19·4
Heat rejected in jacket water	32·5
Heat rejected in exhaust and blank charge, and unaccounted for (by difference)	48·1
	100·0

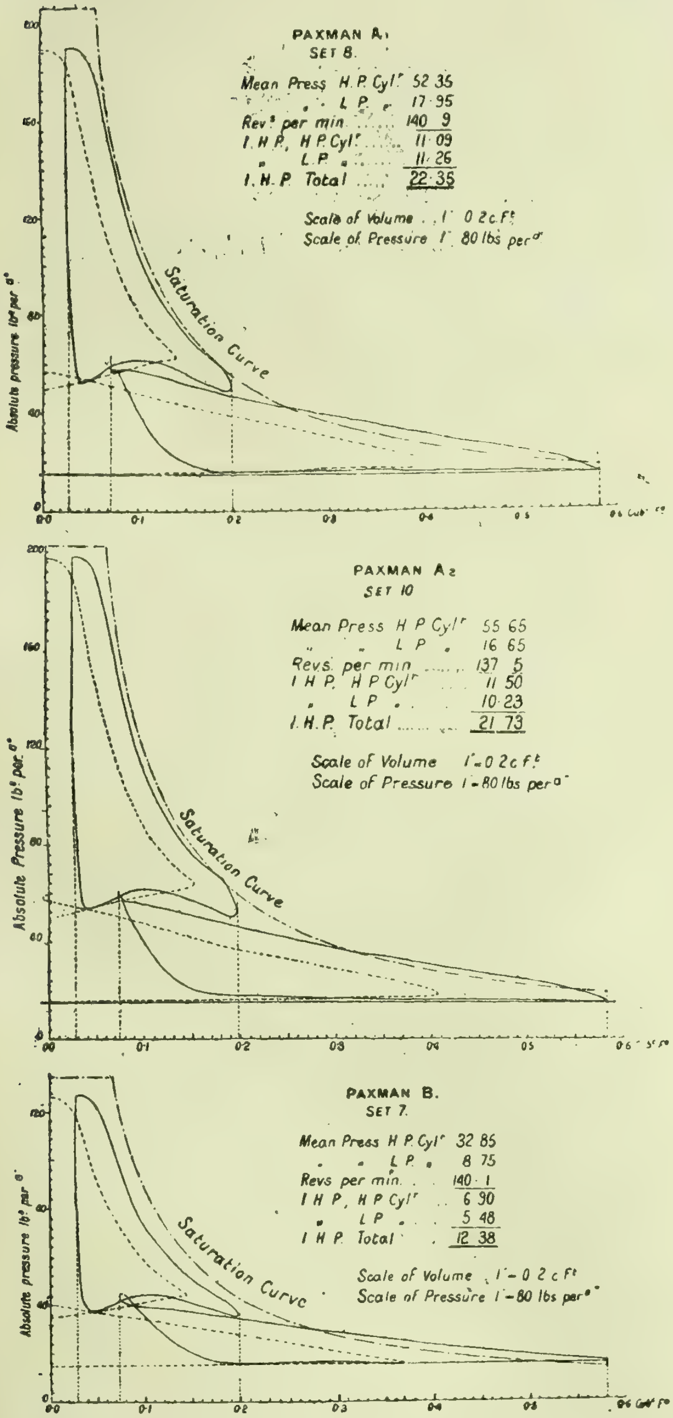


FIG. 12

The speed of the engine during this trial was 201·8 revolutions per minute, the number of explosions per minute 82 6, which corresponds to 51·9 misses per minute. The brake H.P. was 6·30, the indicated H.P. 10 23; the mechanical efficiency was, therefore, 61·6 per cent, and the H.P. expended in driving the engine 3 93. The diagrams are given in fig. 9.

Trial C.—In this trial the engine ran empty. Its mean speed was 200·1 revolutions per minute, with 30 6 explosions per minute, the explosions being in this case counted instead of the misses. The I.H.P. (mean of six sets of cards, fig. 9) was 3·84. The gas per I.H.P. per hour was 24·79 cubic feet, or 25·91 including ignition gas. Running empty, the valves for one end of the cylinder were disconnected, so that the engine worked single-acting.

In this trial the I.H.P. corresponds to 17·5 per cent of the whole heat of combustion of the gas used.

Trial D.—During this trial, which lasted for one hour, the engine was run at 206 revolutions per minute. The trial was made for the purpose specially of testing the working of the engine at a somewhat higher speed than before, and with a somewhat different arrangement of valve gear. The mean initial pressure was 131·6lb. per square inch above the atmosphere. The engine ran with about one governor miss per minute throughout the trial. The indicated H.P. was 16·39 (fig. 9), and the brake H.P. 13·39, the mechanical efficiency being thus 81·7 per cent, and the horse power used in driving the engine itself 3·00. The gas used per indicated H.P. per hour was 22·63, and per brake H.P. per hour 27·69, which quantities become 23·05 and 28·21 respectively, taking into account the gas used for ignition.

In this trial the indicated H.P. corresponded to 19·2 per cent of the whole heat of combustion of the gas used.

PAXMAN COMPOUND PORTABLE STEAM ENGINE.

Four trials were made of the Paxman engine. The first trial, A_1, was made under conditions as nearly as possible the same as those under which the recent experiments of the Royal Agricultural Society at Newcastle were made on a somewhat similar engine. Coal, I.H.P., and brake H.P. were measured throughout, but the whole feed-water was not measured, because a certain quantity of exhaust steam was returned into the tank from which the feed-water was drawn, and the normal conditions under which the engine worked, and under which it was desired that it should be first tested, would not allow this exhaust steam to be weighed. Trial A_2 was of similar duration and carried out in the same manner, except that no exhaust steam was returned to the feed tank. The total amount of feed-water was therefore accurately known. In both these trials the engine was worked at full power. Trial B was a half-power trial under same conditions as A_2, the whole quantity of feed-water being measured. Trial C was a short trial to ascertain the I.H.P. required to run the engine at full speed empty. The principal results of these trials are shown in Table XI.

Trial A_2 (Fig. 11).—In discussing these results we shall commence with the Trial A_2, as being really the most important of the trials made. This trial took place on September 28th, and its duration was about six and a quarter hours. The trial began and ended with the engine running, and start and finish were conducted in the following manner:—

The steam pressure, revolutions, and brake load being all those at which it was intended to work throughout the trial, and the ashpan being cleaned out, the fire was reduced until the pressure fell notably, and then stoking was commenced from the weighed coal. In this case the pressure fell to 150lb. per square inch before it began to rise again. When the whole of the weighed coal had been used, and the ashes, as far as possible, put upon the fire again, the trial was declared at an end when the pressure again fell to that at which the trial started. The speed of the engine was the same at the commencement and finish, and the height of the water in the gauge glass was also the same. It is thought, therefore, that the error due to any difference between the amounts of fuel on the grate at beginning and end must be reduced to a minimum. The fuel used was supposed and stated to be "Powell's Duffryn" coal. From the analysis, however, given in Mr. Wilson's report, as well as from our experience of the behaviour of the coal, it was certainly not up to the standard expected from that coal, and it contained only 84 per cent of carbon. The total amount of coal weighed out was 255lb. It was weighed on a tray placed upon the platform of a weighing machine, so that the amount put upon the fire in each half-hour could be accurately known. It will be seen from the diagram that the stoking was very regular throughout. The steam pressure and height of water in glass were read every ten minutes throughout the trial. The mean steam pressure was 188lb. per square inch over the atmosphere, the atmospheric pressure being 14·8lb. per square inch. The trial lasted 6 hours 16 minutes, or 6 27 hours. Six samples of furnace gas were collected. The analyses of these samples are given in Mr. Wilson's report.

(*To be continued.*)

A gold quartz crushing works has been started at Llanelly. Quartz is being obtained from the Dolgelly and Dolaucothi mines.

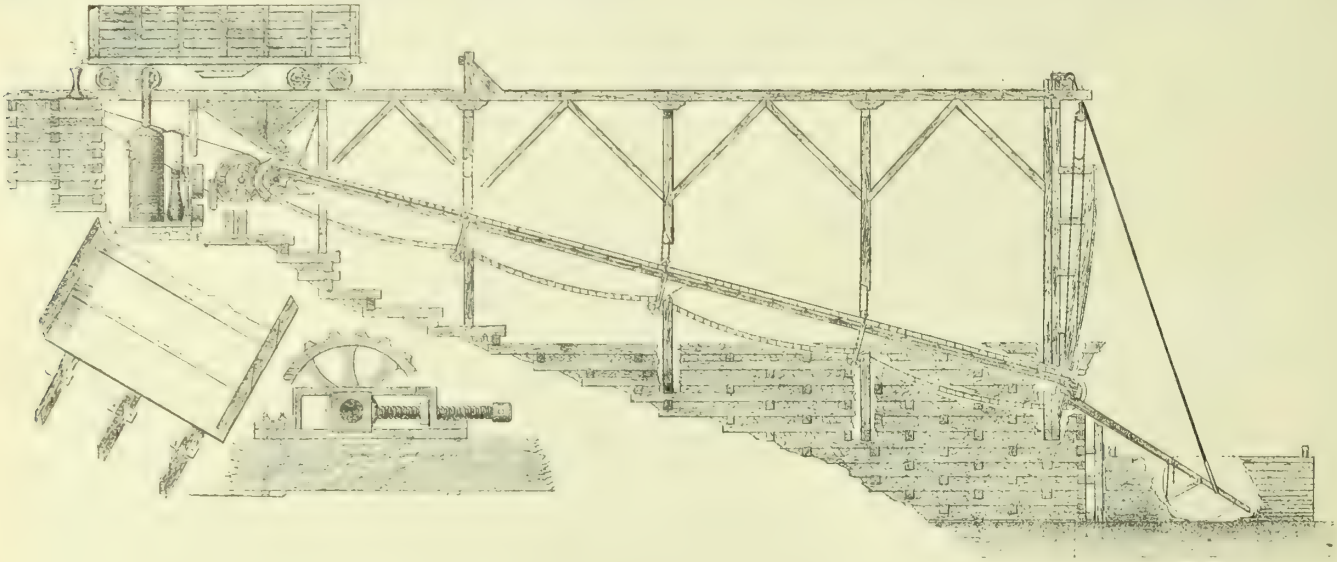
AN AMERICAN COAL TRANSFER.*

Among engineers engaged in mining coal for river transportation, probably no other subject of equal importance has received so little attention as the methods of transferring into barges and other craft.

The liability of all our streams to sudden freshets, and their attendant drift and ice-gorges, seems to have had little effect upon the design and construction of what are commonly known as river-tipples, beyond the building of breakwaters, and other similar devices, to guard expensive structures from damage.

The first method adopted for such transfer was a simple incline, with a movable cradle, which could be raised or lowered to suit the different stages of water. This system, though limited to a small capacity, and to cars not larger than those commonly used underground, possessed two advantages. The first cost was comparatively small; and, since the structure did not obstruct the channel, there was little danger from freshets, the utmost damage from which could be repaired at small expense. Its disadvantages, however, were many, the principal among them being the breakage of the coal by reason of the necessarily high dump; the damage to barges from the same cause; and the difficulties of screening and distributing the different sizes into separate barges.

That system has been almost wholly abandoned of late, in favour of the basket arrangement, lowering vertically into the barge, with the aid of counter-weights which return the empty basket; while pipes or chutes convey the small coals into other barges, from a complete set of screens, which this method will readily accommodate. As far as my observations have gone, the latter system is now universally employed along all the tributaries of the Ohio. It has been elaborated to meet large outputs, until the cost of construction, in many cases, has reached 40,000 dollars or 50,000 dollars. Where mines have been connected with the river by railway, necessitating the transfer into larger cars at the drift-mouth, the same system has been employed to lower the railway cars, so as to avoid the breakage from an extra dumpage. Owing to the fact, however, that a barge must be loaded uniformly, to avoid damage, it has not been found advisable to dump more than two or three tons on any one point; and the largest car I have seen lowered in this manner had a maximum capacity of about six tons, dumping from the centre upon a roofed cage, so as to distribute the load.



The Winifrede Coal Company has an arrangement of this kind, with the largest capacity on the Kanawha, excepting the transfer hereafter described. I believe its maximum work has been about 1,300 tons in twelve or fourteen hours. Without knowing the exact cost, I would estimate it at between 25,000 dollars and 30,000 dollars, including the structures for its protection. At the Faulkner mines, thirty miles above Charleston, a regular basket arrangement has been erected, at a cost of about 26,000 dollars; and the Crescent mines, two miles lower, have a similar arrangement, costing about 20,000 dollars. I do not think either of these tipples can transfer more than 400 tons per diem. They were built by Pittsburgh contractors, and copied from the best devices in use there.

Since the best devised structures, upon such waters as the Ohio, are liable to be washed away and become a total loss, it is clear that one of the first considerations should be economy in construction, and that as little resistance as the conditions will admit should be opposed to the current. Where breakwaters are used, they must be raised, to afford absolute protection, at least fifty feet above low water. Such a structure in stone would be beyond the means of most coal operators; and in timber they are not only expensive, but depreciate rapidly at and above the water-line. Bearing the above conditions in mind, and confining my remarks to the transfer of bituminous coal into barges, I should name the following *desiderata* in order of importance.

1. The arrangement should permit a structure accommodating any car; and since the majority of the mines, in the future, must reach the rivers over lines of railway too extensive for the economical use of small cars, the requirements of the standard railways should be met.

2. All bituminous coals, being more or less damaged by breakage, should be handled as gently as possible. Since breakage occurs not only from the shock and friction on the bottom and sides of a chute, but from the weight and grinding of the superincumbent mass when in motion, it is clear that any method by which the coal can be literally carried, while it remains at rest, will best meet this condition.

3. The barge should be loaded uniformly, otherwise its timbers will spring, and leakage will become a source of expense. The cost of a barge is too great to permit the neglect of any precaution for its preservation.

4. The cost of transfer should be reduced to a minimum, and the machinery should not be so complicated for a large capacity as to make a small output disproportionately expensive.

5. The capacity should be practically unlimited, since gravity furnishes unlimited power.

6. Above all, the structure should be a protection in itself against high water, or subject to such damage only as may be quickly repaired at a small cost.

After a careful study of the conditions and requirements—which are of course slightly modified by circumstances—I have ventured to make a departure from the conservative methods now in use, and submit herewith drawings of a transfer erected on the Kanawha for the Mt. Carbon Company Limited, which I think are sufficiently clear to need little explanation.

As this transfer has been in use for several months past, I can refer to actual as well as theoretical results. As will be seen, it is a simple application of a flexible steel belt, 4ft. wide, with 6in. flanges, and 95ft. from centre to centre of sprocket shafts. The three chains are made of ½in. by 2in. steel bars, with ¾in. steel pins, six inches from centres. Each alternate link has a 2in. flange, to which is bolted a segment of the belt, as shown on the detail drawing; consequently every other link is an idler, which increases the flexibility of the belt. The segments are made of No. 12 gauge soft steel, and lap ¾in. The lower lap is curved downwards, for which the idle link is notched.

The hopper underneath the car holds less than a ton; consequently the belt practically draws the coal direct from the car after this hopper has been once filled. The feed-apron is narrower than the belt, and is adjustable so as to feed automatically, the coal on the belt regulating the charge. I find no difficulty in regulating the feed to any desirable load, and no attendant is required. The links of the loaded chain run in small flanged rollers placed every four feet on 6in. girders, 24ft. in length, with fish-joints at every point of suspension. It will be seen that there are four such points within the 95 feet, for which I have used eight two-ton differential blocks, four on each side. I first proposed to use counterweights at these points, but upon estimation found the blocks were cheaper and more satisfactory.

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* W. N. Page. Am. Inst. Mining Engineers.

The total weight of belt and attachments, exclusive of the upper, or fixed, shaft and sprockets, is five tons, and the level load is five tons, consequently each revolution of the belt conveys a little more than ten tons. The arrangement for returning the empty portion of the belt consists of three pulleys, 2ft. in diameter by 12in. in face, set on the shaft so that each pulley supports a chain. To suit the different stages of water the entire system can be readily raised or lowered at one end by one man, care being taken to have the girders in line when the proper elevation is reached. The guide on the movable end is an arc of the circle to which the belt is radius; though to cover any inequalities or spring in the timbers the fixed ends of the girders are provided with movable connections to the main shaft, which is also provided with extension-boxes to facilitate making the connections. The chute which distributes the load in the barge is built of light steel, arranged so as to convey the coal to both sides at the same time, the proportion delivered to either being regulated by the angle of inclination. It is adjusted so that the coal moves in it very slowly, and has a minimum drop into the barge. When the sides have been fully loaded the hinged apron is folded back and the discharge falls in the centre of the barge, which is thus loaded so as to require little or no levelling.

It is apparent that the greatest inclination of the belt should not exceed the friction angle of coal on iron; and that, within certain angles, gravity will revolve the belt, on the principle of an ordinary incline. Though I put a brake wheel on the main shaft, intending at the time to use gravity power, I determined later to make use of a small 6in. by 8in. engine, which was on hand to operate a capstan for handling the barges. I connected the belt with it and made the greatest angle of inclination only 15 deg. The belt is speeded to 100ft. per minute—the engine making 150 revolutions—and makes a complete revolution in a little less than two minutes. In actual practice the belt empties a twelve-ton car in two minutes, or at a rate of 360 tons per hour. This capacity can be increased without additional expense by simply increasing the speed of the belt, or at a very small additional cost by increasing its width.

As the belt has never been operated by gravity alone, I am not able to say exactly what the factor of friction is, but am satisfied that it will revolve between the angles of 10 deg. and 30 deg.; in other words, it can be operated by gravity alone through an arc of 20 deg.; and with a radius of 95ft. this arc would approximate a difference in elevation of 34ft., which is more than ample to cover all loading stages in the river.

I find that the little engine mentioned will run the loaded belt without difficulty, in a horizontal position; consequently the total friction must be considerably less than the power of its cylinder, as it is geared (the gravity force exerted in direction of belt, at any angle, may be easily determined by the resolution of forces). The total cost of all the iron in the structure was 2,400 dols., excepting only the engine and boiler, which cost originally about 600 dols. To this must be added 100,000ft. of white-oak timber in the crib and trestle, which cost 2,000 dols. erected, and 600 dols. for stone filling, making the total cost, in working order, 5,600 dols., including engine, capstan, and all gearing. The cost in timber and stone will, of course, vary according to conditions. It will be seen from the drawings that I have used timbers lavishly, both in the wings of the crib and for the protection of the bank. The whole structure is so framed and drift-bolted together, that no part can be moved independently of the other, including the stone crib, which extends back to the railway grade, 50ft. above low water, and 10ft. above the Chesapeake and Ohio Railway.

The distance between bents being 24ft., little resistance is offered to the current (none of them are in the channel); and even should drift or ice gain a lodging, there is as much strength to withstand the pressure as is presented by an ordinary breakwater. The belt can be raised clear of the water, up to a 40ft. rise, and should this (the highest gauge yet recorded) be exceeded, it can be lowered in safety beneath the surface. As the crib is filled so that it cannot be undermined, the greatest damage which could possibly result would be the breaking of the bents, which are composed of four timbers of 12in. by 12in. oak, each firmly bolted and braced to the stone crib and its two wing walls. The belt would of course remain; and even such an improbable catastrophe would result in small damage.

In actual working, only two men are required to run this conveyor to its full capacity—an engineer, at 1·50 dols. per day, who also attends the capstan, and one man on the barge at 2 dols. per day, who is a carpenter and calker; consequently, the total cost per diem does not exceed 3·50 dols. The trainmen dump the cars; but if this expense be added it would amount to 2·50 dols. more. The tracks are arranged so that the loads run in, and empties out, on down grades.

In three months' working the cost of repairs has been nothing; and since every member has a large bearing and safety factor, the wear and depreciation will be very slight. No breakwaters have been put in, nor is there need for any, since the current is slacked by Dam No. 2.

Apart from the advantages already named, it has been clearly demonstrated that both coal and coke can be put in barges with half the breakage of any other arrangement I have seen; that there is nothing complicated to get out of order; that, as the barge sinks in proportion to the load, the belt has to be moved only for the different stages of water. Moreover, there is no danger to life or property from the breakage of any part, as is the case with the vertical system, in which I have frequently known the breaking of a rope to cause the loss of life, barge, and car.

With self-dumping cars, I would feel safe in guaranteeing to transfer 4,000 tons with this machine, within twelve hours, at a cost per ton not exceeding two-tenths of a cent, and, with a few hundred dollars extra outlay, I would uudertake to double this capacity, and lower the cost named.

As the mines of the Mt. Carbon Company are connected with the river by five miles of standard-gauge railway, and their coal is screened at the mine tipple, where they have 202 beehive ovens, no arrangement has been made to separate the nut and slack at the river. The vertical distance between the car and belt, however, could be easily utilised for screens; and the small coals could be conveyed to either side of the belt, where they could be carried by a trough and scrapers, connected to the main shafts, into separate barges, which might be arranged inside of the lump receiver. Under favourable conditions, the angle of inclination to these inside barges would be sufficient to slide the coal in fixed pipes, since breakage there need not be considered.

In submitting this transfer to the institute, I am convinced that the principle is the correct one, and that it is capable of modifications to meet the greatest number of conditions, for various purposes other than the handling of coal. To those who may have any doubts, I will take pleasure in pointing out actual results. An engineer of reputation, manager of a large property, and prepared to doubt all things new, recently stood for several hours with watch in hand, timing the cars as they were dumped. When satisfied, he informed me that the rate of transfer, by his time, was 500 tons per hour. Yet, in addition to the brakemen who were dumping the cars, there were only two workmen present, the engineman and the bargeman.

INTERNATIONAL EXHIBITION AT COLOGNE.

A communication has been received at the Board of Trade from Mr. S. Lee Bapty, enclosing the regulations for an international domestic exhibition proposed to be held at Cologne from May to October of the present year.

The exhibition will be opened on Saturday, 18th May next, and will continue open until the 15th October.

The committee will make arrangements to supply belt power, steam, water, gas, or electricity, at the expense of those exhibitors who have made application for it, and they will be charged in proportion to the power used. Preference is to be given in all cases where the applicant is the inventor, manufacturer, or producer of the intended exhibit.

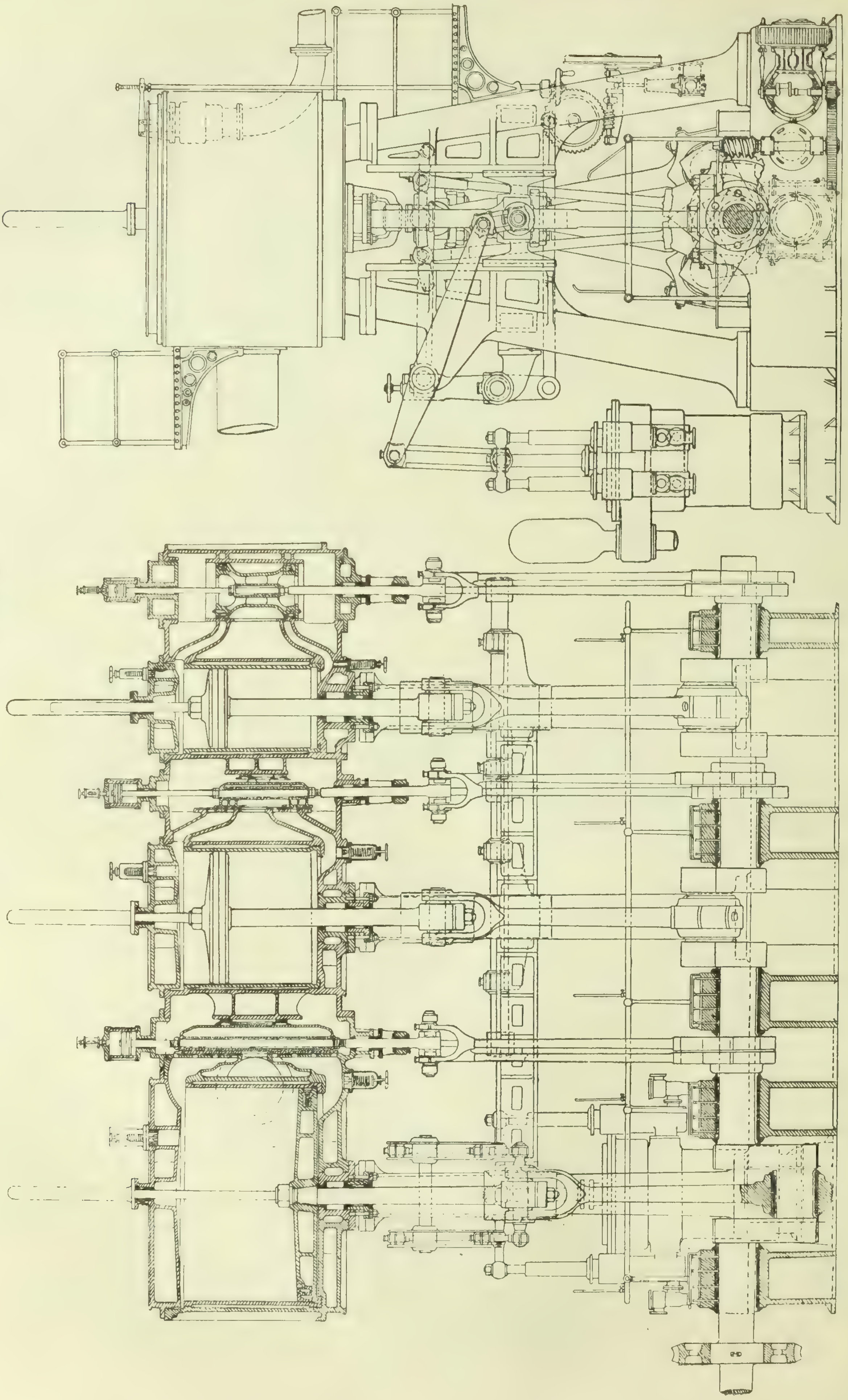
The general charge for space is to be 5s. per square foot, the minimum charge being £5, payable on allotment. The committee reserve the power to modify or remit these charges under exceptional circumstances.

Exhibitors requiring but small spaces, and not wishing to undertake the cost of making a special installation, may take part in a collective display, including representation, reception, and installation of exhibits, attention during the whole period, and returning at the close, with use of case, &c., at special rates with a minimum of £10.

TRIPLE-EXPANSION MARINE ENGINES OF 1200 INDICATED HORSE POWER.

Constructed by Messrs. E. Cravero & Co., Engineers, Genoa.

(For description see page 224.)



AUTOMATIC SPRINKLERS.

A paper was read on this subject before the Manchester Association of Engineers, by Mr. Joseph Nasmith, on Saturday, the 23rd inst. The question of protection from fire was one which had always been of interest to owners of any description of property. The use of iron for building to the extent now common was of very dubious advantage unless the iron beams and pillars were coated with some sort of cement to protect them from the heat, and, as a consequence, there had been during recent years quite an eruption of grenades, fire-extinctors, and similar appliances. The ordinary methods for extinguishing fires were mentioned, but the most important one now in use was the sprinkler.

There were two classes of sprinklers—those that acted by the admission of water by the opening of a cock or valve, and those which were opened by the heat evolved from the burning surface. The earlier sprinklers were of the first type, and consisted of a series of pipes placed near the top of the room, each pipe being bored with a number of holes, so that small streams of water were ejected in all directions. Automatic sprinklers had proved very successful, and several instances of these were quoted. The methods for supplying the sprinklers with water were then mentioned. Where for instance the town's water was the first source of supply, the best course was to use some kind of automatic pump, which would keep the pipes filled with water at a determined pressure. Of these pumps the Worthington had proved successful, and Messrs. Pearn and Co. had recently made a pump with the same object. Automatic pumps had this advantage over ordinary ones, that they only supplied such a quantity of water as was actually required at any time, which was a feature of great value. Tanks should be fitted, where water from the town mains was used, with an automatic feed valve of the ordinary ball type, and it was essential that an indicator, showing clearly the height of water in the tank, should be placed in a conspicuous position, so that it could be seen at any moment. The water from the tank was prevented from entering the pipes by means of an inverted clack valve.

The capacity of the tank should be as large as possible, and, as fixed by the insurance committees, must hold 5,000 gallons for 150 sprinklers, 6,500 where 200 were used, and 7,500 where more than 200 were employed.

In regard to the question of supply, the sizes of pipes required were arranged for sprinklers with an orifice of ½in., and a table of sizes, with the number of sprinklers, was given, this being the scale fixed by the committee named:

Table.

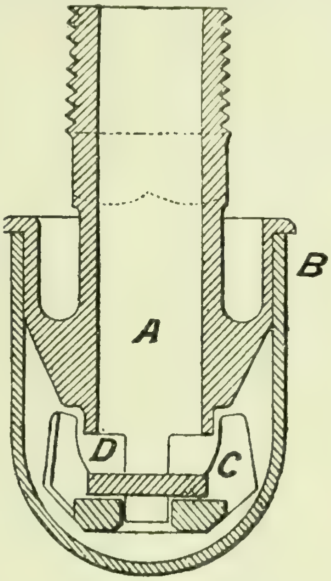
Size of Piping, in inches.	Sprinklers Allowed.
¾	1
1	3
1¼	5
1½	9
1¾	14
2	18
2½	28
3	46
3½	78
4	115
4½	125
5	150
6	200 or more.

It was now the general practice to fix each sprinkler at a distance of 10ft. from its neighbour, so that 100 square feet of space was covered by it.

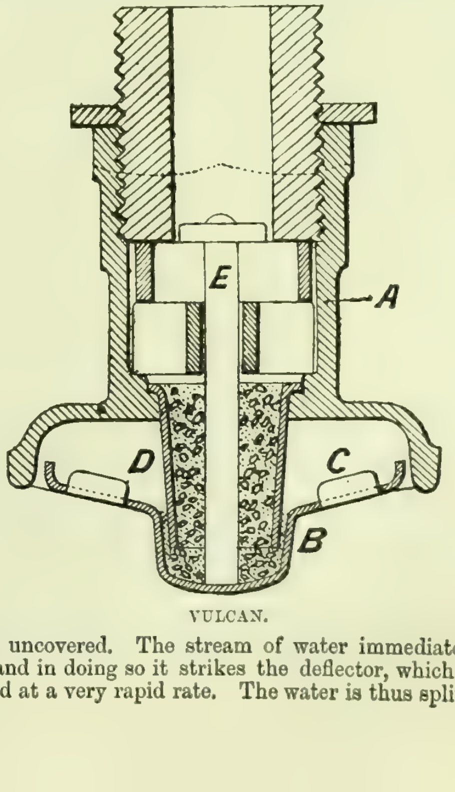
Sprinklers might be divided into two classes, viz., automatic and non-automatic. The latter were chiefly used in America, but the former were undoubtedly the better, and these the author intended to describe.

Before doing so, however, he mentioned the essential features required in all sprinklers. These were shortly as follow: They must be certain and prompt in action, quite free from leakage under the pressures ordinarily existing, distribute their water over a large area, act at as low a temperature as could be conveniently fixed, be simple in construction, be strongly made, so as to be practically undamageable by the ordinary work of a mill, and should be capable of being periodically tested both for speed and certainty of action without excessive trouble.

Having mentioned these, the author proceeded to consider the mode of constructing various types, beginning with sealed sprinklers. The term sealed sprinklers applied to those which have their exit orifice closed by a valve or cap, kept ordinarily in its place by some sort of solder which fused at a low heat. These fusible solders were composed of a mixture of lead, bismuth, and cadmium, and their composition was well understood.



PARMELEE.

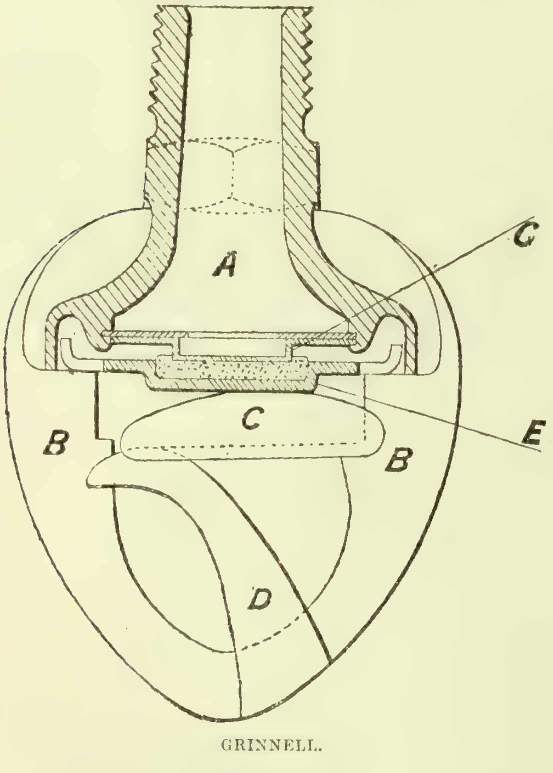


VULCAN.

The first of this class which was at all largely used was the "Parmelee," so called from the name of its inventor, an illustration of which we reproduce. It consists of a body A provided with a screwed nipple, and a space through which the water flows, and which it usually fills. Suspended in the manner shown is a winged circular deflector C, which is free to revolve when desired. The whole of the lower part or nozzle of the Parmelee is covered by a brass cap, which is soldered at the point B by fusible solder. The action is as follows: The water filling the sprinkler is, of course, kept at a pressure which varies with the position of each head. When the heat of the air around the sprinkler becomes great enough to fuse the solder, the cap is pushed off the nozzle by the water pressure, and the exit orifice D is thus uncovered. The stream of water immediately begins to issue, and in doing so it strikes the deflector, which begins to spin round at a very rapid rate. The water is thus split up so as to form a heavy spray, which is thrown all round to a distance which is greater or smaller according to the pressure of the water.

There were one or two points to notice about the Parmelee. It was very strong in construction, with no parts liable to damage in the event of a stray blow being given to it. It had, however, the fatal defect that, in order to heat it sufficiently to melt the solder and free the cap, it was necessary to raise the water it contained to the same temperature, a process which was somewhat difficult in view of the fact that the heat communicated could pass readily into the pipes. Then the area of the soldered surface is somewhat large, and unless the heat communicated was very great, the cap had a tendency to stick and not to fall away freely, which it ought properly to do. The pressure exerted on the cap was a little greater than that in the water pipes, being thus in the highest head about 8½lb., while the area of the sprinkler orifices in other forms was only about ⅕in., and where the head was placed in an upper room, in which the pressure obtained from the tank was only 7lb. to the square inch, there would only be 1½lb. exerted on the nozzle to push it downwards. It might be safely asserted that if the fire was a slow one, and the heat created comparatively low, the pushing off of the cap in either case would take a considerable time, comparatively speaking.

The same objection applied to a sprinkler which was modelled on the Parmelee, and which it was desirable to describe. The one referred to is the "Vulcan," also illustrated, which is the invention of Mr. J. H. Lynde, C.E., of Manchester. It will be noticed that the body A of the sprinkler is provided with the usual passage or bore, into which at one point is introduced a cross piece, which serves as a support for the deflector C. The latter is a flat disc, fastened on the end of a spindle E, and provided with a number of slits, the edges of which have raised lips or projections. The centre of the deflector is formed like a cap B, and covers the exit nozzle D, being kept over it in ordinary working by being sealed by sensative solder.



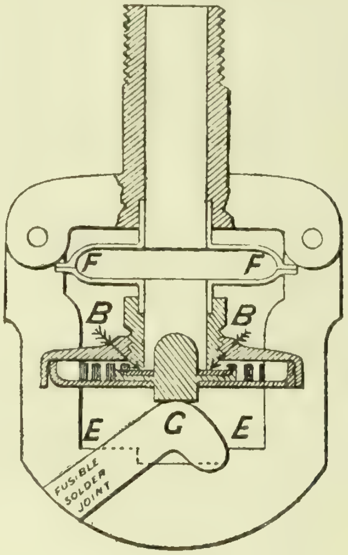
GRINNELL.

So far, with the exception of the form of the deflector, it would be seen that the Vulcan was practically the same as the Parmelee. It had been recognised by the inventor, however, that the delay existing in opening the latter had been caused by the cooling effect of the water, which was in direct contact with the nozzle. In order to obviate this, Mr. Lynde filled the latter with a mixture of paraffin wax and carbonate of barium, as high as was necessary to prevent the water reaching the soldered part of the nozzle.

The author then described a second class of sealed sprinklers, those in which the sealing was effected out of contact with the body of the sprinkler, the orifice being closed by a stirrup or bar. The first one of these was the "Grinnell," which we illustrate.

The Grinnell, as will be seen, consists of a brass body A, with the usual water space, the deflector covering the nozzle effectually, and being kept in position by the following means: Attached to each side of the body is a frame B, on the side of which a stirrup or crossbar C is hinged. This bar C is kept in position by a lever D, which is of such a shape that when it is brought up to the position shown, it exercises a considerable pressure on the valve or disc covering the exit orifice. Being brought to the required position, the lever is soldered to the two arms, and the sprinkler is ready for action. In the event of fusion occurring the lever falls away, and the pressure of the water pushes away the valve, thus allowing a free emission of water.

In describing this, the author said that primarily there was the same remark to be made with reference to the small power exerted by the water, when pressures were low, in the Grinnell as in others; but any chance of sticking was brought down to a minimum by the ingenious construction of the disc valve, which was formed as shown. When the valve was forced towards the nozzle, a special spring washer was pressed inwards, and in effect put into tension. The Grinnell had several little defects in its construction, but, on the whole, he thought that it was one of the best types of sealed sprinkler at present before the public.



MAYALL.

The Mayall sprinkler, one of the latest put upon the market, was also illustrated. It consists of a short tube screwed into the supply pipe, which carries two arms to which the stirrup or bridge piece E is fixed. Attached to the lower end of the tube is an expansion disc F, which is also fastened to the nozzle, at the lower end of which the valve B is formed. The valve is closed by the deflector shown, which has a number of serrated raised projections at each side, and when free can be slid vertically in the frame E. The inner surface of the deflector is flat, and when pressed against the nozzle at B forms a perfect joint. A lever C, the cranked end of which rests on the frame E, is pressed against the under side of the deflector, and by lifting its free end a considerable force is exerted on the valve, the point of the lever acting as a fulcrum. When the lever C is raised into its proper position, as shown, it is fastened to the frame E by fusible solder. The downward pressure of the valve is thus taken almost vertically by the lever, and the fusion of the solder is of course followed by the fall of the valve.

It was claimed for this sprinkler that the expansion case compensated for variation in the water pressure, and that the greater the pressure the tighter the valve. The case was made very strong, and would stand a high pressure without bursting. When the solder was fused the lever C fell away, and the slight spring in the case F caused an immediate release of the valve and the emission of the water.

(To be continued.)

Bridging the Danube.—According to the *Oesterreichische Eisenbahn-Zeitung*, the new iron bridge across the Danube, near Krems, is by far the most artistic, as well as the most substantial structure of the kind on the great river. Its length is 690 metres (760 yards); and of the thirteen bays four measure 82 metres, two 62 metres, and the other seven 31 metres each. This makes the fourth railway bridge built across the Danube above Vienna.

CORROSION AND PITTING IN MARINE BOILERS.

oncluded from page 196.)

It would certainly seem that the most logical method of preventing corrosion is to make the water non-exciting or incapable of acting chemically on the iron or steel of the boiler; thus the cause is at once attacked, whereas the other method only deals with the effect, and there is, moreover, avoidance of the great difficulty in making and maintaining the metallic contacts, owing to corrosion at the point of juncture, or the breaking of the contacts from other causes; and such imperfections can only be remedied when the boilers are opened. In those methods which aim at destroying the corrosive or exciting power of the sea water, the protective agent is added either at the condenser or hot-well from time to time, and in greater or less quantities as desired. There are several ways of making or causing the sea water to be non-exciting, and there are many compounds offered as meeting all the requirements, but care should be taken not to put into boilers any compounds which contain a constituent that of itself is capable of combination with iron, or which contains a constituent that can by any means be made to furnish compounds capable of such combination, because it should be a *sine quâ non* that the protective agent should be in itself harmless. Lime preparations added to the water are beneficial, their action being to keep the surfaces of the boiler always coated, and thus protected from corrosive action. This subject has occupied so much of the writer's professional attention that it has caused him to take more than an ordinary interest in the solution of the problem, apart from any commercial consideration of the question, although he felt it would be a great advantage if some reduction could be made in the present costly application of zinc, and the writer is of opinion that a basic solution of zinc would effect this economy; but, after all, he assumes that the vitality of the boiler is the first consideration.

The great advantages in the use of such anti-corrosive or anti-exciting compounds is that they can be introduced in small quantities at stated intervals. They render the water non-exciting, and diffuse themselves through all parts of the boiler, thus protecting all parts equally.

In treating of corrosion, mention of that special kind generally known as pitting has been omitted. This pitting is occasioned by the same causes as induce the more general corrosion, but these causes are intensified and accelerated by two other influences, which tend to concentrate the effects of such corrosion by rendering it very local, instead of general. These influences are rust or iron scale and variations of temperature. Rust or iron scale is frequently, indeed generally, in the form of "magnetic oxide of iron," and when the metal of the boiler, especially if it be steel, is acted on chemically by the sea water, and whilst in intimate contact with this oxide, such chemical action induces electricity, the oxide and the metal in its very immediate neighbourhood constituting a voltaic couple, and the metallic iron or steel, being the most readily acted on, becomes the corroded or positive element, while the oxide becomes the inactive or negative one. This couple induces a current of electricity having only a very local influence, thus concentrating the action on that limited portion of the iron or steel which has become the positive or corroded element through the influence of the oxide or scale, instead of allowing that action to expend itself more generally over a larger area.

Variation of temperature affects more particularly the question of the very serious and dangerous pitting observable on the sides of the furnaces. In cases where two portions of even the same plate of iron or steel are subjected to unequal temperatures when immersed in a liquid capable of chemically acting on them, these two portions become virtually two different metals so far as molecular arrangement is concerned, and are capable of forming a voltaic couple; the most highly-heated portion, being the most readily chemically acted on by the sea water, becomes the positive or corroded element, while the less highly-heated portion, being also the less liable to the chemical action, is the negative or inactive one. Thus, when through any physical or structural cause one part of the metal becomes more highly heated than another part—and portions of the furnaces and combustion chambers are very liable to this, especially along the fire-line—this more highly-heated portion becomes positive to the less highly-heated portion, and thus concentrates on itself all the corroding or chemical action which would have diffused itself more generally over the whole surface had the temperatures been equal.

To counteract or stay this pitting is much more difficult than it is to stay the general corrosion. In the case of general corrosion there is a general cause which may be met by a general cure, but in the case of pitting there are several causes, each perhaps similar, but yet each requiring to be separately neutralised and overcome. Each case of pitting being due to a local and not a general cause, in any endeavour to effect this cure by means of metallic zinc it will be necessary to remove this cause and bring the part affected into intimate metallic contact with the metallic zinc. Bringing the zinc into this contact with these parts will very greatly increase the consumption of zinc, seeing that these parts are so prone to chemical action. Supposing the causes, such as rust or iron scale, and the variations of temperature to be removed, this increased use of zinc will be effective. But, though it may be possible to remove the rust, it is not so possible to do away with the variations of temperature. Therefore the best method of effecting a cure of this pitting would be to strike directly at the cause by rendering the water non-exciting. By this means the rust and the variations of temperature are rendered innocuous.

In conclusion, the writer would point out that prevention is better than cure, and that if it is desired to keep a boiler in good order certain precautions must be taken. Firstly, great care must be taken in the selection of cylinder oils, and only use such as have a vaporising point at a higher temperature than the temperature of steam at the pressure at which the boiler is worked, and do not take the statement given of the vaporising points of these oils for granted, even though it may be a certain brand or make, but see that each particular lot as supplied is equal to the sample, and bears out all the statements made respecting it and which influenced its purchase. Such supervision will always give a good return for the trouble, because, whether it is cylinder oils or any other goods that are sold and which are *not* subjected to this supervision, it may be taken for granted that the lowest quality accepted, without serious complaint or rebate in price, will eventually become about the highest quality that will be supplied.

Secondly, work the boiler with the greatest amount of regularity practically possible on board ship, and endeavour to keep the specific gravities of the water as regular as possible. Samples of these waters might be taken at stated times during the voyage, and of deposits whenever opportunity offers; these samples to be kept for examination when necessary. The taking of these samples answers two good purposes: one is, that if the boiler should happen to show signs of corrosion, these samples will enable the cause of such corrosion to be traced. The other purpose is that by taking samples systematically and for a certain purpose, the attention is thereby drawn to the boiler and a certain interest created, which induces regularity in working and treatment generally, and all means which have this effect are most valuable, and cause a very material reduction in the wear and tear of the boiler.

THE LOOM: ITS HISTORY, USE, AND CONSTRUCTION.

A paper was recently read on this subject before the Manchester Association of Engineers, by Mr. C. P. Brooks, M.S.A.

He said the loom took a highly-important place among the machines employed in the industries of England. In 1885 there were 773,704 looms working in the United Kingdom, 560,995 of which were engaged in the cotton trade, while this year 450,000, or nearly three-fourths of the cotton looms in the kingdom, were working within a radius of thirty miles from Manchester. The process of weaving comprised three motions, which were known as shedding, picking, and beating up. The loom itself was then described, beginning with a very primitive one as used by the Hindoos; and then it was stated that, in 1773, John Kay, of Bury, invented what was then called the fly-shuttle, the forerunner of the present system. In August, 1787, the power loom was invented by Dr. Cartwright. Substantial improvements on the Cartwright loom were made by Horrocks, in 1803. After giving a short sketch of the various looms by different makers, there were described the three motions mentioned, taking shedding first. In a piece of cloth the threads which run lengthways were called warp, and the transverse the weft. In weaving a plain warp each alternate thread is drawn through alternate healds, which were suspended over a top roller, one on each side. Thus by raising one heald, and depressing the other, the sheet of warp might be separated into two equal portions. This movement was made by cams, called tappets, which were fixed on a horizontal shaft, and each acting downwards on a lever or treadle, fixed at one end to a pin acting as fulcrum, and attached at the other to one of the two healds. It was absolutely necessary that the dropping and raising of the healds should be done easily, and without jerk. When two healds only were used little variation of pattern could be made by the manipulation of the threads, as any movement of the healds moved one-half of the threads. By dividing the threads on a larger number of healds figured cloth of various kinds could be produced, and these could be increased until the patterns passed out of the range of tappet weaving, and had to be made by a dobby or jacquard loom. The dobby, or witch machine, was next described. This was a most ingenious contrivance, but the best shedding motion in existence, and the one acknowledged as the masterpiece of all machinery, was the jacquard. If the capacity of a plain loom was taken as one, the dobby would be ten, and the jacquard would stand at a hundred.

He illustrated a 400-hook machine, the commonest size used in cotton weaving. In it was a row of needles, or lances of thin wire, arranged horizontally. At the right each of these was attached to a spring, and the other end projected about ⅜in. through the needle board. Each lance regulated a vertical wire, hooked top and bottom, with each upper hook standing over its respective griffe, or knife. These griffes, eight in number, were lifted simultaneously, through being connected together at the ends. The lower end of the hook rested on a wire grid, slotted so as to allow the lower end of the hooks, to which were attached neck cords, to pass through. A bottom board, below the bend, was used for those machines which had no wire grid. To these neck cords was attached the harness—*i.e.*, linen threads or leashes, some 7ft. in length, carrying a brass mail eye, through which the end of warp was drawn. Just above the mail eye the harness passed through a cumber board, for the purpose of keeping in proper order and regulating the number of leashes per inch. At the bottom of each leash was fixed a metal weight, called a lingo, intended to pull the leash down after having been raised to form the shed.

The method of raising the ends was as follows: A square cylinder was suitably placed, and made a quarter of a revolution at each pick. This cylinder carried a set of cards—sheets of cardboard perforated in places. In a 408 machine each card had 408 perforations, the holes corresponding in position with the ends of the 408 needles projecting through the needle board. A hole indicated a lift. The cards were only perforated by groups of holes distributed incidentally, and where no perforation was made the needles at that point are pushed back ⅜in. by the cylinder.

The "picking" motion was next mentioned, and its object was to throw the shuttle through the shed or opening in the threads. This had to be done by a sharp blow, as the time allowed for the passage of the shuttle across a fast-running loom was only about one-seventh of a second, and yet the blow must impart no unnecessary vibration to the machine or the threads. Picking by compressed air, by magnetism, by gravity, by screw motion, by springs, cams, scrolls, and rods of all shapes had been tried, but the one which found most favour in the plain weaving branch of the cotton trade was the cone, or overpick. He described this minutely, and then passed on to the process of "beating up." The opening made for the shuttle consisted of two planes, forming an acute angle of perhaps 30 deg., and as the shuttle passed across one of the planes—*i.e.*, a sheet of warp, at the wider part of the angle, and parallel to the edge of the cloth—it would be seen that the thread of weft that it left behind was at a distance of say five inches from the edge of the cloth, and was parallel to it. It was necessary that the thread should be pushed up to the cloth, or, as it was termed, "beaten up." The machinery necessary for this was described, and in conclusion Mr. Brooks mentioned the more recent improvements in looms.

TRIPLE-EXPANSION MARINE ENGINES OF 1,200 I.H.P.

WE illustrate on page 220 triple-expansion marine engines of 1,200 I.H.P., constructed in Genoa by Messrs. E. Cravero and Co., and described in our esteemed Italian contemporary, *L'Industria*, to which we are indebted for our details. The engines have three cranks and cylinders, are of simple design, and the steam distribution is performed by piston and slide valves. Following the practice in this country, a piston valve is used for the high-pressure cylinder, while slides are used for the other two, which slides are carefully balanced as shown. The air-pumps, two bilge-pumps, and two feed-pumps are driven from a lever attached to the crosshead of the low-pressure cylinder, and the condenser is outside and separate from the main engines, with a feed-water heater attached to it. The circulating pump is centrifugal, driven directly at a high speed by a small separate engine.

The principal dimensions are as follow :—

Diameter of cylinder	H.P.	550mm.
” ”	M.P.	900 ”
” ”	L.P.	1,460 ”
Stroke of pistons	....	800 ”

Revolutions per minute, 93.

The relative proportions of the cylinders to each other by volume are—H.P. to M.P. as 1 : 2·7., M.P. to L.P. as 1 : 2·63, H.P. to L.P. as 1 : 7·1.

The diameter of the air-pump is 550mm., and its stroke is 400mm. ; the feed-pumps are plunger, diameter 90mm., and stroke 400mm., as are also the bilge-pumps.

The condenser surface is 225 metres, or 0·187 metres per indicated horse power. The starting and reversing gear is simple, and is arranged to permit of varying the distribution of steam in any particular cylinder, without interfering with the valve action in the others ; and separate steam valves allow of steam admission at any part of the stroke, if the engines should chance to stop in any position where the steam could not enter by the usual ports.

BELT AND ROPE GEARING.—V.

LIMITING VELOCITY FOR MAXIMUM POWER DUE TO A GIVEN MAXIMUM WORKING STRESS.

THE amount of *power* which may be transmitted by a belt or rope, *with a given maximum intensity of stress*, attains a maximum value when the linear velocity in feet per second is equal to that found by the formula

$$v = \sqrt{10{\cdot}73\ \frac{s}{w}} \qquad (35)^{*}$$

where s is the maximum working stress and w equals, as before, the weight of a running foot of the material of which the belt or rope is made (*see footnote*).

In the case of *leather* belting, when $w = {\cdot}43$ pounds, and where the stress s is taken as 300 pounds, we obtain

$$v = \sqrt{10{\cdot}73\ \frac{300}{{\cdot}43}} = 86{\cdot}6\text{ft. per second};$$

or a little less than the velocity of a mile a minute.

With respect to the limiting velocity in hemp rope gearing. Taking the working strength of an inch rope as 840lb., and the weight as $\frac{1}{3}$ of a pound per running foot, we obtain

$$v = \sqrt{10{\cdot}73 \times 840 \times 3} = 164{\cdot}8\text{ft. per second},$$

and at this speed the stress in the rim of the pulley (if of cast iron) would be by formula (34)—

$$\text{Stress} = {\cdot}097 \times 27040 = 2623\text{lb. per square inch.}$$

---

* From formula (18) we may obtain $R = T \times \frac{r-1}{r}$, and if K be made to represent the value of the fraction $\frac{r-1}{r}$, we may write $R = T \times K$,

$$\text{or } T = \frac{R}{K}.$$

Now, as by formula (33) $T_2 = T + \frac{wv^2}{g}$ when A = unity,

we obtain by substitution $T_2 = \frac{R}{K} + \frac{wv^2}{g}$;

that is to say, $\frac{R}{K} = T_2 - \frac{wv^2}{g}$;

so that (resistance) $R = KT_2 - \frac{Kwv^2}{g}$;

and as transmitted work equals resistance multiplied by velocity, we have—

$$\text{Work transmitted} = KT_2v - \frac{Kwv^3}{g};$$

and as the work transmitted is required to be of a maximum amount, or

$$KT_2v - \frac{Kwv^3}{g} \text{ is to be a maximum,}$$

we differentiate with respect to the velocity v, and obtain

$$KT_2 - \frac{3Kwv^2}{g} = 0,$$

Therefore, $KT_2 - \frac{3Kwv^2}{g}$,

and it follows that $$v^2 = \frac{T_2g}{3w} \qquad (35a)$$

and, considering the effect on *one* square inch of section, it is evident that

$$T_2 = \text{stress or } s,$$

so that the *maximum (limiting) velocity*

$$v = \sqrt{\frac{sg}{3w}} = \sqrt{10{\cdot}73\ \frac{s}{w}} \qquad (35)$$

(It would appear from this that it would not be *safe* to run a hemp rope at the *limiting velocity* which we have just been considering, owing to the amount of stress induced in the rim of the pulley.)

In order to make the matter a little more clear, I have worked out three examples to prove the truth of this formula (35).

DATA: Arc of contact ·3 of the circumference.
Co-efficient of friction $\mu = {\cdot}4$.
Leather belt $w = {\cdot}43$lb. per running foot.

Maximum working stress = 300lb. $= s = T_2$; then from formula (35)—

$$v = \sqrt{10{\cdot}73 \frac{300}{{\cdot}43}} = 86{\cdot}6\text{ft. per second.}$$

From diagram No. 1 we obtain *ratio of tensions* $\frac{T}{t} = 2$.

Formula (30) gives us—

Centrifugal stress $= \frac{v^2}{75} = 100$lb. *per square inch of section.*

Therefore, the difference between the maximum working stress and that due to centrifugal tension will give us the value of T, the *available* working tension, that is—

$T = T_2 - T_c = 300 - 100 = 200$lb. *per square inch of section,* and by using the formula (18)

the resistance R, that is $T - t = T\left(1 - \frac{1}{r}\right) = T\left(1 - \frac{1}{2}\right)$

so that $R = T \times {\cdot}5 = 100$lb. *per square inch of section*, and this multiplied by the velocity $v = 86{\cdot}6$ft. per second, gives us the *maximum* value of the foot pounds of work *per second* that a belt (of *one* square inch of section) could transmit under the above conditions. That is—

Foot pounds of work per second $= 100 \times 86{\cdot}6 =$ *8660 (ft. lbs. per sec.)*

Let us now take a *higher* value for *v*, say 90ft. per second, then the

$$\text{Centrifugal stress} = \frac{8100}{75} = 108\text{lb. per square inch,}$$

and $T = 300 - 108 = 192$lb.

Also $R = T \times {\cdot}5 = 96$lb.,

and if we multiply this by the velocity $v = 90$ft. per second, we obtain work $= 96 \times 90 =$ *8640 foot pounds per second*, or 20 foot pounds per second *less* than in the previous case.

Now let us take a *lesser* value for *v*, say 80ft. per second.

$$\text{Centrifugal tension} = \frac{6400}{75} = 85{\cdot}\dot{3}\dot{3}\text{lb.,}$$

$$\therefore T = 300 - 85{\cdot}\dot{3}\dot{3} = 214{\cdot}\dot{6}\dot{6}\text{lb.}$$

and $R = T \times {\cdot}5$ (as before) $= 107{\cdot}\dot{3}\dot{3}$lb.;

and this multiplied by the velocity gives us

work $= 107{\cdot}33 \times 80 =$ *8586·4 foot pounds per second,*

or a *reduction* in the power transmitted of 73·6 foot pounds per second.

These three examples prove conclusively the truth of formula (35).

It will be noticed that *when the velocity* is of the *maximum value* found by formula (35), the centrifugal *tension* amounts to one-third of the maximum *working* tension allowed; that is to say,

$$\text{Centrifugal tension} = \tfrac{1}{3} T_2 \qquad (36)^*$$

In other words, at this speed the maximum tension T_2 becomes one and a half times the greatest tension which would be calculated if the centrifugal tension were neglected; it follows, therefore, that a belt, whose width calculated out to say 10 inches by the ordinary rules which neglect the effect of centrifugal tension, would be to preserve the *same* maximum stress required to be 15 inches wide, if the extra amount of initial tension necessary (due to this force) were taken into account.

THE INITIAL TENSION NECESSARY WHEN CENTRIFUGAL FORCE IS CONSIDERED.

The actual amount of initial tension necessary for the transmission of a given power at a given velocity, with a given maximum limit of stress, is expressed by the formula:

$$I_2 \text{ initial tension} = I + \frac{A \times w \times v^2}{g};$$

I being the value obtained (in terms of the resistance R and the ratio *r*) by the formula (26) and the fraction $\frac{A + w \times v^2}{g}$ the increase of tension necessary to resist the centrifugal force, and as by formula (26) $I = R \times i$, we may write (for leather belts),

$$I_2 \text{ initial tension} = R \times i) + \left(A \times \frac{v^2}{75}\right) \qquad (37)$$

values of *i* being given in diagram No. 2, and values of $\frac{v^2}{75}$ in column 3 of Table 2.

On substituting for the resistance R, its value in terms of the horse power and velocity, we obtain

$$I_2 \text{ initial tension} = \frac{550 \times HP \times i}{v} + \left(A \times \frac{v^2}{75}\right) \qquad (38)$$

From this we may obtain the correct value of the least initial tension necessary for a leather belt of a given area, transmitting a known horse power at a certain velocity, with a known ratio of tensions (see formula (27) and remarks thereon).

If a belt be put upon a pair of pulleys with a greater initial tension than that found by this formula, it will be evident that the stress—provided for in the factor A (the sectional area of belt)—will be exceeded, as the following example will show:—

Suppose a belt of one square inch of section is required to transmit a force of 100lb. at a velocity of 86·6ft. per second, the ratio of tensions *r* being taken as 2. Then from diagram 2 we obtain (when $r = 2$) the results $c = 2$; $k = 1{\cdot}$; and $i = 1{\cdot}5$; also from table (2) column (3) at velocity 86·6ft. per second we get $\frac{v^2}{75} = 100$lb.

$$\text{so that } T = c \times R = 200\text{lb.}$$
$$t = k \times R = 100\text{lb.}$$
$$(\therefore T - t = 200 - 100 = 100 \text{ as required}),$$

and formula (38) will enable us to obtain

$$I_2 \text{ initial tension} = (100 \times 1{\cdot}5) + 100 = 250\text{lb.}$$

It will be noticed that the increased value of T (*viz.*, T_2)

$$T_2 = T + \frac{w\,v^2}{g} = 300 \text{ (maximum stress produced).}$$

$$\text{and of } t_2 = t + \frac{w\,v^2}{g} = 200;$$

also,

$$I_2 = \frac{T_2 + t_2}{2} = \frac{500}{2} = 250 \text{ (as before).}$$

Now, suppose the belt put on with an initial tension of 300lb., then as

$$T_2 = I_2 + \frac{R}{2} \qquad \text{(formula 6)}$$

$$T_2 = 300 + 50 = 350\text{lb.};$$

that is, an *increase* in the *stress* of 50lb. per square inch; also

$$t_2 = 300 - 50 = 250\text{lb.}$$

Subtracting from T_2 and t_2 the centrifugal tension = 100, we obtain—

$$T \text{ (available tension)} = 350 - 100 = 250$$
$$t \qquad = 250 - 100 = 150$$

It is evident that $(T - t) = 100$ as required, and that

$$r = \frac{T}{t} = \frac{250}{150} = 1{\cdot}66$$

(it will be remembered that we started with $r = 2$), so that by increasing the initial tension beyond that which is required by the formula, we reduce the liability to slip.

This is precisely what we might have expected, only it will be noticed that the belt is more severely strained in consequence.

EXCESS OF INITIAL TENSION.

It may be safely asserted that many instances occur where belts and ropes have an "initial" tension far in excess of that absolutely necessary for the power which is transmitted, and this excess of tension cannot but have a diminishing effect upon the efficiency of transmission, by reason of the extra friction in the bearings due to the increased amount of resultant pressure. It should be borne in mind that in this class of gearing the size of the shafts or axles is, comparatively speaking, very small, so that any bending or springing of the shaft brought about by this pressure will have a detrimental effect, and produce unnecessary friction in the journals.

As a particular instance, I may mention the case of a rope driving a travelling crane, where formerly the initial tension was produced by means of a constant *weight*, attached to a stretching pulley; the average life of the rope being about nine months. When the weight was removed, and a stretching *screw* substituted,

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* This follows from formulæ (35) and (29):—

$$\text{Formula (35) may be written } v^2 = \frac{T^2}{3}\frac{g}{w}; \qquad (35a)$$

(See footnote to same).

$$\text{Formula (29)} \quad T_c = \frac{w\,v^2}{g}, \text{ so that } v^2 = \frac{T_c \times g}{w}; \qquad (35b)$$

(35*a*) therefore equals (35*b*); so that

$$\frac{T^2 \times g}{3w} = \frac{T_c \times g}{w}$$

$$\text{therefore,} \quad T_c = \frac{T_2}{3} \qquad (36)$$

the life of the rope was increased to from four or five years, the initial tension being by such means so arranged as to be of the *least* possible amount consistent with the power required.

Referring to the question of the tension due to the centrifugal force, it is sometimes stated that each of the existing tensions in the two sides of the belt (that is T_2 and t_2) is increased by the amount of the centrifugal tension, whereas its effect is to *absorb*, not to increase, the existing tensions, and therefore to diminish the tension available for the transmission of power.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

ECONOMY OF EXPANSION.

To the Editor of "The Practical Engineer."

SIR,—I am in charge of a pair of engines, and should like to know if any of the readers of *The Practical Engineer* could inform me, through your valuable paper, if I shall save anything by cutting off at quarter-stroke at 80lb. pressure, or at half-stroke at 40lb. pressure. Of the two modes of cutting off, which will save the most coal? Any reliable information will much oblige, yours, &c., ECONOMY.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

SIR,—I also would like to know how the water tubes are kept clean if they use water like ours, where we get out a large ash-barrow full of mud and dirt every three weeks, and we find it the cheapest to withdraw our tubes when the scale gets too thick, in order to keep our Lancashire boilers clean. In my opinion there is no boiler so good as the Lancashire or Cornish, as all the deposit sinks down below the intensely heated parts, and what lodges on the top of the tubes is easily removed. I would like also to ask some of your readers if conical cross tubes are for anything else besides strengthening the flue tube, as I remember some years back, when I was firing two Lancashire boilers, they put six cross tubes in each flue of the two boilers; afterwards I burnt as much fuel as I did before—I am inclined to think, as far as my rule of thumb goes, a little more. It used to make me think that all the heating surface they put in was not so good as what they took out to connect them in, along the best part of the flue. Now, sir, I think if the flue past the bridge was half the size, or if something was put in to throw the heat all round the tube, the boiler would get more steam. If you have a 3ft. tube, when the heat gets over the bridge it seems to me to be almost lost. I would advise your readers, who have anything to do with Lancashire or Cornish boilers, to have a small hole put in the back end of the boiler flue to peep through, to see how lazily the flame goes along the flue. In a few hours after cleaning the flue the bottom part is covered with dust, and only along the top part of the flue is giving steam. I have worked at boilers where they would not stop to clean out the flues, and have seen the flue dust level with the top of the bridge, right along to the end of the boiler, but I cannot say that the boiler made more steam when the flue was clean. I used the shovel, and felt no difference. This makes me say the tube should be smaller beyond the bridge. I think that you only want the same area past the bridge as the area over the bridge, as you cannot get more through than goes through the smallest place of the passage, and if smaller the dust would pull right through, and not lodge in the tube. I have tried it with models, and find it so. What is the opinion of some of our practical engineers?—Yours truly,

FIREMAN.

QUERIES AND REPLIES.

16. SETTING CORLISS VALVES.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—ENGINEER.

22. ANTIMONY.—Will any reader kindly inform me of the best way to melt ground antimony? The only means at my disposal for doing so are in a ladle over gas or over a large stove, and this is not effectual, as the powder simply cakes.—H. P. S.

23. LIGHT MIXING MILL.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—EASTERN.

26. CAVITIES IN SIEMENS CAST STEEL.—Can any reader explain the cause of the hollow cavities occasionally met with in Siemens cast-steel ingots? I mean hollowness so bad as to completely destroy the ingot.—W. P.

27. FORGING MUSHAT STEEL.—Will some practical reader kindly inform me of the best way of forging Mushat steel? I can forge ordinary cast steel, but Mushat steel seems to fall to pieces under the hammer.—STEEL BAR.

28. YACHT ENGINES.—What is the greatest I.H.P. I would get out of compound engines $\frac{9\frac{1}{2}\text{in.} \times 16\text{in.}}{10\text{in.}}$ and boiler (horizontal) 6ft. 3in. by 5ft. 6in., and what should the areas of ports, and separate parts, and diameter of steam pipe be, so as to get the greatest power of them?—S. J. M.

29. CEMENTING RUBBER TO METAL.—Can any reader give me information as to the best cement for fastening a rubber stamp to metal. The cement must stand frequent pressure upon the rubber without being loosened.—J. A. L

30. METALLIC PISTON-ROD PACKING.—Who are the makers of Cruikshank's metallic piston-rod packing, and what is their address? Also where is the United States Metallic Packing Co.'s packing to be had?—J. W.

31. SETTING SLIDE VALVE.—The slide valve of my "Fowler" traction engine does not admit steam evenly to both sides of the piston head, and although it seems to be set fair, yet steam enters for three-fourths of the forward stroke and only for one-third of backward stroke when in last notch of reversing lever. If I alter the valve rod so that valve works evenly, then, by putting reversing lever in second notch from centre, one port opens altogether, and the other one not at all, during a revolution of flywheel. Will some reader kindly point out where the mistake is?—TRACTION ENGINE.

32. COULD any of our practical readers inform me how to calculate the thickness of liners to be put under a bearing next to a paddle wheel? Suppose a crank shaft of a paddle boat and the bearings next to the wheels in paddle box had dropped, I require the thickness to put under them so as to only have to lift them once or so. Centre of crank pin to centre of shaft, 2ft. Distance from face of crank cheek, 5ft. Difference the crank shows top and bottom centres, $\frac{7}{16}$in. Hints will much oblige.—DUMMY.

33. PROTECTED BEARINGS.—Could any reader inform me of a maker of protected lubricated bearings arranged for protection against dust, such as coal dust.—W. G.

34. WEIGHT ON CHOCK ON COLLIERY INCLINE.—What is the weight resting on a chock placed across the rails of an incline which has a vertical rise of 1 in 12? Set of 30 tubs, each of which weighs 12 cwt. The chock prevents the downward movement of those tubs.—STUDENT.

EXPANSION.—Have you made any alteration in the engines you describe which could cause difficulty in starting? It is a serious difference starting at 6lb. pressure and at 40lb. Explain the engines fully, and state changes made clearly.

T. N., Glasgow.—An engine of 8in. steam cylinder, 24in. stroke, and running at 73 revolutions with 40lb. steam pressure, carried the whole stroke, would indicate about 17 horse.

BRONTES.—We are not aware of any mills driven by the rise and fall of the tides. Although such tidal engines have often been discussed and proposed in various forms, yet the expense has so far proved an insuperable obstacle. There is no difficulty in constructing a tidal engine, but it seems so far impossible to make one a commercial success.

R. R., Aberdare.—Your letters shall be fully dealt with in our next issue.

H. G. B., Mortlake.—We shall consider the publication of the paper you mention upon hydraulic machines.

H. M., Dover.—A provisional patent will protect your invention for nine months; the Government stamp fee is £1. You can obtain the stamp by application at any post office, but your best course is to apply through a patent agent. Agents' charges vary with the nature of the invention, and if there is little work in your provisional, a good agent may do the work for you, including stamp, for £3 3s. See our advertising columns.

A. W. M., Leeds.—We cannot say what is the length of the longest endless wire or hemp rope ever made, but for cable trams and other purposes three miles in one length is not uncommon.

E. L. R., Tewkesbury.—The error to which you call attention is very obvious, and is due to the printer.

H. R. S., Shipley.—The lifting ropes of a cage hoist would not work safely in the manner you describe, merely laid over a drum from the cage to the balance weight. Such ropes always wind on the drum, and are wound off by the balance weight. It would take a complete article to explain the matter fully, and as we are writing a set of articles on hoisting gear, we shall not go further with the question at present.

MISCELLANEA.

The Mekarski compressed-air motor for steam tramways is being taken up by American capitalists for introduction into the United States.

A monster crane, capable of lifting a weight of no less than 250 tons, has been completed at Chatham Dockyard. The crane measures 134ft. from the end of the jib to the ground, and is the largest in the world.

PRODUCTION OF METALS IN RUSSIA.—The *Gazette de Moscou* states that, according to a report recently issued by the Russian Administration of Mines to the Government, there were extracted in 1886 in Russia 62,092lb. of fine gold, 9,512lb. of platinum, and 445 tons of copper.

SUBMARINE TELEPHONE IN SOUTH AMERICA.—According to an article in *Uhland's Wochenschrift*, the first submarine line of telephone, laid between Buenos Ayres and Monte Video, is now opened and is found to work infinitely better than the majority of overground telephones.

THE PULSOMETER ENGINEERING COMPANY, of Nine Elms Works, London, send us a new edition of their catalogue, dealing with ice-making and refrigerating machinery, in which complete and interesting details are given of their improved system, using compressed anhydrous ammonia. We observe with interest that in a machine of fair size the total cost of fuel and wages per ton of ice made is only two shillings, and the loss of ammonia is so slight that the renewals only amount to one farthing per ton of ice produced. These results are far in advance, in point of economy, of the best capabilities of cold dry-air machines. The catalogue is neatly got up, and nicely illustrated. Plans of cold chambers of various capacities are given.

During the year 1888 the additions to the railways in the German Empire measured 655 miles, all but 92 miles of which were State railroads. All the new roads are worked as branch lines, and 55 miles of them are of narrow gauge.

The Metal Imports of Japan—The quantity of metal imported into Japan in 1887 amounted to the value of about 4,250,000 yen, the iron and steel being almost exclusively obtained from Great Britain and Germany. Belgium's share in the trade was, strange to say, almost insignificant. The heaviest item in this class referred to iron and steel rails, which figured for 653,534 yen, or about 24 per cent above the returns for 1886.

The Steam Power of the World.—It has been estimated that the total amount of steam power developed in the world amounts to about 46,000,000 H.P. The principal countries which figure in this total are the United States for 7,500,000, Great Britain 7,000,000, Germany 4,000,000, France 3,000,000, and Austria-Hungary 1,500,000 H.P. The steam power now utilised would thus be almost equivalent to the hand labour of the whole population of the world.

Colonel North's Steam Fire Engine.—The elegant steam fire engine, constructed by Messrs. Merryweather and Sons, named Balmaceda, to be presented by Colonel North to the Iquique Fire Department, is built upon the Greenwich type, similar to those used by the Corporations of Manchester, &c., with all the latest improvements. It has its fire hole behind, with foot plate for engineer, so as to be stoked on the way to a fire. There are four delivery hose connections for working four lines of hose simultaneously, and, by an arrangement of breeching pieces, six jets can be worked when required, and each reach a distance of 120ft. As a test, steam was raised in frosty weather from cold water to working pressure of 100lb. in 7¼ minutes. The trials proved in every way satisfactory, and exceeded the contractor's guarantee on all points.

Lighting and Heating the House of Commons.—It appears that the addition of the electric light to the arrangements of the House of Commons has by some unaccountable process increased rather than decreased the expenses for gas. Last year the gas bill was £3,300, whilst the cost of the supply for the coming year is estimated at £4,000. This is in addition to an increase in the expenditure on electricity of £40. The supply of oil lamps in the Houses of Parliament still maintains its immense proportions. This year, as last, not less than £2,000 is paid for oil for the lamps, which are used only in the committee-rooms, some of the lobbies, one of the reporters' rooms, in the ventilation department, and in the residences of officials. The total cost for warming, ventilating, and lighting the Houses of Parliament in the coming year is estimated at £16,100 against £14,520 last year.

Electric Lighting of Trains in Wales.—For the first time in Wales a train was lighted by electricity on Wednesday, the 13th inst. The train is one of the two that run regularly on the Penarth branch of the Taff Vale Railway. Fifty Swan-Edison lamps of 12-candle power each were placed on the train. The electricity is generated by means of a dynamo fixed in the guard's van, and run from the axle by a belt. Till the train attains a speed of 10 miles an hour current is obtained from the accumulators (which are supplied by the Electrical Power Storage Company), but at and over that speed it is driven direct from the dynamo. The second train is now being fitted in the same manner, and there is every reason to believe that the directors will extend the system of electric lighting to the whole of their trains on the main line, and the Aberdare and Treherbert branches.

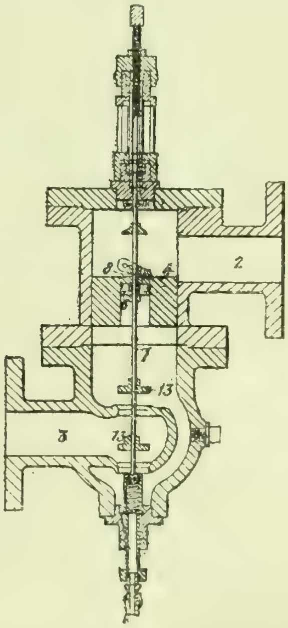
The Proposed Huge German Floating Exhibition.—About £250,000 are already said to have been raised by the German Export Society for the purpose of building the huge ship to be named the Kaiser Wilhelm, and to be used as a German floating exhibition. According to the plans the vessel is to be 564ft. long, 66ft. wide, and 46ft. high. She is to have four screws, propelled by four sets of engines, and is to be built principally of German steel. The Germans are of opinion that the qualities of their goods are not sufficiently known, and that international exhibitions do not occur with sufficient frequency. The prospectus of the intended show says that such exhibitions "must be supplemented in this way." It is intended to sail from one port to another all round the world, and to continue the exhibition for two years. The cost of the voyage or tour is expected to be about 3,150,000 marks. It is estimated that the income from rents of spaces and from sales will, after payment of this cost, leave a balance of £100,000 annually. The intention at present is that the ship shall sail about the spring of 1890.

The Italian Experiment Tank for Ships' Models. The Italian naval authorities are just now fitting out an experiment tank at Spezzia, with the view of submitting their designs for future warships to actual experiment on models of the same. The necessary appliances and apparatus for the carrying out of such experiments are being made in this country, and Messrs. Kelso and Co., Commerce Street, Glasgow, have just completed the delicate dynamometric apparatus for measuring the resistance of ships' models at varying speeds corresponding to the required speeds for the full-sized ship. The apparatus is mounted on a carriage, which also supports an ingenious arrangement for measuring the rise and fall of the bow and stern of the model in its progress through the water at different speeds. Electric arrangements are provided for accurately recording on a revolving cylinder the speed at which the model is running. The circumferential travel of this cylinder is a function of the speed of the carriage supporting it, and on it is also recorded the resistance diagram, which is obtained by the extension of a helical spring attached to the dynamometer. The experiment tank at Spezzia is 500ft. in length by about 22ft. in breadth. The use of such a tank and the apparatus already alluded to is to determine the form of ship which shall have the least possible resistance at a certain speed conforming to practical considerations, and to ascertain the relation of power to speed with the form of ship under consideration. The dynamometric apparatus is beautifully made, and the careful finish of its delicate parts reflects credit on the maker, Mr. Kelso, who also constructed a similar apparatus for the experiment tank in connection with the establishment of Messrs. William Denny and Brothers, at Dumbarton, and which has been in operation there for the last six years.

Shipbuilding.—Recently, Messrs. W. Gray and Co. launched from their West Hartlepool shipyard a fine steel steamer, called the Thurston, to the order of Messrs. Murrell and Yeoman, of that port. She takes Lloyd's highest class, and will carry 2,700 tons, her dimensions being 280ft. over all, 37ft. breadth, and 20ft. depth. Her poop contains handsome saloon, stateroom, and captain's and officers' rooms. She has a long raised quarter-deck, long bridge to the fore hatch, and topgallant forecastle, the crew being berthed in the fore end of the bridge and the engineers in the after part. She is on the web-frame principle, with double bottom and all latest improvements, including steam winches and steering gear, Emerson and Walker's patent windlass, &c. She will be fitted with 800 H.P. triple-expansion engines, at Messrs. Gray and Co.'s Central Marine Engine-works, with two steel boilers to work at 150lb. per square inch. She was named by Miss Jennie Murrell. At Stockton, on Tuesday afternoon, the 20th inst., Messrs. Ropner and Son launched a steel screw steamer of the following dimensions: Length, 324ft.; breadth, 40ft. 6in.; and depth moulded, 23ft. 7in. She has been built under special survey to class 100 A1 at Lloyd's, and will carry 4,350 tons cargo of fuel on Lloyd's summer free-board. She has break poop, raised quarter-deck, long bridge extended to foremast, short well and T.G.F., cellular bottom for W.B. She is built on the web-frame principle, and, having very large hatches, is well adapted for carrying heavy cargoes. She will have four steam winches, Meredith's patent multitubular donkey boiler, steam steering gear amidships, Hastie's screw gear aft, Emerson, Walker, and Co.'s patent windlass, &c., and all the latest improvements for a first-class large steamer. Her engines are by Messrs. Blair and Co., Limited, on their improved triple-expansion principle, of 1,200 H.P., with two steel boilers working at 160lb. The steamer has been built to the order of Messrs. R. Ropner and Co., West Hartlepool, and will be a valuable addition to their fleet. She was named the Maltby, by Miss Evelyn Ropner, of Preston Hall, Stockton-on-Tees.

ILLUSTRATED PATENTS.

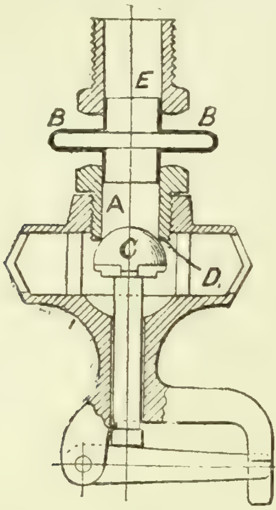
14,987. Governors for Fluid-pressure Engines, W. J. H. Fresen, Oude Malstraat No. 2, The Hague, Netherlands.



Relates to governors of the class in which changes in the velocity of flow of the fluid in the supply pipe are utilised for adjusting the throttle valve. On a vertical spindle 7, passing through a casing traversed by the fluid entering by the branch 2 and passing out at 3 on its way to the engine, is mounted a compound piston 6, 8 by the action of the fluid on which the adjustment of the double-beat equilibrium throttle valve 13, 13 on the same spindle is effected. This piston works in a cylindrical chamber supported by ribs 4 (past each side of which the fluid has free access from the upper to the lower portion of the casing). It consists of two discs, one fixed and the other movable, thrust apart by the action of a spring, but prevented by entirely separating by a pair of slips or bearing pieces (not shown). The latter slide in grooves in the cylindrical chamber, and, the contact surfaces with the movable disc being inclined, are pressed outwards against the walls of the chamber with a force that varies with the difference of pressure on the upper and under ribs of the piston. They thus serve as brakes for the piston and throttle valve when the flow is normal, automatically relieving when the conditions of pressure are such as to require a movement of the valve. A glass inspection tube, lubricator, drain valve, and disconnecting apparatus may be added if required.—November 3, 1887. [11½d.]

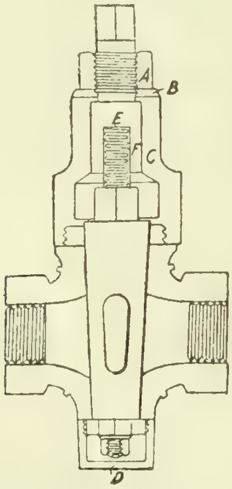
15,049. Fire-extinguishing Sprinklers, W. Mayall, Bottoms Mill, and T. Thomasson, 57, Egmont Street, both in Mossley, Lancashire.

Consists in the application of an anti-concussion ring to sprinklers in general, but more especially to that described in Specification No. 1,372 A.D. 1887. In the illustration B, B is the expansion ring, which is brazed at top and bottom to screwed sockets or nozzles A and E. D is the valve seat (preferably of soft metal alloy) for the valve C.—November 4, 1887. [6½d.]

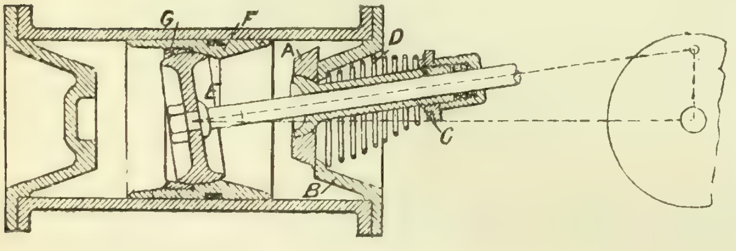


15,091. Steam Tap, J. Eccles, 14, Adelaide Street, Blackburn, Lancashire.

This invention consists of a plug cock, the ends of the plug being covered by steam-tight screw caps C and D. The lower cap D contains the nut by which the plug is tightened. The upper cap C contains a key E fitting on the square head of the plug, and has a spiral spring F, which forces the key against the inner surface of the cap, thus making a steam-tight joint. The part of the key which protudes through the cap receives a nut A and a washer B.—November 5, 1887. [6½d.]



15,233. Sliding Cover Engines, H. H. Lake, Southampton Buildings, London. (S. E. Jarvis, Lansing, Michigan, U.S.A.)



The sliding portion A of the cover works on a facing on the inwardly projecting conoidal portion B of the fixed part. The sleeve C, on which the stuffing-box is formed, fits with a cup and ball joint in the slide A, and both the sleeve and the slide are held in place by the spring D. The ball and socket joint between the piston and its rod is constructed so that the ball portion E forms the whole or a great portion of the central diaphragm of the piston. The remainder of the piston is merely a deep ring F, in which one half of the socket is formed, the other half consisting of a screwed ring G. This construction of piston enables all clearance to be taken up by suitably forming the cylinder covers as shown, while friction is reduced by the pressure of steam tending to lift the central portion in its inclined positions.—November 8, 1887. [8½d.]

Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

March 11th.

4208 Dynamo Machines, H. T. Harris and A. Gay, London.
4217 Thrashing Machines, J. Richardson and S. Quipp, Lincoln.
4219 Sewing Machines, W. E. Hickling, Leicester.
4225 Valves, D. Irving, Manchester.
4227 Gas Governor, R. Dempster and J. Dempster, Manchester.
4229 Furnace, &c., E. R. Joicey, Gateshead
4232 Shuttles, E. Duerden and J. Cheetham, London.*
4237 Motors, W. Schmidt, Berlin.
4243 Torpedo Boats, L. C. F. Coelho, London. (Ribeiro da Costa, Brazil.)
4244 Grinding Mills, O. Polysius, London.
4245 Excavating Earth, E. Schrabetz, London.
4249 Slide Valves, H. Tipping, London.
4250 Electric Lamps, J. E. Spagnoletti and J. Crookes, London.
4255 Sleepers, W. G. Bagnall, Middlesex.*
4262 Cotton-seed Cleaners, C. Baumgarten, London.
4267 Water Wheels, J. F. Evans, London.*

March 12th.

4269 Ball Valve, R. C. F. Wyatt, London.
4276 Engine Packings, J. Moseley, Manchester.
4279 Steam Generators, C. L. Seabury, London.
4284 Torpedo Boats, R. J. Gatling, London.
4296 Galvanic Batteries, J. Kynoch, London.
4302 Hot-air Engines, W. H. Phillips, Birmingham.
4317 Looms, F. Hebden, London.*
4319 Lamps, S. A. Johnson, London.*
4339 Furnaces, M. Boecker, London.
4340 Condensing Steam, D. Halpin and P. W. Willans, London.
4342 Screw Propellers, A. Marque, London.
4343 Feed Gauges, L. Conant, London.*
4351 Traction Mechanism, H. L. Vanzile, London.*
4354 Calcining Furnaces, E. B. Parnell, Middlesex.

March 13th.

4357 Pumping Air, M. C. Bannister, Liverpool.
4358 Projectiles, T. Archer, jun., Newcastle-on-Tyne.
4375 Sight-feed Lubricators, W. James, Chester, and F. R. Putz, Manchester.
4389 Lock Nuts, T. W. Lench and H. Lench, Birmingham.
4395 Ventilator, Busso Von Busse, London.*
4400 Draught-regulating Dampers, A. V. Bay, London.*
4407 Code Signalling, H. E. M. D. C. Upton, London.
4409 Paper-cutting Machines, L. U. Gill, London.

March 14th.

4423 Gas Stoves, T. Batty, Colchester.
4429 Railway Signals, D. B. Adams, Edinburgh.
4437 Screws, William de Courcy Prideaux, Bristol.
4439 Water Gas, F. W. Harbord, Bilston.
4445 Valves, T. Hunt, Manchester.
4446 Pumps, R. G. Briggs, Leicester.
4449 Water Heater, D. H. Saul, London.
4454 Steam Injectors, J. Fraser, London.
4455 Driving Bands, A. J. Boult, Middlesex. (O. Schmidt, Germany.)
4471 Drilling Rock, E. Salendre, London.
4474 Breaking Coke, C. W. Tanner, Westminster *
4498 Projectiles, H. A. Schlund, London.
4501 Ventilators, R. Harnett, London.
4502 Screw Propellers, R. Harnett, London.

March 15th.

4515 Gauge Tubes, J. Dewrance and G. H. Wall, London.
4519 Electric Cranes, W. Hartnell, Leeds.
4531 Steam Boilers, N. B. Clark and F. B. King, London.*
4542 Mechanical Stokers, W. Simpson, London.
4557 Multiple Piston Pumps, B. Leroux and G. Leroux, London.
4559 Voltaic Batteries, D. G. Fitzgerald, London.
4570 Steam Engines, C. Capeyron, London.
4572 Marine Torpedoes, N. J. Halpine, London.*

March 16th

4582 Tool for Boring, W. Beasley, Staffordshire.
4583 Boring Bar, A. May, Kent.
4584 Lubricators, R. W. Anderson, Liverpool.
4591 Steam Boiler, H. Walker, Birmingham.
4609 Rotary Pump, C. Körte, London.
4613 Winding Frames, W. Knowles, London.
4623 Metal Reflector, J. Farquharson, London
4641 Gas Furnaces, F. Siemens, London.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE
PRACTICAL ENGINEER,
APRIL 5TH, 1889.

THE SOCIETY OF ARTS ENGINE TESTS.

THE interesting report upon the Society of Arts trials, now appearing in our columns, supplies information of a kind much required by engineers, whether practical or theoretical. A supplementary paper, by Prof. Kennedy, dealing with the various points in an accurate, yet popular manner, has also been read and discussed, so that we are now in possession of a considerable mass of accurately determined data, whereby we may compare the relative efficiencies of various kinds of motors, and inform ourselves of the sources of loss still requiring attention. We reserve for a further occasion the detail discussion of some of the results, but here we shall consider briefly the leading points adduced; and now we may say that no new facts have been discovered which were unknown to experts in engine matters before, but valuable information has been given in an authoritative manner to statements of which otherwise the general public would be somewhat slow of belief.

The method of accounting introduced by Hirn has been used with excellent effect, and the disposition of the heat given to each engine has been traced in the most careful manner. It is plain that if the heat evolved by the combustion of various kinds of fuel be known, and also the amount used in any engine for the production of a given amount of power, then the proportion of that heat which is converted into work can be calculated, and the difference between that amount and the total heat given is used in some other way than work, or is rejected. The careful measurement of the disposition of this difference, and the amount disappearing from various causes, is most necessary, in order to discover possible sources of saving. Thus, suppose 100 heat units are given to an engine in the form of fuel, a complete account of this total requires the exact measurement, first, of the fuel actually burned, then the indicated power of the engine; and, further, the amounts of the various losses, such as hot gases passing up a boiler chimney, radiation from boiler and from cylinder, heat carried away in exhaust, and so on. Those numerous items, if correctly determined, should exactly amount to 100. As in all measurements, including chemical analyses, it is very unusual to be able to account for everything. Errors may act in both ways to cause a deficit in the account, or to cause an overbalance—generally the former. In all measurements it is most desirable that quantities should be measured directly, not by difference; when difference steps in, doubt also follows.

Four engines were tested, one a compound steam engine, and three gas engines. Careful experiments were made to find the efficiency of the steam boiler, from which an admirable result was obtained. The heat account of the boiler was as follows:—

Heat given by combustion	100	Heat expended in heating and evaporating water..	82·00
Error due to over estimating expenditure......	1·6	Heat expended in raising temperature of furnace gases	10·50
		Heat lost by radiation	9·0
		Heat expended on evaporating moisture in coal..	0·1
	101·6		101·6

The whole measurements were positive, and a slight error occurred in determining some of the quantities which caused a united error of 1·6 per cent, but that error cannot appreciably disturb the ratios of the items. For a small boiler of the kind used at the trials, 82 per cent efficiency is most excellent practice. The determination of all the expenditures in the engine was impossible, because the exhaust steam was discharged up the chimney to create a draught; but, indicating 21·55 horse power, 12 per cent of all the heat present in the steam supplied was converted into indicated work, and the united efficiency of engine and boiler combined amounted to 9·6 per cent. The fuel used was 1·891b. per I.H.P. per hour. Considering the fact that no condenser was used, this is a most exceptionally excellent result, and the details of indicator diagrams and proportions of the cylinders are worthy of careful study. We propose at a future time to discuss those details very completely.

It has been known for some years now that the proportion of heat which a good gas engine can convert into work is greater than that of the very best steam engines; that is, the efficiency of a good gas engine, from a heat engine point of view, is greater than that of the best steam engines. This, we believe, was first pointed out by Mr. F. W. Crossley in a paper read before the Institution of Mechanical Engineers in 1874, referring to the Otto and Langen engine. Sir Frederick Bramwell mentioned it, we believe, as a characteristic of the Otto compression engine, and later the point was calculated from his own tests by Clerk, in a paper read before the Institution of Civil Engineers in 1882, and very fully discussed by many of our leading engineers, including the late Sir C. W. Siemens, Baron Armstrong, and Sir William Thomson. Professor Kennedy joined in that discussion, and then took a view of the methods of calculating efficiency which we observe he has now modified.

Professor Thurston, of New York, a little later made an admirable series of measurements upon an Otto engine, proving the same fact. The general body of engineers seemed, however, to pay little attention to it, and this trial now puts it authoritatively beyond doubt. In the gas engines the absolute indicated efficiency ranged from 19 per cent in the Griffin to 23 per cent in the Atkinson; that is, the Atkinson engine converted 23 per cent of all the heat it obtained into indicated work, a result nearly double that of the steam engine. This is a matter engineers should never forget. With all its imperfections from a mechanical point of view, the gas engine is vastly superior to the steam engine as a heat engine or machine for converting heat into work. If fuel in the form of gas could be made as cheaply as steam, or if a gas producer could be constructed giving the same efficiency in the production of gas as a steam boiler does in steam, then a gas engine of existing construction would, in an engine of only 6 horse power, use only two-thirds of a pound of coal per indicated horse power per hour.

Now, it may be said that although the indicated efficiency was good, what about the brake or ultimate efficiency. It has been for some time supposed that the friction of gas engines is greater proportionately than that of steam engines in a considerable degree, but those trials prove that the difference is but slight.

The mechanical efficiency of the Paxman steam engine was 88 per cent, the Otto gas engine 86 per cent, Atkinson gas engine 85 per cent, Griffin gas engine 82 per cent. The friction of the Otto engine was only 2 per cent more than that of the steam engine, or the friction was 14 against 12 per cent.

Considering the fact that the steam engine was the most powerful, we think that with engines of equal power the absence of stuffing boxes and glands to pack quite compensates for the larger cylinder and heavier crank and connections. The friction of gas and steam engines is nearly equal.

This being so, it follows that the relative indicated efficiencies fairly measure the relative actual efficiencies of steam and gas engines, and in the course of time, when the mechanical difficulties of gas engines are overcome, and regular running ensured in large as well as small powers, it seems exceedingly probable that gas will largely displace steam power.

It is to be regretted that the judges in these trials did not succeed in measuring positively the air used by the engines as well as the gas. Professor Thurston, in experiments conducted in America, made this measurement with considerable accuracy, and discovered that the proportions of gas and air used were very different from those commonly supposed. This determination would have supplied a valuable check upon the temperature values, especially the initial temperature before compression, which formed the basis for all the other calculations. The assumption made on this point was probably very nearly correct, but it would have been better had it been actually determined by measurement.

In the discussion which followed Professor Kennedy's paper, Sir Frederick Bramwell spoke in his well-known style, and referred to the advance of engineering opinion as to the value of such trials. Mr. W. H. Preece theorised upon the causes of loss by the water-jacket, and seemed to consider radiation from the white-hot gases as one point which might be improved upon. It seems to us that Clerk's experiments upon gaseous explosions, in which it was shown that hydrogen mixture gave a comparatively poor effect, disprove this point. Mr. Davy, Mr. Atkinson, and Mr. Dowson joined in the discussion, but on the whole nothing new was enunciated.

The brakes used throughout the trials acted admirably, and consisted of ropes working upon dry flywheels. Such brakes, we know from our own experience, work exceedingly well in occasional testing, and are extremely steady, but not more steady than the brake we described in a recent issue. The rope brake is not so well adapted for daily use in the engineering workshop, nor so well suited for long runs, as the strap brake.

Professor Kennedy replied on the discussion, and stated that particulars of the Davy-Paxman boiler, which gave the extraordinary efficiency we have mentioned, will be forthcoming at an early date. We shall await these details with interest, and shall reserve for discussion in a future issue the details both of engine and boiler.

THE DEVELOPMENT OF CHINA.

THE *Newcastle Daily Chronicle* publishes an interesting article on Western engineering in China. The author of it is Mr. James Stevens, mining engineer, Durham, whose long connection with the principal engineering company in the Flowery Land enables him to write with authority on the subject. There is much that is interesting in the article about the mines of that wonderful country—about its railways, its docks, its steamships, its telegraphs, and other matters. Just now China is attracting more notice than ever was given to it before. The newspapers have recently contained a great deal about the sufferings of the Chinese peasants in the famine-stricken districts, and this has, to some extent, directed popular attention to the country. But, apart from this, men of business whose thoughts are ever running on the opening out of new fields for trade and commerce, are turning longing eyes to the East. China proper has an area of 1,298,000 square miles, and a population of 383,000,000, leaving out of reckoning her dependencies of Manchuria, Mongolia, Tibet, Jungaria, and Eastern Turkestan. Take these in, and the area runs up, roughly, to 4,000,000 square miles, and the population to 400,000,000 of people. The natural wealth of this vast country is enormous. Coal, it is said, is found in every province of China, and other minerals are plentiful. But all this is lost to the outer world, whose only communication, practically, with China is in the way of business done at the Treaty Ports. The interior is almost a closed book, and foreigners know nothing of it except what they have learned from chance travellers. Chinese history goes back by tradition to the very remotest antiquity. There were scientists and engineers in the land even when our own country was overrun by woad-stained barbarians. The principle of the mariner's compass is said to have been invented by a Chinaman. The Great Wall and the Grand Canal witness to the engineering skill of the Chinese. Suspension bridges are said to have existed in China before they were known to Western science; and the very drills that are used to-day for boring the brine wells of South Durham are American improvements upon implements that were used in China long ago. But there has been no progress in the land, and the younger nations of the West have outstripped the older one in the race of civilisation. A new era has now, however, begun. The Chinese authorities, having adopted the telegraph with alacrity, and having seen the benefits of mines, docks, &c., worked after the European fashion, have at length overcome their prejudice against railways.

The only railway at present is that connected with the Kaiping coal mines, to which Mr. Stevens was attached. But rapid extension may now be relied upon, and it is from this that the future development of the country may be expected. There has been much speculation as to the best way of getting into the interior. From the east, of course, the road lies through the Treaty Ports, where already the trade with other countries is very considerable. At the other end, the entrance will doubtless be from the southwest. The railway for which Mr. Colquhoun and Mr. Holt S. Hallett prospected some time ago is proposed to run into China through Burmah. It will begin at Bangkok, on the Gulf of Siam, and going northwards, be joined at Raheng by a branch line from Moulmein. Then it will proceed to Lapoon and Kiang Tung, in the Burmese Shan States; cross the Chinese frontier at Sumao, pass through Yunnan-fu, and meet the Yang-tse river at Chung-king, in the province of Si-Chuan. This river, one of the noblest in the world, will afford a splendid waterway to Shanghai, the chief port on the coast. There is now no noubt as to the navigation of the Upper Yang-tse. It was an open question at the end of the year 1887, when Mr. Archibald Little, by permission of the Government, ascended in a special steamer as far as Chung-king, the terminus of the projected Colquhoun-Hallett railway, which it is contended would throw open to British commerce the whole of Burmah, as well as the western and central provinces of China. The French propose to initiate a line of railway at Tonquin, in the south eastern portion of the empire. Once begun, railways will probably soon make a network in China, as they have done in other lands, and the development that has already begun may be expected to extend almost beyond the limit of imagination. Lieut. Mills, who lectured in Newcastle a week or two ago, looked upon China as the empire of the future, and drew a picture of a deserted and ruined village on the banks of a stream called the Tyne, with China exporting coal to every nation of the earth. This, doubtless, was too gloomy a view to take. Western progress in China has already been of some benefit to Newcastle. We have built for the Chinese engines of war and engines of peace—battle-ships, guns, and locomotives. It is only reasonable to suppose that a further opening out of the country will result in more benefits of these and other kinds.

ELECTRICAL TREATMENT OF SEWAGE.

Mr. William Webster, who has for some years devoted his attention to the question of sewage purification by electrolysis, last week invited a number of persons interested in the subject to inspect the experimental works which he has erected, by permission of the Metropolitan Board of Works, at the southern outfall at Crossness. Mr. Webster's process is intended to take the place of the purification of sewage by chemicals, a mode of treatment which to be effective involves three processes—precipitation, oxidisation, and disinfection—and which is attended by the further disadvantage that, if too many chemicals are used, fermentation in the river may take place.

The principle of the electrolytic system is that the compounds always present in sewage are split up into their constituent parts by the electric current passed through iron electrodes. At the positive plate chlorine and oxygen are set free and combine, with the water and the iron plate, to form acids which act powerfully on the organic matter. A flocculent precipitate of the impurities in suspension and in solution is formed, which, after being first carried to the surface by the hydrogen generated, gradually settles to the bottom, leaving a perfectly innocuous effluent. The effluent can, indeed, if sufficient electric power be used, be converted into an absolute disinfectant.

The plant which Mr. Webster has set up at his own expense for the purpose of his experiments consists of an engine 20 H.P. nominal and a dynamo capable of developing 43 H.P., together with a wooden shoot and a couple of precipitating tanks fitted with iron electrodes. The sewage is pumped by the engine (which also drives the dynamo) into the shoot, and in travelling along the shoot every particle of the sewage is brought into direct contact with the plates, or electrodes. The fluid passes from the shoot to the tanks, where the precipitate of suspended matter, or "sludge" as it is termed, settles at the bottom in about two hours, the effluent being afterwards drained off. The electrodes are made of cast iron, and those in the shoot are divided into twelve sections, which can be connected either in series or in parallel, the plates themselves being connected in parallel.

When once the necessary plant, which can be adapted to any existing tanks, has been set up, the only outlay involved by the process, beyond the ordinary working expenses, is in the renewal of the positive electrodes, for these are acted upon by the acids formed. It is calculated that to treat a flow of ten million gallons of sewage a day, the consumption of iron should not exceed 470 tons per annum; while the mechanical power required would be eight horse power per 300,000 gallons. These calculations are based upon the treatment of London sewage, which is often diluted with rain-water. But in cases where the sewage is stronger the power employed need not be so great, because the chlorides which form the precipitating agency would be present in greater proportion to the volume.

It is estimated that the working cost of the electrolytic process, when applied to a large volume of sewage, would be about 13s. per million gallons, and that the whole sewage of London might be treated for about £36,000 a year. Taking into account depreciation of plant, interest on capital, &c., the amount would probably be within £50,000. The cost of treating sewage by chemicals has been stated at from 30s. to 70s. per million gallons. It is, in fine, claimed for the electrolytic process that it is not only cheaper than the chemical process, but is more efficient, by setting at work a precipitating and a disinfecting action in one operation.

At the demonstration last week Mr. Webster's process was in full working order; but as a considerable time is required to appreciate the results when the work is carried on at the scale of 12,000 gallons per hour, the efficiency of the method was illustrated very successfully by a number of laboratory experiments with fresh London sewage of different qualities.

VACUUM-CONDENSER.

The question of vacuum was a much more important one in the early days of steam power than it is now. Then the steam engines of the time depended almost entirely upon the production of a vacuum for their power; the Newcomen engines did depend entirely upon the vacuum, and Watt's engines for many years worked with a pressure of a few pounds above the atmosphere. A good vacuum in condensing engines is, however, still a very important point, and in this article we intend to explain, as simply and clearly as possible, the physical facts and phenomena upon which engineers depend, whether knowing it or not, for the production of a vacuum in engines. It is not quite accurate to say that power is obtained from a vacuum, but the term is so continually used that it would be highly inconvenient to dispense with it, and, provided that we understand thoroughly what we mean when we use it, no harm can follow.

The fact that the air surrounding us presses upon everything with a very considerable intensity per square inch has now been known for hundreds of years, and since the invention of the barometer by the Italian, Torricelli, the amount of this pressure has been pretty accurately understood. He found that if by some means the air was very completely taken or pumped out of a closed space, then the pressure caused by the outside atmosphere forcing its way into that empty space, or vacuum, was able to support a column of mercury contained in a glass tube equal to about 30in. high. The simplest way of testing this practically is to procure a glass tube of say 40in. long; fill it carefully with mercury, taking care that no air bubbles lodge in its length, and then place the finger upon the mouth of the tube and invert it. Place the open end, still keeping the finger upon it, into a small dish containing mercury, and on withdrawing the finger it will be found that the mercury falls from the top of the tube, and settles at about 30in. from the surface of mercury in the dish. This tube filled with mercury, and standing in it, is, in fact, a barometer, and its height is the measure of the difference between the pressure of the outside air and the pressure or lack of it in the space above at the top of the tube.

It will be found that, however long be the tube filled with mercury and inverted in this way, it will always settle at about 30in. from the upper to the lower surface. If a bubble of air be allowed to pass up the tube to the upper space, the mercury will fall a little; or if a stopcock at the top end of the tube be opened, then air will rush in with a sharp hiss, and the mercury will fall. The admission of air has vitiated or spoiled the vacuum is the expression which would be very commonly used, but it really means that the pressure above has been increased, and, therefore, the difference of pressure between the closed space and the outer is less than it was. The vacuum or difference of pressure between the exterior air and the interior is expressed by the number of inches of mercury which stands above the lower level. If the height was 28in., then the vacuum would be said to be 28in.; if 25in., then the vacuum was 25in. Such mercury columns were first used to measure the vacuum in condensers, and they are still used, though principally for checking the correctness of vacuum and pressure gauges.

There are other very simple means of showing that the air surrounding us has pressure. The following is one which all can try, which may interest our younger readers. Take a common glass tumbler and a fairly sized basin; fill the basin with water, put the glass into it, fill it, keep the mouth under water, and then withdraw the glass, bottom upwards, the water will remain in it, and will follow the bottom of the glass even if it were over 30ft. long. If while the glass is filled with water a sheet of stiff paper, such as notepaper, is laid across it, and held there while the glass is inverted, the hand may be withdrawn and yet the water will not run out. The pressure of the air will keep the paper upon the mouth of the glass, and prevent the weight of water from forcing it off. The illustration may help our younger engineering readers to clearly understand that the air surrounding us has pressure. If the pressure of the atmosphere were measured by the height of a column of water, it would require generally over 32ft. instead of 30in., as with mercury. Mercury is much more convenient, as it is so much heavier than water.

In the old Newcomen pumping engine, which was at work in Britain in considerable numbers before the time of James Watt, steam was used only to produce a vacuum, and the work of moving the piston was directly accomplished by the actual pressure of the atmosphere. Smeaton, the famous builder of the Eddystone lighthouse, was also a mechanical engineer, and in the year 1767 he examined at work, in the neighbourhood of Newcastle, no fewer than 57 of these engines, giving together about 1,200 H.P. The best of those engines had a steam cylinder of 42in. diameter, and the work performed by it was done at a consumption of 23lb. per H.P. per hour, and its total power was only 16·7 horse. It consisted of an open-ended cylinder, with a single-acting piston coupled to mine pumps by a beam placed above it; the weight of the pump rods pulled up the piston, and steam was admitted under it from a boiler at a pressure about that of the atmosphere. When the top of the stroke was reached the steam supply was cut off, and a jet of water thrown into the cylinder to condense the steam and produce a vacuum; the pressure of the air on the top of the piston then forced it down to the bottom of its stroke, and lifted the pump rods again. The vacuum in this cylinder was only equal to about 18·9in., or 9¼lb. per square inch; that is, the difference of pressure between the external air and the pressure within the cylinder under the piston was only 9¼lb. This is the correct meaning of vacuum.

It is very convenient to remember when dealing with questions of vacuum, where it is desirable to be able rapidly to convert the readings of the gauge in inches into pounds per square inch, or the converse, that, roughly, if you know the vacuum in inches, the number of lbs. per square inch equal to it is about one-half. For instance, 30in. vacuum—which, of course, can never be obtained in ordinary engine practice—is equivalent to 15lb. per square inch nearly. It may be taken as a rule nearly correct. Divide the number of inches vacuum by two, to get its corresponding pounds per square inch; and on the other hand multiply pounds per square inch by two, to get the corresponding inches of vacuum. This is not quite correct, as 30in. of mercury is equal to only 14·7lb. per square inch nearly, and the more accurate rule is as follows: To get pounds per square inch from inches of vacuum, multiply inches of vacuum by 0·49; to get inches vacuum from pounds per square inch, multiply pounds per square inch by 2·04. Thus, a vacuum 25in. is 25 × 0·49 = 12·05 pounds per square inch, and 12·05lb. per square inch is 12·05 × 2·04 = 24·99, practically 25in.

The Newcomen engine was exceedingly wasteful, and the losses of steam, and therefore fuel, were very considerable. James Watt, as early as the year 1760, clearly saw the causes of a great part of this loss, and he invented, as a means of overcoming it, the separate condenser. All engines previous to his condensed by jet within the cylinder itself, and he was the first to perceive what to all of us seems very simple now, the advantage to be derived from separating the steam cylinder and condenser.

Before discussing the separate condenser, it will be advisable to revise briefly the nature of steam and those properties or qualities inherent in water which bear upon the matter, or qualify in any way the perfection of vacuum attainable within a cylinder. The amount of heat required to raise water from the liquid water into steam is very considerable, and is most easily remembered in the following way: Suppose one pound weight of pure water to be placed at the bottom of a vertical open-ended cylinder, which has a light piston resting upon the water practically without weight, fitting closely in the cylinder, but moving without friction, and suppose the piston to have an area of 144 square inches. The pound weight of water will measure at 32 deg. Fahr., the freezing point, about 27·7 cubic inches. Suppose, now, that heat is applied to raise the temperature to 212 deg. Fahr., the boiling point, the amount of heat used by the water to produce this increase may be called 212 − 32 = 180 heat units,[*] as the heat required to increase its temperature one degree within that range is very nearly the same for any degree chosen. Any further heat now added causes the water to become steam, and at the ordinary pressure of the atmosphere, 14·7lb. per square inch, the temperature remains quite constant till all is boiled away and has lifted the light piston against the outside air pressure. The heat required to convert the whole pound of water into steam at that pressure, if no heat be wasted in any other way, is 966 heat units, or 5·36 times as much as is required to raise the same weight from the freezing to the boiling point, and the volume of steam produced is 1,642 times that of the original water, or 26·30 cubic feet nearly. That is, an amount of water weighing one pound, and only filling 0·192in., or roughly one-fifth of an inch at the bottom of a cylinder of 144 square inches area, would, if converted into steam at atmospheric pressure, fill

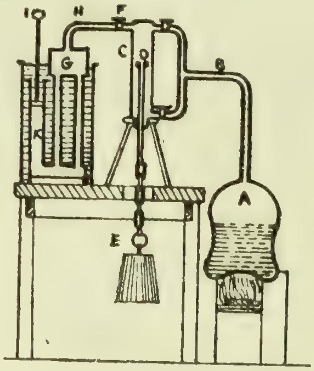

FIG. 1.

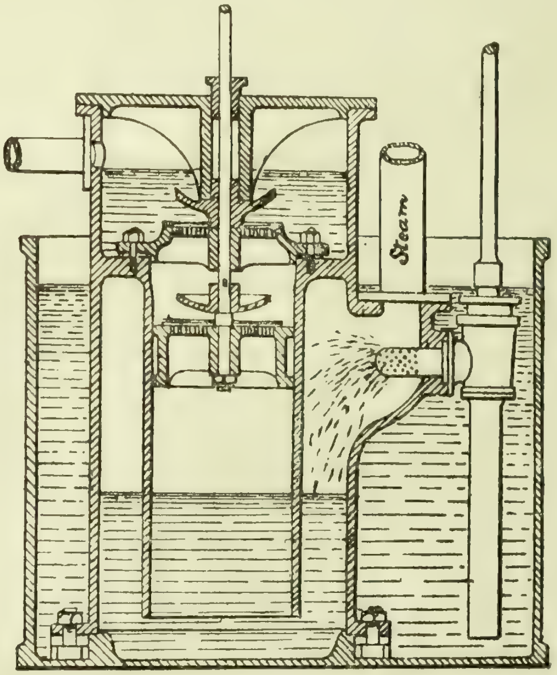

FIG. 2.

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[*] A British heat unit is the amount of heat required to heat one pound weight of water 1 deg. Fahrenheit.

that cylinder entirely if it were 26·30ft. long—that is, it would raise the piston through about 26⅓ft.

If this steam were entirely condensed by water injected in quantity sufficient to entirely cool down the water produced to almost 100 deg. Fah., then a vacuum of about 13·7lb. per square inch would be produced, and that pressure would be available for driving down the piston by the external air. But there are many causes which act together and prevent such a good result being obtained. In the first place, all ordinary feed-water contains a considerable amount of air. This can easily be proved by boiling the feed water in a glass vessel, and condensing the steam by passing through water; air bubbles, however, remain, which do not condense, and when subjected to chemical analysis they are found to consist of nitrogen, oxygen, and carbonic acid gases.

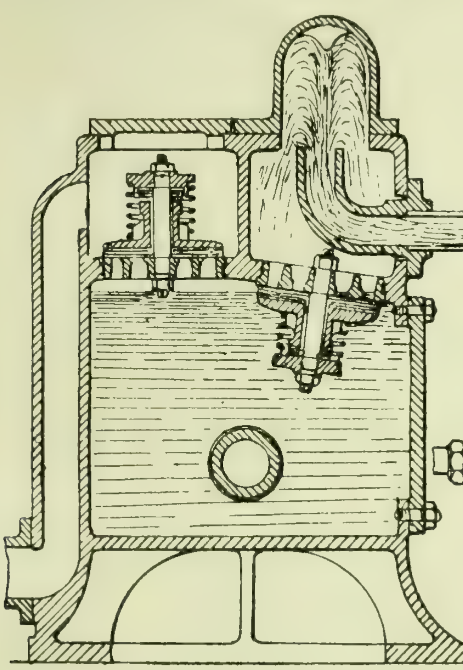


Fig. 3.

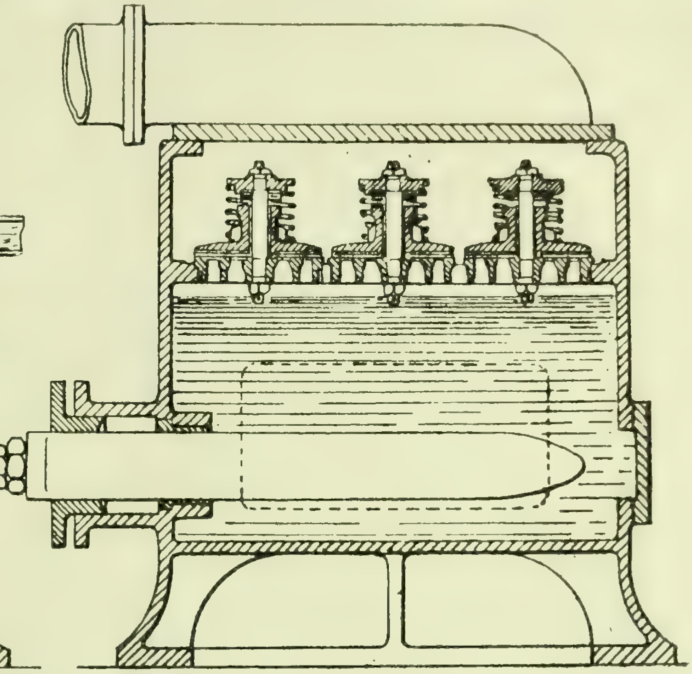


Fig. 4.

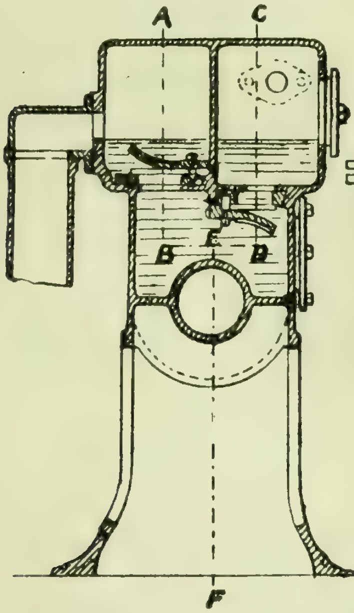


Fig. 5.

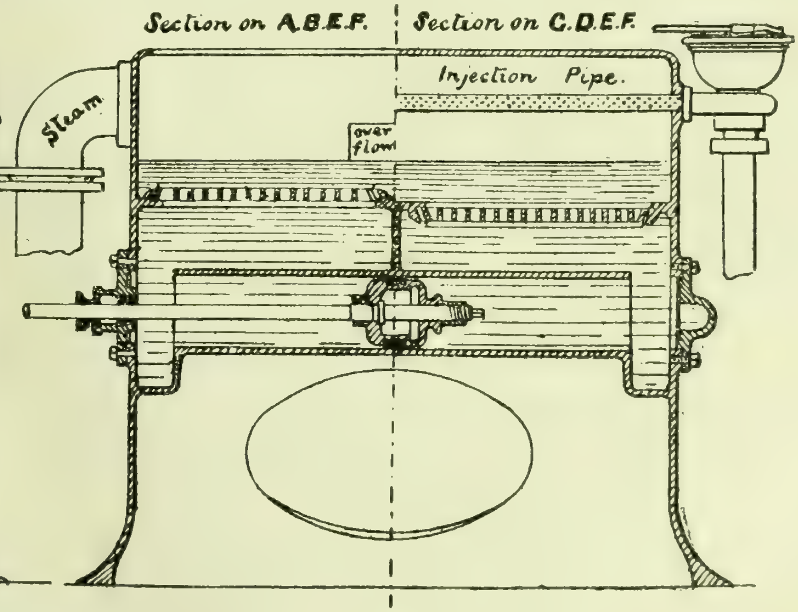


Fig. 6.

In actual engines there are additional sources of air; packings leak to some extent, and air finds its way in small quantities into the vacuum. It is therefore necessary to provide means of removing both air and water from a condenser in a continuous manner, or the vacuum cannot be long kept good. In the Newcomen engines the steam piston itself acted as air pump, and discharged both water and air from the cylinder by a valve placed at the bottom.

With the separate condenser it is necessary to provide an air pump for those functions.

The idea of the separate condenser is now an exceedingly obvious one, but it may be interesting to describe Watt's original experimental apparatus to illustrate its theory. Fig. 1 is a section showing the general arrangement of this apparatus. The steam cylinder was a large brass surgeon's syringe of 1¾in. internal diameter and 10in. long. At each end was a pipe leading from the boiler A to the cylinder C. A weight E was hung upon the rod by a chain, and the separate condenser consisted of two tin tubes and a chamber G connected with an air pump K. The condenser and connections were placed in a tank of water, as shown. The condenser was therefore of the surface kind. Steam was raised in the boiler A, but allowed to blow off at atmospheric pressure. It was allowed to fill the cylinder C on the upper side of the cylinder D. Then the bottom cock was opened, the upper one to the boiler shut, and the cock F, leading to the condenser by the pipe R, was opened. The steam at once rushed from the cylinder C to the vacuum in G, and was then condensed. An occasional stroke of the pump K disposed of the air and water. Watt found this would act so well that, although the cylinder only had a diameter of 1¾ inches, the vacuum was sufficient to allow a weight of 18lb., hung at E, to be lifted through the entire stroke. By this arrangement the condensing water never touched the cylinder C, which was thereby maintained at a temperature not greatly less than that in the steam boiler.

The mechanical arrangements have been much improved since Watt's time, and steam pressures are daily used which would then be, and were long after deemed, impossible; but the principle of the condenser remains substantially where it then was. Many valuable improvements have been made in detail of the mechanism and valve parts, but Watt's engines acted with as beautiful smoothness as the best of modern engines. We had the pleasure some time ago of inspecting a flour mill beam engine of Boulton and Watt's construction, still hard at work, as it had been for over 100 years, and doing very fairly well.

This improvement reduced the fuel consumption from Newcomen's best figure of 22lb. per horse power per hour, to in many cases less than 7lb. for the same power.

Fig. 2 shows a compact arrangement of air pump, jet condenser, and hot well, as commonly used in the older class of beam engines. The steam enters the condenser from the cylinder by the pipe marked "steam." It meets a spray of water, as shown. This water absorbs the heat of the steam, and restores it to its original liquid state again, becoming heated itself in the process. Enough injection water must be used to keep the temperature down below a certain point, or the pressure of the water vapour will greatly reduce the vacuum. The air, which always finds its way into the closed condenser with the steam from the boiler and with the injector water, is removed by the air pump illustrated. Both air and water pass through the rubber valves shown, and escape into the hot well. Figs. 2 and 3 show a modern form of jet condenser and air pump as arranged for a horizontal engine, moving a speed which may be as high as 200 revolutions per minute. The plunger is single-acting, and is immersed entirely in water. Both supply and discharge valves are of the disc type, and are placed above the plunger. This is an advantageous arrangement, as the plunger is always travelling in solid water, and the air passes down and up through the discharge valves without reaching it at all. It is the condenser used in the Allen high-speed engine.

Figs. 4 and 5 show another good form of horizontal condenser. As in the Allen, the air pump is driven direct from the main piston rod, tandem fashion, but it is a piston, not a plunger. The construction of the valves is neat, and the arrangement of injection effective. The illustration is self-explanatory. In these two condensers the upper part of the casting is divided into two chambers, one of which is the hot well or delivery side; the other receives the steam and condenses it, in the first case by a full-bore discharge of water, which is broken up, as shown, in the exhaust steam admission passage; in the second by an injection rose or series of small holes.

In a future article we propose to go more fully into the matter, and discuss proportions of air pumps to steam cylinders, area of cooling surface, temperature of hot well, and so forth; meantime, we conclude by saying, that although not so important as in times gone by, yet attention to the condenser and its parts is very necessary when the best economy is desired.

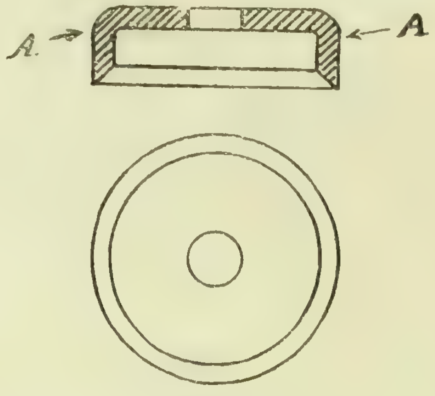
HYDRAULIC MACHINERY EMPLOYED IN THE TRANSMISSION AND CONCENTRATION OF POWER.—V.

LEATHER PACKINGS—*(continued).*

THE most simple self-acting packing for rams, pistons, and plungers, next to the spiral leather packing described in our last, is the cup type of packing, which is constructed in three forms, commonly termed cup, hat, and U packing respectively. The cup packing is illustrated by figs. 18 and 19, and simple tools for and the process of manufacture by figs. 20 and 21.

The cup packing is used as a packing for pistons, for making water-tight joints at the ends of plugs and plungers, and similar purposes, and owes its self-acting tightness to the pressure of the water on the internal surface of the cup, which expands the rim of the cup and forces it against the pump barrel or other surface with which water-tight connection is to be maintained. It might at first sight appear that the whole depth of the cup would be directly useful in forming the joint; or, in other words, that the hydraulic pressure acting on the internal surface of the rim of the cup would press the whole external surface of the rim of the cup against the pump barrel, and that hence the water-tightness of the packing would be enhanced by increasing the depth of the cup rim. This is not, however, found to be the case in practice. The effective portion of the cup is merely a narrow ring of surface near the point where the piston touches the barrel (at A, fig. 18), and the remaining portion of the cup leather is in a great measure superfluous. This fact is evidenced in several ways in a very convincing manner. For instance, the wear takes place almost entirely at A, figs. 18 and 22.

Fig. 22 represents a section through a worn-out packing. The indentation B inside the packing is due to the external wear of the packing at A, as the leather is forced out by the internal pressure from the inside of the cup to supply the portions worn away by external friction. The localisation of the wear is so marked as to lead superficial observers to suppose that the leather has been cut by the pressure of the edge of the piston. The effect is, however, entirely due to fair wear, and is not to be obviated by rounding the edge of the piston or other such expedients occasionally suggested.



Figs. 18 and 19.

Another proof is furnished by the fact that the friction of the cup is independent of the depth of the rim, and is the same practically for a packing 2in. deep as for one an inch or less in depth; whereas, were the water-tightness of the cup due to the pressure on the whole internal surface of the rim, it would be reasonable to suppose that the friction would increase with the depth of the cup.

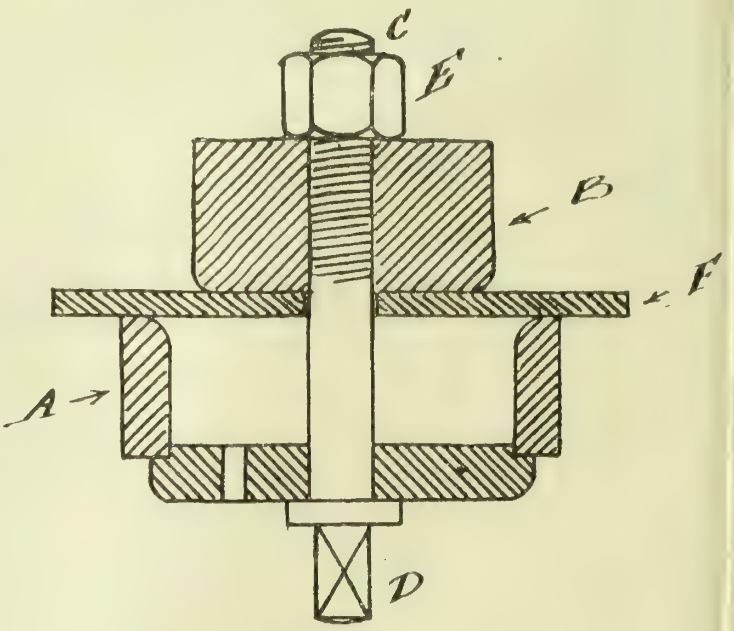


Fig. 20.

The manufacture of a cup leather is a very simple operation. A disc F, of leather (see fig. 20) of suitable diameter, is soaked in warm water until quite pliable. It is then placed centrally on the hollow mould A (figs. 20 and 21), and the plunger B screwed down on it by means of the central screw C (the head D of which may be conveniently held in a vice), and nut E until it is forced into the mould A. When the leather is dry the edge is trimmed off to an angle of 45 deg., either by means of a sharp knife, or, preferably, in a wood chuck in the lathe. If the leather is required without a central hole, external clamps may be used in place of the central screw C to force the plunger B into the mould. If a number of leathers are to be manufactured a small hydraulic press, of about ten tons power, will be found very convenient, as also a sheet-iron oven heated by steam for drying the packings. The latter, however, requires great care in use, as, if overheated in drying, the leathers rapidly fail in ordinary work. It is poor economy to use inferior material for hydraulic leathers. Sound oak-tanned leather should be selected, cut from the best part of the butt. If the packings are not subject to much wear india-rubber cups may, however, be used with advantage in all cases where packings are liable to become dry through being used only occasionally.

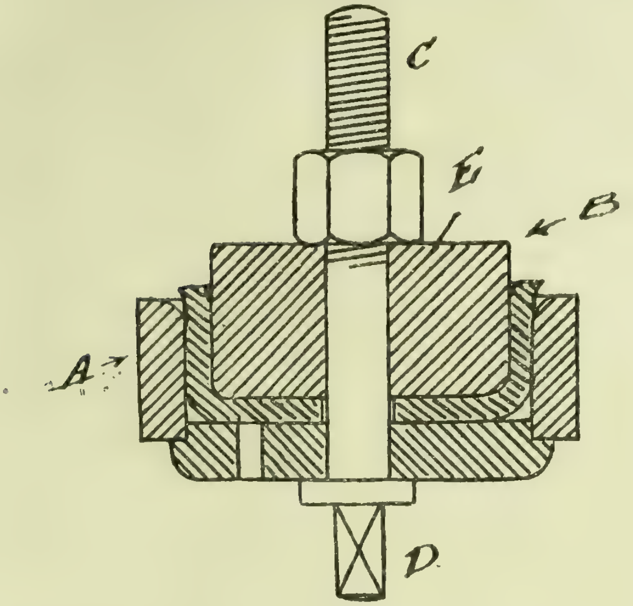


Fig. 21.

It has been remarked above that the depth of a cup-packing has but little influence on its water-tightness. We may further add that it is really prejudicial to the efficiency and durability of the packing to make the rim of the leather unduly deep, for the simple reason that the stress on the leather during its manufacture is greatly increased by increasing the depth of the cup. This stress is greatest also at the very part of the leather which is subject to the greatest wear in actual work, viz., at A (figs. 18 and 22). If the cup be deep and very great care be not taken in the manufacture, the leather is liable to tear at this point, or, if not actually torn, to suffer great deterioration, which, although it may be disguised and concealed by subsequent dexterous manipulation, never fails to show itself afterwards in an abnormally short life of the leather. There is no advantage whatever in making the cup more than 1in. deep, and any greater depth than this is not merely useless, but, for the reason here pointed out, really undesirable as leading to injury to the packing at the very part at which the greatest soundness is required.

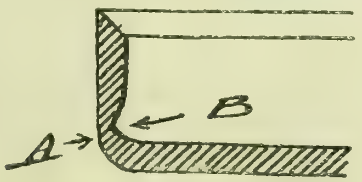
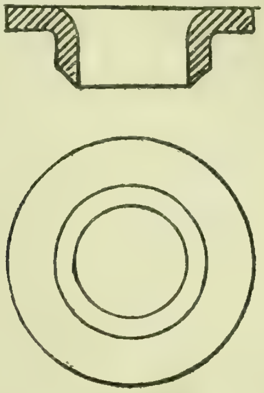
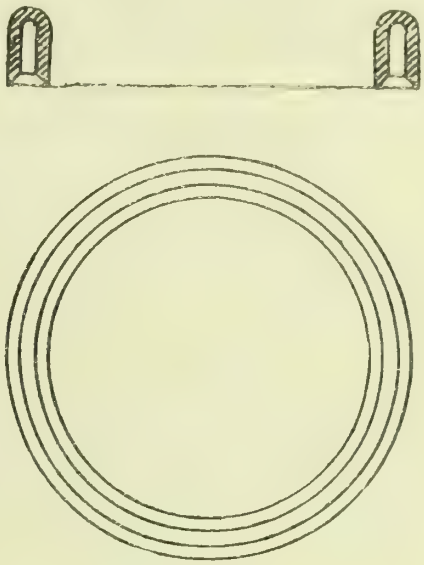


Fig. 22.


Figs. 23 and 24.

The barrel in which the cup leather works should, if possible, be lined with gun-metal or brass. For medium and high pressures it should invariably be so lined. The attempt to use leather packings under high pressures for pistons working in cast-iron barrels, unlined, always results in great annoyance and frequent delays from the rapid deterioration of the box of the cylinder and consequent constant failure of the packings, which are only durable when they have an absolutely smooth surface unaffected by corrosion to work against. In the case of thick cast-iron cylinders working at high pressures, owing, apparently, to the comparative porosity or looseness of texture of the interior surface of the casting forming the bore, which has already been commented on, the friction of the leathers appears at times to tear away considerable portions of the internal surface, leaving rough places which destroy the packings after a few passages over them. Steel castings are not free from this defect, and suffer occasionally even more than cast iron. These remarks do not, however, apply so strongly to cast-iron rams, the external surface of which is generally very close in texture and capable of receiving a high polish, and can also be readily kept in good condition as regards polish and lubrication. Even in the case of rams, however, it has been found highly conducive to the durability of the leathers to case the lower part of the rams of hydraulic presses, for instance, with gun-metal. The rams of hydraulic presses for baling Manchester goods, and for cotton pressing, are invariably so cased by first-class makers.


Figs. 25 and 26.

The laws governing the friction of cup and similar leathers were investigated carefully by Mr. Hick, of Bolton, and found to be in the main very simple. The writer's own experience fully endorses Mr. Hick's results, which may be stated in the following form :—

Let P be the total load on a ram or piston, and D its diameter in inches. The whole friction of the packing of the ram or piston is—

$$f = \frac{4\,P}{100\,D} = \cdot04\,\frac{P}{D},$$

the leather packing being in the condition as regards lubrication usually met with in practice, and the ram and cylinder in first-class condition as regards polish and soundness of surface. For instance, let the ram of a press be 10in diameter and the load be 100 tons, corresponding to an hydraulic pressure of 1·27 tons per square inch, then the friction of the packing will be—

$$f = \frac{4 \times 100}{100 \times 10} = \cdot4 \text{ tons} = 8 \text{ cwt.};$$

or $\frac{4}{10}$lb. per cent of the whole load. The friction in this case is a very inconsiderable amount compared with the total load, but if the packing be small in diameter the percentage of the whole pressure absorbed by friction becomes very appreciable, and must be taken carefully into account when designing apparatus involving the use of pistons or plungers packed with leather for determining the intensity of hydraulic pressures.

For instance, if the packing be $\frac{1}{4}$in. in diameter, the percentage of the whole load absorbed by the friction of the packing will be

$$4 \div \tfrac{1}{4} = 16 \text{ per cent,}$$

which is a very notable amount. We shall recur to the subject of apparatus used in determining the intensity of hydraulic pressures subsequently.

It will be observed that the above remarks as to the friction and wear and tear of leather packings apply equally to all leather packings of the cup type, and not merely to cups, but also to hat and U packings.

The action of the hat packing (figs. 23 and 24) and U packing (figs. 25 and 26) is, indeed, identical with that of the cup packing proper. The point of greatest wear and the method of calculating the friction are the same for all three kinds of packing. The tools used in and mode of manufacture are, however, different, and will be fully considered and described in our next article.

THE TRANSMISSION OF POWER BY ELECTRICITY.

By Frank J. Sprague.*

The transmission of power by electricity is now an established fact, and every day, for the ordinary uses of life, its application is rapidly spreading. The principles of its application are well settled. The dynamo and motor have been brought to a remarkably high efficiency, and leave little to be desired as converters of energy. The future of the transmission of power from central stations, under ordinary conditions, is a matter of commercial development. The special application of the transmission of energy over long distances depends chiefly upon the demand which exists for such transmission and the intelligent application of principles already well known. Distance is a relative term. It does not seem a difficult matter to transmit five horse power ten miles, but a gigantic problem to transmit 1,000 horse power one mile ; the latter appeals to our imagination, and yet the former is, in one sense, the more difficult problem, not so much because of any difference in the general principles involved, as in the fact that in the construction of machines of high electro-motive force we meet with more serious difficulties in the matter of insulation and the element of personal danger to the operator.

It is not my intention to enter into any general discussion of the question, nor to go into the particulars of dynamo and motor construction, for the limits of this paper would not permit this ; but I shall briefly point out the different phases which the transmission of power by electricity may assume, show some of the general conditions which must be met, emphasise the practicability of such transmission, and then more particularly discuss a new method for the determination of the elements of a single transmission which my own practice has brought out, and which I have found it advisable to adopt. I shall here consider only the use of a continuous current and a direct transmission.

For the purpose of this paper, we may consider the following cases of transmission :—

1. Transmission from a central station conveniently situated near the centre of a manufacturing district, over an area of from one to 100 square miles, in units varying from a fraction of a horse power to 50 or 100 horse power. Such a system is illustrated by the Edison two and three wire circuits in operation in a large number of cities in the United States. Referring to my own work alone, its practicability is illustrated by the fact that in Boston I have nearly 150 motors in operation, in New York about 125, and in New Orleans nearly 100 ; there being in various stations not less than 1,200 machines, varying from a half to thirty horse power, and used in no less than 130 different industries. These machines are operated under potentials, varying from 100 to 440 volts, and are run on constant potential circuits. The maximum distance in this class of work is, at present, about one mile on 220 volt circuit, and the practical limit for this potential, from a single station, is about four square miles.

In considering how far this central station work can be carried, we must bear in mind certain facts. Power transmitted means the transference of an energy whose value may be expressed, as in all cases of fluid transmission, by the product of the quantity and pressure—that is, by the product of the electro-motive force and the current. With any given amount of energy transmitted, the electro-motive force and the current will vary inversely. The laws of distribution are clear. With any given work done, loss on the line, electro-motive force at the terminals of the motor, and distribution, the weight of the copper will vary as the square of the distance, its cross section, of course, varying directly as the distance. With the same conditions, the weight will vary inversely as the square of the electro-motive force used at the motor. With the same cross section of conductor, the distance over which a given amount of power can be transmitted will vary as the square of the electro-motive force. If the weight of copper is fixed, with any given amount of power transmitted and given loss in distribution, the distance over which the power can be transmitted will vary directly as the electro-motive force. Hence, if it is practical to economically transmit power one mile under 200 volts pressure—that is, if the investment in copper is not disproportionate—then, by increasing our pressure to 800 volts, we can transmit this power four miles without changing the ratio of the investment. Of course, I am now speaking of the use of a bare wire, and assuming that the cost of stringing the four miles of given weight of wire is no more than stringing an equal weight one mile. Of course this is not strictly so. As a matter of fact, however, it is a practical thing to transmit and deliver over an area of 100 square miles, from one central station, under a pressure not exceeding 1,000 volts ; and the larger the amount of power distributed and the greater the number of units, the more cheaply it can be done. The question arises, "Would it be economical, in a district of this character, to deal with the larger horse powers?" My answer is unquestionably, "Yes." It is true that the actual efficiency of double conversion would vary from 50 to 70 per cent, depending upon the distance and the pressure used, but experience has developed the fact that not over about 35 to 40 per cent of the maximum capacity of all the machines in a circuit represents the average duty demanded ; and since this is so, it follows that the amount of power that can be contracted for will at least equal, probably considerably exceed, the steam power in the central station. I say "steam power," because, in a large majority of cases in this kind of transmission, steam, and not water, will be the prime source of energy. When we consider the economy of operating a large, well-designed, and properly-constructed steam plant, and the great advantage to the user where the electric motor replaces the ordinary steam engine, it does not need a very shrewd commercial sense to see the advantages of this method. In fact, there is not a city in the United States, no matter how numerous its factories, which could not have them run better than to-day by a well-constructed electrical plant, working under pressures which would not be dangerous to life.

2. Somewhat analagous to the system we have just discussed is the transmission at constant potential with the motors applied with various loads at constantly varying points. Such a system of transmission is that which exists in the parallel circuit system for railroad work. There are now in the United States alone no less than sixty or seventy electric railways in operation or under construction. The most extensive of these, up to the present writing, is the Richmond Union Passenger Railway, whose characteristics may be cited as an illustration. This has about 12 miles of track, and is operated under a pressure of about 450 volts. The central station has a capacity of about 375 horse power. The farthest point reached is about three and one-half miles from the station. The equipment consists of forty-one cars, with eighty-two machines, whose aggregate normal capacity is between 600 and 700 horse power, nearly double the steam capacity. The car units develop anywhere from nothing to 20 horse power. The maximum load which has been put upon the system at one point at any time is the starting of about twenty-two cars about two miles from the station, requiring probably about 125 to 150 horse power. This road now having made nearly 600,000 miles, the practicability of this kind of transmission may be accepted as an assured fact.

3. The transmission from one station to another, at which latter point are a number of independent machines, each of which has a variable load and is required to run at constant speed. An example of this is the transmission from a water power to a stamp mill, where the different batteries of stamps are operated by independent machines. The most satisfactory method is to maintain at the receiving station a constant potential, and to use for the receiving machines motors wound to be self-regulating, according to laws which I gave some time since. The dynamos should either be compound wound or the field regulators adapted to increase the electro-motive force of the machine as the load increases. Constancy of prime speed is an essential ; or, if it does not exist, then there must be a combined mechanical and electrical governor which will assure a definite electro-motive force, which shall correspond to each variation of the current.

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* Lecture delivered before the Franklin Institute, Philadelphia.

4. The transmission between two stations, as last mentioned, save that the condition of automatic regulation is not essential. In this case the dynamos may be either shunt, compound, or series wound, and the motors either shunt, cumulative, or series. Such a plant is now running in one of the mines at Aspen, Col. The electro-motive force there used is about 450 volts, and the distance somewhere about a mile.

5. Transmission with a single line over a long distance, with the motors distributed throughout the entire line. This is a case which may occur in some manufacturing districts, but is more apt to occur in such work as canal building, dredging, or mining in river beds. It can be accomplished by the use of a constant current circuit, using constant current motors, or with the same aggregate electro-motive force on a constant potential circuit. A marked case is the mining operations carried on at the Big Bend Tunnel of California, in a large river canon, where about a dozen machines, developing from five to ten horse power, are used for operating pumps and derricks, and are supplied by two lines of from 600 to 1,000 volts potential over a distance of about eight miles from the central station.

(To be continued.)

MATERIALS OF ENGINEERING.—XIV.

Stone and Cement.

The building stones used in engineering are the granites, clay-slates, and the various limestones and sandstones. The first two yield fine-grained, hard, and compact stones. The two latter embrace many kinds, of very variable qualities. The qualities which have to be regarded in a building stone are availability, strength, facility of working, and its absorbent or non-absorbent character. The stresses to which stones are subjected are almost invariably compressive. They are seldom subjected to pressures greater than one-sixth of their crushing strength—usually the maximum stress is much less than this. But so many causes, due to imperfect bedding, &c, arise to complicate the stresses and make them of a less favourable character than those due to compression pure and simple, that the nominal or calculated stresses are often less severe than the actual ones.

The porosity of stones varies very widely. The granites and clay-slates absorb very little moisture, seldom as much as one per cent of their weight. On the other hand, the Box and Corsham limestones absorb as much as nine or ten per cent, and Portland stone five or six. The sandstones are also very absorbent, ranging from three or four to ten per cent.

The strength of stones is tested by cubical blocks carefully prepared, and made level on opposite faces. The effect of compression is usually to fracture the material at an angle, the shearing stress operating on all sides, so that a cube will break into six pyramidal pieces. The reason why it is important that the surface against which the pressure is applied shall be absolutely parallel is that, without this precaution, the results of testing become vitiated. Professor Unwin employs a thin layer of Parian cement, or plaster of Paris, to impart absolutely true faces to the specimen blocks, which have been already dressed approximately true, and encloses the whole between sheets of millboard which is practically incompressible. He shows that the practice of interposing sheets of pinewood or lead between the block and the crossheads of the testing machine is wrong, both in theory and practice. The lead flowing under the crushing pressure causes tension at right angles with the direction of the crushing pressure, and splits the specimen into wedge-like prisms, whose shearing angles are nearly vertical.

No materials used by the engineer vary so much in composition as the cements. They owe their value to the chemical reactions which occur between their constituents, either in the presence or absence of air. The ordinary cements set in consequence of the absorption by their lime of carbonic acid from the air; the hydraulic cements set by the chemical action of clay, silica, &c., upon their lime, in the presence of water. Portland cement—a term originally applied to a composition having a resemblance to Portland stone—now furnishes an industry of national importance. It is an hydraulic cement, nearly as strong as stone, and alters little in volume. In consists of chalk and clay roughly in the proportion of about four-fifths of the former to one-fifth of the latter. The most intimate mixture of these materials is necessary. They are ground together with very little water, are dried and calcined at a definite temperature to what is called "clinker." The regulation of the temperature is of great importance, as over or under burning are equally injurious. The clinker is broken up and ground to powder, and this comminution should be so minute that complete chemical action shall be able to take place between the particles. Cement sifted through a mesh of fifty to the inch (2,500 meshes to the square inch) will adhere, but the particles left on the sieve will not adhere at all. It is usual to specify that the cement shall be ground so finely that not more than ten per cent shall be left on the fifty-mesh sieve. The German standard is that not more than ten per cent remains on a seventy-six mesh sieve.

"Neat" cement is that which is absolutely pure. In practice cement is never used neat, but is mixed with some proportion of sand in order to lessen expense. The better the cement, and the finer it is ground, the greater the admixture of sand it will bear without deterioration. As much as from three to seven times its weight of sand will be mixed along with it.

Portland cement is usually of a specified weight—112lb. or thereabouts per striked bushel—the materials being lightly filled or sifted into the measure, and strickled off without shaking. This alone is not an absolute test, because coarsely-ground cement weighs more than that ground more finely.

The strength of cement is tested by means of what are termed "briquettes," moulded to a double-ended form for the gripping of the shackles, and tested by tension in lever machines. As a matter of fact, cement is seldom used in tension, but almost invariably in compression. It is, therefore, as a matter of convenience that tensile tests are employed, the machines being less costly and cumbrous than those required for compression tests.

Bauschinger states that the ratio of the resistances to crushing and tension vary between eleven to one and seven to one, so that the crushing strength of a cement can be approximately estimated from its tensile strength. If cubes of cement are tested for crushing, the same precautions are necessary to obtain perfectly level surfaces as in the case of cubes of stone. Sometimes the cement in the briquettes is used neat, sometimes mixed with sand, as in practice. As time goes on the cement hardens, and its strength continues to increase for a considerable period. Mr. Grant's experiments in Portland cement show that neat cement reached its maximum strength in 104 weeks, and cement and sand in equal mixtures in 156 weeks. The rate of gain in strength is found to be nearly proportional to the cube roots of the time of hardening. The French official minimum standard of strength for briquettes of neat cement is 248lb. per square inch at seven days, 498lb. per square inch at 28 days, and 640lb. at 84 days. The German test of briquettes of one cement and three of sand, after hardening one day in air and 27 days in water is 227½lb. per square inch. As an average, a Portland cement should, after seven days immersion in water, require at least 2½ cwt. per square inch of section to break it.

Concrete is a term applied to an artificial mixture of cement, sand, and gravel. Its utility in modern harbour and breakwater construction is immense. Moulded concrete blocks of from 20 to 40 tons weight are not uncommon, and mammoth cranes are erected for their deposition. For ordinary concrete blocks and walls, 6½ parts of clean gravel or shingle, 2½ parts of sand, and one part of Portland cement are mixed. With these proportions 2½ bushels of cement will be required for a cubic yard of concrete. For large masses of concrete for foundations two bushels of cement per cubic yard will suffice. In cases where extra strength is required the proportion of cement may be increased to three bushels per cubic yard. In each case also the concrete may be cheapened without deterioration by placing large stones in the fresh mixed material, care being taken that the stones are all surrounded and separated from each other by concrete.

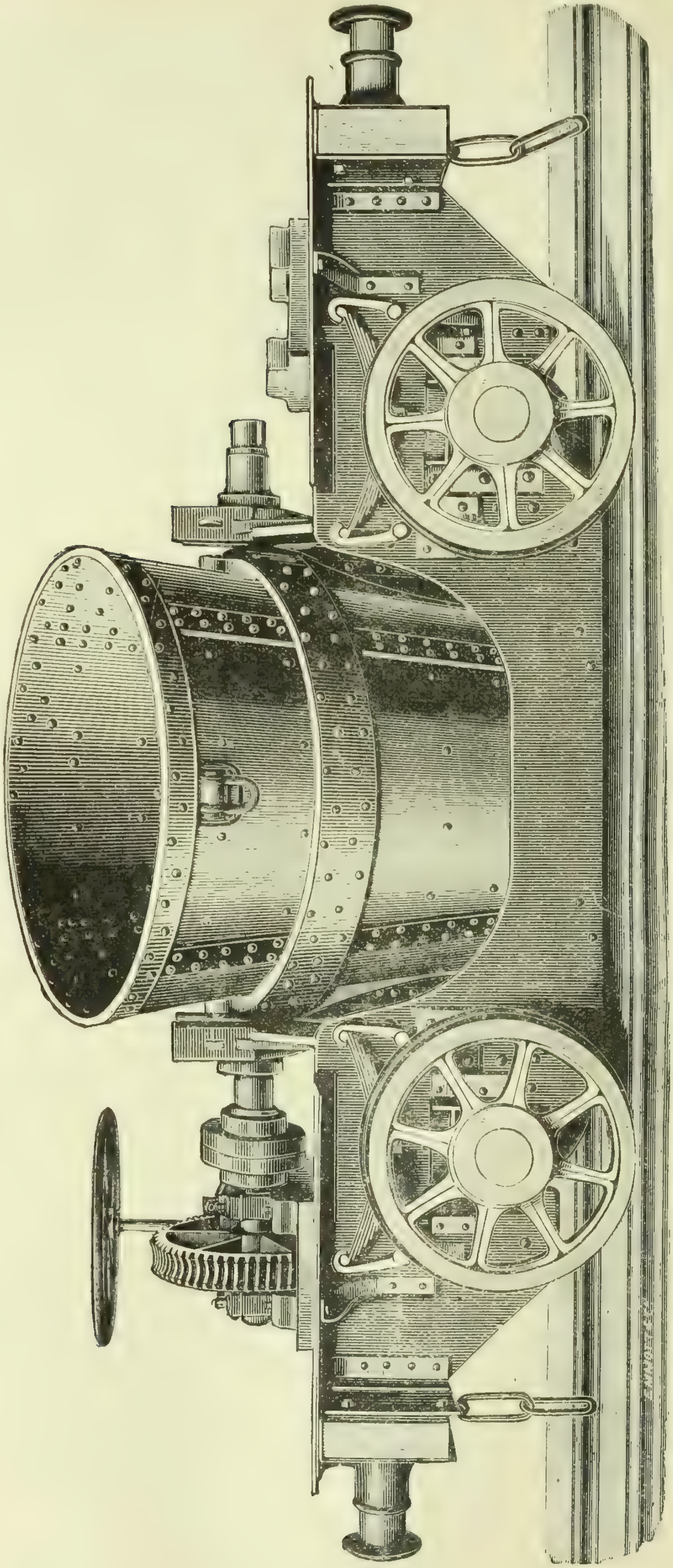
Roman cement is a natural product, and is prepared from certain stones containing on an average 60 per cent of carbonate of lime or of magnesia, and from 30 to 40 per cent of clay. The clay is ferruginous, but alumina and soda are almost absent. For these reasons, and because of the variable character of the stones, the Roman cements are far inferior to good Portland, and have been greatly supplanted by the latter. Roman cement is of a dark brownish colour, Portland cement of a light grey. Roman cement is better the lighter it is; Portland is at its best when heavy. Roman cement is mixed with sand, but it will not bear so great a proportion as the Portland. Like the latter, it is an hydraulic cement.

The strengths of the various stones, cements, and concretes differ so widely that there would be little benefit in compiling a table of only moderate length. Very complete tables and data will be found in the works which treat specially on these subjects, as well as in most engineers' books of reference.

A Monster Blast.—Recently a monster blast was fired at Bonawe quarries, upwards of six tons of powder having been used. In 1886 a similar blast dislodged about 85,000 tons of rock, and it is calculated that this blast brought down fully that quantity.

TEN-TON STEEL PLANT LADLE AND CARRIAGE

Constructed by Messrs. Stevenson & Co., Engineers, Preston



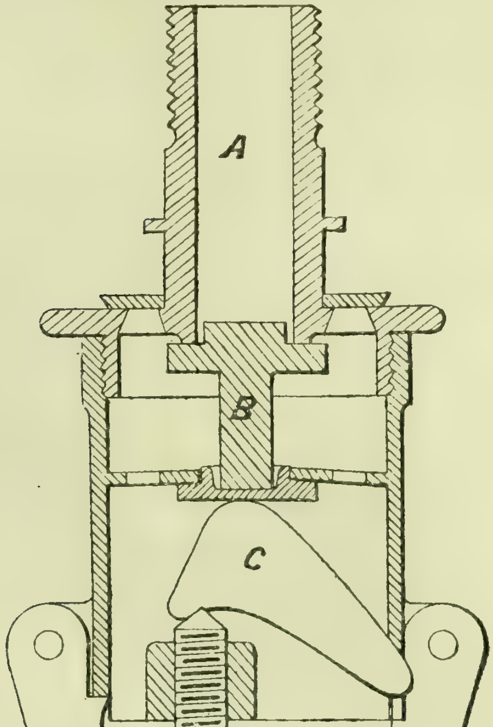
The accompanying illustration, representing a 10-ton ladle and carriage, is one of the specialties made by Stevenson and Co., Canal Foundry, Preston. It is an exceptionally strong structure, designed for carrying the molten metal from the blast furnaces to the Bessemer steel converters. The carriage frame is constructed throughout of 1in. wrought-iron plates, and is made to suit the ordinary 4ft. 8½in. railway gauge. The axle boxes are cast iron, fitted with gun-metal steps; the wheels are made of forged iron, with steel tires and axles. The carriage is provided with strong oaken buffers, planks, and spring buffers; the drawbars also have helical compression springs of the usual type. The ladle is built up of ½in. wrought-iron plates, butt jointed, and double-riveted butt straps, and the trunnions and flange couplings are of cast steel. The tipping gear, clearly shown in the illustration, consists of a worm and wheel, both of steel, which can be fixed on either side of the ladle, as may be desired.

From this description of the ladle and carriage, it will be seen that Messrs. Stevenson and Co. have made a thoroughly strong structure in every respect, and one therefore that will commend itself to most steelmakers. We understand that these carriages are made in various designs and sizes to meet special requirements.

AUTOMATIC SPRINKLERS.

(Concluded from page 222.)

There is another valve sprinkler, which has recently been put in the market, known as the "Witter," which we illustrate. It will be seen that it consists of a body A, in which the water always rests. The upper part of the body is tubular in shape, and is closed at the bottom by a valve B, which is held to its position by a bridge or lever C, acting through an inverted cap, which, when pressed, causes the diaphragm to be put into tension, and so act as a spring. This does not, however, affect the valve, which has to be pushed away by the water only. The bridge is detached, being arranged so that one end rests upon a shoulder formed in the lever D. D and E are two levers, both pivoted at one end, and are soldered together by fusible solder at the other. A set screw is fixed in the lower part of the case as shown, and is set so that when the heel of C rests upon the shoulder in D the valve B is pressed against its seat, and closes the orifice. The action of the sprinkler is as follows : When the fusible solder melts, the levers D and E drop away, and C is allowed to fall from under the valve B. The water then rushes through the orifice into the chamber formed by the diaphragm shown, and finds its way through the holes formed at the top and bottom of the chamber, which surround the tubular portion of the body A. A deflector is raised, and the spray formed in the usual manner.

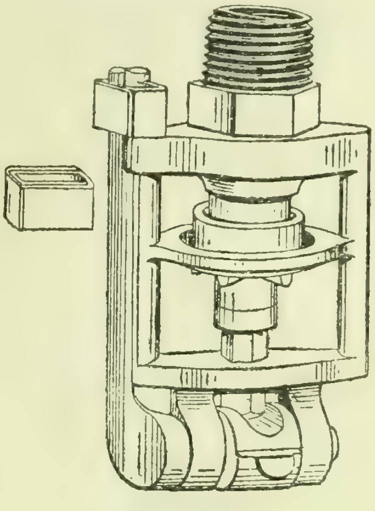


WITTER.

It was claimed for the Witter that the arrangement of the screw was such that much less strain was thrown upon the solder joint, the whole of the pressure being put on the screw. It was also claimed that by turning the screw the action of the sprinkler might be tested, a matter of great importance, and that the form of the deflector ensured the spray covering the whole area.

The "Wallworth" sprinkler was next described, and it was one of the best in use, as it afforded great facility for testing.

It was now necessary to call attention to the second class referred to, viz., the unsealed. The "Draper-Hetherington," which was the latest of these introduced, did not depend for its action on the fusion of the metal. Referring to the illustration in section of this sprinkler, it will be observed that the body A has a seat for a flat or mushroom valve, formed conveniently within it, the seat being arranged so as to allow of the free passage of the water. The valve B is loosely attached to the top of the spindle C, which passes downwards and terminates in the nipple shown. The lower part of the case beneath the valve seat is formed with a number of exit orifices, immediately below which a circular disc forming part of the body A is formed. The disc has a lip or projection E extending round its upper surface as shown, and attached to the under part of it is a tripod frame, the boss in the centre of which is bored to allow of the passage of a short screw, one end of which is fastened to the nipple in the centre of the lower part of the expansion case shown. Nuts are placed above and below the boss in the centre of the tripod frame. The expansion case is formed of thin brass, and is cylindrical in shape, the upper and lower covers being concave. Surrounding the case is a brass guard, which is large enough in diameter and deep enough to cover the case completely, and leave a considerable space all round it. It only needs to be pointed out that, resting on the top of the flat disc, and surrounding the exit orifices, is a corrugated brass washer D, which acts as a deflector.



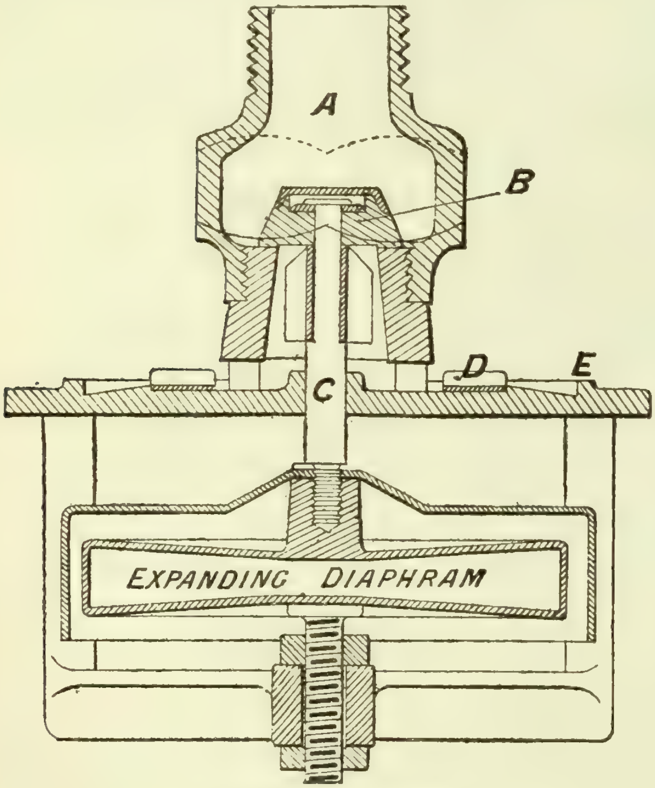
WALLWORTH.

The action of this sprinkler was as follows : The expansion case was partially filled with a special mixture which boiled at a very low point, and was then hermetically sealed. When the air surrounding the sprinkler began to be heated by the fire, the liquid within the case expanded, and when sufficiently heated, became of such a volume that the covers of the case were forced outwards at the centre, and became convex. The effect was to create a tendency in the valve spindle and the screw, attached to the top and bottom of the case respectively, to move vertically. As, however, the valve was always held on its seat by the water pressure, and the vacuum usually existed in the expansion chamber, it was clear that if the screw was clear to move vertically, the force of the expansion of the liquid would be expended in that direction. By adjusting the nuts, however, the downward movement of the screw was arrested, and the whole expansive force was applied to the valve spindle. The amount of power obtained in this way was amazing, and would lift the valve if a dead weight of 130lb. to 140lb. was laid upon it. As soon as the valve was lifted the water was emitted, and, passing over the corrugated washer, was thrown into a spray. Even if no washer were used the lip or projection on the disc acts much in the same way, the stream being flattened out into a sort of rose all round as it passed over the surface of the disc. By varying the shape of the corrugations on the washer the spray might be made to direct itself downwards towards the floor, or up towards the ceiling, a spray of 10ft. diameter being easily obtained in that direction, which was very desirable where buildings are non-fireproof, or the upper floors are borne by joists. As soon as the fire was under control and extinguished, the air began to be cooled and the liquid in the case commenced to contract. As soon as it had assumed its original volume, thus re-establishing the vacuum, the valve was brought down on to its seat, and so closed the orifice, stopping the emission of water.

There were one or two points in connection with this type which called for special remark. It would have been noticed that the valve was within, and not without the sprinkler body, and that the pressure of the water was exerted to keep it on its seat, and not to force it away. The chances of leakage were thus minimised, because, once accurately formed, the valve and seat would practically remain perfect. The valve was so attached to the end of the spindle, that even if the latter was not truly vertical, the valve always bedded itself thoroughly.

Again, the force exerted by the expanding liquid was greatly in excess of that exercised by the water on the valve. In order to prevent the opening of the valve, there would have to be a pressure of over 1,000lb. to the square inch in the pipes, a condition which would never be attained.

Some very exhaustive tests had been recently made by Professor Dewar, of the University of Cambridge, who placed three sprinklers of this type in an air bath heated uniformly. The operation was repeated ten times, and the sprinkler opened in times varying from 1⅙ minute to 2½ minutes, this being the extreme variation in the three sprinklers. It would, perhaps, be interesting to say that No. 1 opened at a temperature of 135 deg. F. to 138 deg. F. in from 1½ to 2½ minutes; No. 2 at 139 deg. F. and 140 deg. F. in from 1½ to 2 minutes; and No. 3 at from 139 deg. F. to 140 deg. F. in from 1⅙ to 2 minutes; and the report stated that very little change was observable in the action. A further test was conducted with a sprinkler attached to the water main, and subject, of course, to the water pressure; the heat being here obtained by the contact of a Bunsen flame. After fifty tests had been made in this way, the sprinkler was again tested in an air bath, and opened at the original temperature of 130 deg. F. to 150 deg. F. No sealed sprinkler possessed this advantage, for after once acting they required to be re-adjusted, and, with the exception of the Wallworth, soldered before being in condition to act again.



DRAPER-HETHERINGTON.

The writer was of opinion that the Draper-Hetherington was a very considerable advance on anything which had gone before, and alike in its sensitive nature, its certain action, non-liability to damage, protection from the cooling influence of the sprays, its self-closing property, and its complete re-adjustment without manipulation, it is in advance of any type which had been put upon the market.

Before closing this part of the subject it would be of interest to point out that some apprehension might very naturally be felt that a slight loss of the volatile liquid in the case would occur under repeated tests, or in the course of time after exposure to the heat of a room. Professor Dewar made a series of tests which practically resulted in dissipating all fears of this kind, as when heated for 15 hours to a temperature in excess of that which opens the valve, the loss of weight was inappreciable, and the sprinkler was as good as at first. The liquid used was chemically neutral, and no corrosion of the metal could occur.

The temperature at which the sprinklers were arranged to act varies, of course, with the conditions for which they are wanted. Usually, under ordinary circumstances, the sealed sprinklers were arranged to act at a temperature of about 155 deg. F., and the Draper-Hetherington at 140 deg. F. By varying the composition of the liquid in the expansion case in the latter, the temperature at which its expansion would lift the valve could be correspondingly adjusted, and might be as low as 100 deg. F., and as high as 200 deg. F. The tests usually made of these sprinklers were conducted in various ways, but a very slow fire and a low pressure of water appeared to the author to be the crucial test. The sealed sprinklers usually acted in these tests in times varying from 12 to 80 seconds, according to the character of the fire, the extinction of which ordinarily took about 30 to 50 seconds. In several tests made of the Draper-Hetherington action had begun in about a minute, and the fire was extinguished and the water closed off in times varying from 2½ to 4 minutes. All the tests were with slow fires, but with a quick fire the commencement of operations was very rapid. In one case where the fire was a very slow one the sprinklers acted, extinguished the fire, and closed again in about 3½ minutes, a circle only 6ft. in diameter comprising the whole of the burnt material.

In conclusion, it was but necessary to say that the sensitive nature of sprinklers was now so fully developed that if properly applied there were few cases in which a fire need cause considerable damage; and if the Draper-Hetherington was adopted, the extinction of fires could be accomplished with the minimum expenditure of or damage from water.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

(Continued from page 217.)

The temperature of the chimney gases was read every five minutes; the chimney draught was also taken at frequent intervals. For measuring the temperature of the chimney gases a mercury thermometer was used, the space above the mercury being filled with nitrogen under pressure, so that the thermometer could be employed without fear of accident above the normal boiling point of mercury. It will be seen, however, that there was no occasion for this precaution with this particular engine. For feed-water measurement a large tank, which contained sufficient water to last throughout the whole trial, was placed upon the platform of a 50 cwt. weighing machine, carefully adjusted. An indiarubber pipe from this tank led the water to a small open tank beside the engine, from which the feed tank drew its supply. This tank was also placed upon the platform of a weighing machine. The steelyard of the large weighing machine was arranged so as to make a contact and ring an electric bell every time it fell down on its lower stop. Each time this happened the weight on the steelyard was reduced by one hundredweight, so that the steelyard at once lifted, and only again fell when another hundredweight of water had been used. In this way the exact times at which each hundredweight of water passed out of the large tank could be noted. By noting at the same moment the weight of water in the small tank, the amount of feed-water which had gone into the boiler was exactly known. The temperature of the feed-water in the small tank was noted at frequent intervals; it was, of course, simply the temperature of the water in the mains, and so was practically constant. In the Paxman engine, as has been already stated in the earlier part of this report, the feed-water, before going to the boiler, passes first through a feed-heater, which is in point of fact a kind of surface condenser for the exhaust steam, and then through a coil of pipe in the smoke-box, by which its temperature is still further raised. A thermometer was placed in the closest possible contact with the feed-pipe between these two feed-heaters, its bulb being carefully wrapped round with a large thickness of non-conductor. This thermometer was read every five minutes throughout the trial, and it is believed that its readings give a very close approximation of the temperature to which the feed-water was raised by the exhaust steam. The temperature at which the feed-water actually enters the boiler proper, after having passed through the feed-heater coil in the smoke-box, could not be measured.

It will be seen from the table that the mean temperature of the feed-water, after leaving the exhaust feed-heater, was 201 deg. F., although the initial temperature was only 63 deg. F. As the temperature of the exhaust steam could not have been sensibly above 212 deg. F., it will be seen that this feed-heater is in itself so efficient that there is no necessity for actually returning any condensed steam into the feed-tank to heat the water before it goes to the feed-heater. The weight of condensed steam, which would otherwise have gone to the feed-tank, was measured separately.

Table XI.—Paxman Engine.

1	Date	Sept. 26	Sept. 28	Oct. 1	Oct. 1
2	Trial	A1	A2	B	C
3	Duration	6·43 hrs.	6·27 hrs.	3·12 hrs.	½ hour
4	Power	full	full	half	empty
5	Revolutions per minute	140·48	137·35	138·10	144·20
6	Mean initial pressure, high-pressure cylinder	176·6	176·8	113·0	....
7	Mean ratio of expansion	....	....	....	....
8	Mean effective pressure, high-pressure cylinder	52·93	54·98	33·25	11·32
9	Mean effective pressure, low-pressure cylinder	17·56	16·78	8·92	– ·19
10	Indicated H.P. effective pressure, high-pressure cylinder	11·14	11·30	6·85	+2·40
11	Indicated H.P. effective pressure, low-pressure	10·98	10·26	5·47	–0·12
12	Indicated H.P., total	22·12	21·56	12·32	2·28
13	Brake load, net	288·8	288·0	147·6	....
14	Brake H.P.	19·44	18·95	9·76	...
15	Mechanical efficiency	0·879	0·879	0·792	....
16	Indicated H.P. in driving engine	2·68	2·61	2·56	2·28
	Boiler.				
17	Mean boiler pressure (above atmosphere)	191·35	187·98	120·10	....
18	Atmospheric pressure for the day	14·9	14·8	14·8	....
19	Boiler pressure (absolute)	206·25	202·78	134·9	....
20	Temperature of boiler steam	384·3°	382·9°	350·1°	....
21	Pounds of feed used per hour	[448·7]	447·1	392·2	....
22	Pounds of feed used per indicated H.P. per hour	[20·28]	20·74	26·72	....
23	Pounds of feed used per brake H.P. per hour	[23·08]	23·59	33·73	....
24	Mean temperature of feed-water in tank	63·0	63·0	69·9	....
25	Mean temperature of feed-water before entering coil	[201]	201	....	....
26	Mean temperature of feed-water before entering exhaust feed-heater	115·7	63·0	....	....
27	Temperature of chimney gases (Fahr.)	355·4°	304·4°	369·1°	....
28	Coal per hour	39·66	40·70	27·25	....
29	,, ,, per indicated H.P.	1·79	1·89	2·21	....
30	,, ,, per brake H.P.	2·04	2·15	2·79	....
31	Pounds of water per pound of coal	....	10·99	12·08	....
32	Pounds of water per pound of coal from and at 212° F.	....	11·71	12·76	....

Indicator cards (fig. 12) were taken three times per hour, in the middle of each interval of twenty minutes. The counter was read every twenty minutes, having been set to zero at the start, and the indicated horse power of each set of cards was computed from the revolutions corresponding to the interval within which that set was taken. The mean indicated horse power, 21·56, is given in the table. The minimum horse power for any set of cards was 21·2, the maximum 22·2. The mean revolutions per minute were 137·4, the minimum for any twenty minutes 135·9, the maximum 140·2.

Four Crosby indicators were used, a separate indicator on each end of each cylinder, with the shortest possible pipes to the cylinder. The steam jackets were not used during the trial, Mr. Paxman electing to run without them. The rope brake employed has been already described. The spring balance was read every five minutes throughout the trial. The weight on the brake was altered a little from time to time, so as to keep the net brake resistance as uniform as possible. Throughout the greater part of the trial the weight was about 320 pounds, the spring balance reading being about 32 pounds. The brake horse power was 18·95. The flywheel rim was of trough section, and water was allowed to drip into it and evaporate away. No lubricant of any kind was employed on the surface of the brake. The amount of water run into the rim was about 0·65 pounds per minute at full power, which, if evaporated at 212 deg., corresponds (the water temperature being 62 deg. F.) to 725 thermal units per minute, or the equivalent of 17 brake horse power, which is nearly 88 per cent of the whole power taken up by the engine. This figure, however, is certainly somewhat too high, as a small, but not insensible, quantity of water was lost by splashing.

The thermal results of the trial work out as follows, commencing with the furnace and boiler:—

The calorific value of the coal is about 14,200 thermal units per pound.[*] The fuel used per hour during the trial was 40·7 pounds, and we have, therefore, to account for 577,900 thermal units per hour. This heat is expended in (*a*) heating and evaporating water, (*b*) heating coal and furnace gases, (*c*) heating surrounding objects by radiation, (*d*) evaporating the moisture in the coal; and these points will be considered in order.

(*a*) *Heating and Evaporation of Water.*—The total feed-water per hour was 447·1 pounds; its temperature on entering the coil in the chimney—that is, when it began to receive heat from the furnace gases—was 201 deg. F. The steam temperature was 383 deg. F. The total heat taken up by each pound of water under these conditions would be 1,029·6 thermal units. The total heat, therefore, expended usefully in the boiler per hour was 460,300 thermal units, or 79·7 per cent of the whole heat of combustion, and this fraction represents the actual boiler efficiency.

(*b*) *Heating Coal and Furnace Gases.*—The following figures give the mean of Mr. Wilson's analyses of the furnace gases during this trial, and also the corresponding composition of the gases by weight:—

Table XII.

	Percentage Composition of Chimney Gases.	
	By Volume.	By Weight.
CO_2	11·86	17·21
CO	0·56	0·52
O	7·27	7·67
N	80·31	74·60
	100·00	100·00

It was attempted to determine the moisture in the gases also, but this was found to be quite impossible, because of the amount of exhaust steam close to the place from where the gases were collected. The analyses given are therefore of dry gas. By comparing the weights of nitrogen and carbon in the gas, it will be found that the amount of air used works out to 19·74lb. per pound of carbon. As 1lb. of coal contained only 0·84lb. of carbon, the weight of air per pound of coal must have been 16·68, so that the weight of the whole furnace gases must have been very closely 17·7lb. for each pound of coal. The air temperature in the testing house was 65 deg. Fahr. The mean chimney temperature (measured *above* the heating coil) was only 304 deg. Fahr.; the rise of temperature of the furnace gases being, therefore, 239 deg. Fahr. The mean specific heat of the gases was about 0·237. The amount of heat expended in raising their temperature was, therefore, 40,700 thermal units, or 7·1 per cent of the whole heat of combustion.

(*c*) *Radiation.*—An endeavour was made to determine this loss by a separate experiment. Steam having been got up, and everything being in its normal condition, as nearly as possible, the fire was drawn and small quantities of coal put on from time to time, just sufficient to prevent the pressure from falling. The total quantity of coal burnt amounted to 13·5lb. in 3 hours 23 minutes, or four pounds per hour. Some unknown proportion of this quantity was no doubt expended in heating air and furnace gases passing up the chimney. It may probably be taken as a fair approximation that about the same proportion of heat was employed in heating the furnace gases and lost otherwise as in the run when the engine was working—*i.e.*, 9·9 per cent, leaving a balance of 90 per cent lost by radiation. We may, therefore, take it that 90 per cent of four pounds, or 3·6lb. per hour approximately, represents the quantity of coal corresponding to the losses by radiation. In default of any more accurate means of determining this quantity, it must be assumed that the loss by radiation when the engines are running is the same as when they are stopped, the steam pressure and other conditions being the same. We may, therefore, say that approximately 3·6lb. of coal per hour, with a value of 51,075 thermal units, or about 8 9 per cent of the whole heat of the combustion, was lost through this cause.

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[*] In this assumption no deduction is made from the hydrogen on account of oxygen already present in the fuel and shown by its analysis. Although this deduction is so commonly made, it does not seem to be founded on any clearly defined basis, for it is quite certain that in whatever form the hydrogen may exist in the fuel, that form is *not* one of simple combination with oxygen as H_2O. Practical determinations of the calorimetric value of fuel, moreover, appear always to give figures in excess of that found by calculation when the hydrogen which would combine with the oxygen is deducted. The calorific value of the hydrogen is taken at 52,200 thermal units per pound, which corresponds to the production of *gaseous*, and not *liquid*, water in the furnace gases. There is, therefore, no correction to be afterwards made for the latent heat of the steam in the furnace gases.

(*d*) *Evaporation of Moisture in Coal.*—The evaporation of the 1·21 per cent of moisture in the coal corresponds only to 570 thermal units per hour, or 0·1 per cent of the total heat of combustion.

Loss by Formation of Carbonic Oxide.—An examination of the gas analysis by weight shows that 4·48 per cent of the carbon was burnt only to CO instead of to CO_2. It will be found that this corresponds to a loss of about 380 thermal units per pound of coal, or 15,450 thermal units per hour, which is 2·68 per cent of the whole heat of the combustion. The whole heat account for the boiler stands therefore thus :—

TABLE XIII.

	Thermal units.	Percentages.
Calorific value of 40·7 pounds of coal..........	577,900	100
Heat expended in heating and evaporating water, including heat given up by gases to coil in chimney........................	460,300	79·65
Heat expended in raising temperature of furnace gases	40,700	7·05
Heat lost by radiation........................	51,070	8·85
Heat lost by imperfect combustion............	15,450	2·68
Heat expended in evaporating moisture in coal.	570	0 10
Heat lost in ash, and otherwise unaccounted for.	9,810	1·67
	577,900	100·00

One very notable point about these results is the extremely low temperature of the chimney gases, considerably below that of the steam in the boiler. This is obviously due to the very efficient action of the coil in the chimney as a feed heater. There was no possibility of measuring the temperature of the feed-water as it left the coil and entered the boiler. If the furnace gases left the tubes at a temperature of about 400 deg. F.—and they could hardly be cooler—they must have been reduced in temperature by the coil about 100 deg. F. As there were 1·16lb. of furnace gases for each pound of water, and as their respective specific heats are 0·237 and 1·00, 100 deg. fall in temperature of the furnace gases would correspond to about 38 deg. rise in the temperature of the water.

The steam, which was condensed in the feed-heater, was collected and measured. It amounted to 63·8lb. per hour. Taking each pound to have given up simply its latent heat at atmospheric pressure (and with feed at 210 deg. F. it could hardly do more), this corresponds to 61,640 thermal units per hour. The heat taken up by the feed-water, 447lb. per hour, raised from 63 deg. to 201 deg. F., amounts to 61,690 thermal units, which differs from the quantity just given by an amount far within the limits of accuracy of the measurements. The water actually evaporated per pound of coal was 10·99lb. This was raised from 201 deg. to 383 deg. F., and evaporated at the latter temperature. Reduced to evaporation from and at 212 deg. F., the figure becomes 11.71lb. Perhaps a still better standard for comparison with other engines may be obtained by taking the evaporation per pound of carbon value of coal. The weight of carbon in each pound of coal was 0·845lb. The hydrogen in the coal was equivalent to 0·131lb. of carbon, so that each pound of coal had a calorific value equal to that of 0·976lb. of carbon. The water evaporated under standard conditions per pound of carbon value was therefore just 12lb. It is assumed that the steam was *dry*, and that there was no priming. There was no indication whatever of priming, but probably the best evidence of its absence is the closeness of the heat balance in Table XIII.

Engine.—The work done, 21·55 indicated horse power, corresponds to 55,300 thermal units per hour, or 12·0 per cent of the whole heat taken up by the water. The efficiency of a perfect heat engine, working between 383 and 212 deg. F. would be 0·205. Such an engine, receiving the same amount of heat as the Paxman engine, namely, 460,300 thermal units per hour, would turn into work 93,200 thermal units per hour. The actual efficiency of the engine, therefore, compared with such a perfect engine, is 59 per cent. The heat received by the engine per indicated horse power per hour was 21,350 thermal units.

The brake H.P. of the engine was 18·95 ; its mechanical efficiency was therefore 87·9 per cent, the indicated H.P. expended in driving the engine itself being 2·61.

Boiler and Engine.—The combined efficiency of the furnace, boiler, and engine, as represented by the consumption of fuel per horse power, works out to 9·6 per cent, 55,300 thermal units being turned into work per hour, with an expenditure of fuel having a value of 577,900 thermal units. The coal used per indicated H.P. per hour was 1·89lb., and per brake H.P. per hour 2·15lb.

Steam by Indicator Cards.—The amount of steam shown by the indicator diagrams (figs. 11 and 12), has been measured at two places, with the following results :—

	Percentage of whole weighed feed-water.
Steam in H.P. cylinder at a pressure of 150lb. per square inch above the atmosphere, which corresponds to a point at 0·39 of the stroke, a little after cut-off in all cases	65·0
Steam in L.P. cylinder at a pressure of 10lb. per square inch above the atmosphere, which corresponds to a point at 0·67 of the stroke, well before release in all cases..........................	78·8

Trial A_1 (Fig. 16).—This trial took place on the 26th of September, and was nominally of the same duration as Trial A_2. As already mentioned, the engine was tested in its normal condition of working, with condensed steam from the feed heater added in unknown amount to the feed water. The boiler was stoked by Mr. Paxman himself. Speed, brake power, boiler pressure, &c., were all nominally the same as in Trial A_2, the small differences between them being fully given in Table XI. The same amount of coal was used, but it kept the engine going with somewhat larger indicated H.P., namely, 22·1 for 6 hours 26 minutes, or ten minutes longer than in Trial A_2. The brake H.P. was 19·4, so that the mechanical efficiency was again 87·9 per cent. The coal used per hour was 39·7lb., which corresponds to 1·79lb. per indicated H.P. per hour, and 2·04lb. per brake H.P. per hour. Worked out per pound of carbon value in the coal, these figures become 1·75 and 1·99 respectively. It may be noticed in passing that the coal used on the Newcastle trials was of distinctly better quality than the coal here employed. Measured in the same fashion, each pound of coal there used was equivalent to 1·015 of a pound of carbon, instead of 0·976, and had, therefore, a heating value nearly 4 per cent in excess of the coal used in these trials.

(To be continued.)

PROPOSED VISIT OF THE AMERICAN ENGINEERING SOCIETIES TO EUROPE.—The American Society of Civil Engineers, with the Society of Mechanical Engineers and the Institute of Mining Engineers, are organising a trip to Europe to visit the Paris Exposition and such other objects of interest as may prove practicable. The proposed excursion has attained already such dimensions, as indicated by the responses of members, that it is believed that two steamers will be required to accommodate the travellers. The civil engineers alone will fill one vessel. It is proposed, therefore, to charter one or two vessels of the Inman Line, and perhaps to reserve all the first-class cabin accommodation on the Egypt or Spain of the National Line. The maximum fare for the ocean voyage and return will be 110 dols. The magnitude of the delegation indicates well the immense growth of the engineering profession in the United States, and it is gratifying to feel that America is to be so well represented at the exposition. Her position at all previous exhibitions, from the standpoint of inventiveness and ingenuity displayed by the exhibits, has been very high, and will be so in 1889. The engineering societies will give a personal aspect of American professional life that we are confident will make itself felt in scientific circles there.—*Scientific American.*

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

Sir,—Now that a special effort is being made to force the above type of boiler on the British market, the questions raised by "Manchester Engineer" are very pertinent and opportune. Of all land boilers my experience is perhaps more limited in regard to the water-tube type than any other, this limited knowledge being due to the fact that they do not number more than perhaps one per every 2,000 of existing boilers. Such experience as I possess I am willing to offer your readers, and reply to "Manchester Engineer's" queries *seriatim.*

The different types and makes may all be grouped under one head, the difference being in detail only, such as end connections, covers, devices to ensure circulation and delivery of steam into upper cylinder or steam drum. Where limy water is used, just the same trouble is experienced as in other boilers, that is, if sulphates are present a hard scale is formed, which induces overheating; if carbonates, the water thickens, and a circulation is kept up of water charged with carbonates of lime, which, not being very adhesive, is swept forward by the violent currents set up by an intense fire burning under the thin tubes. With water charged with mud, or earthy matter, a similar condition exists, the water becoming more dense as the boiler is kept at work, and all the corners and lurking places are readily filled with deposit, which, when once it commences to accumulate, does so very rapidly, and on removing tube end covers, the boxes or connections are found very dirty. So long as the fires are burning the sediment is kept in motion and cannot settle, but when work ceases all the sediment in mechanical suspension at the time settles down in the tubes and boxes, and often remains there until the tubes, weakened by overheating, either burst or are burnt through. These tubes will, however, withstand severe punishment, as there are no seams to spring or leak, and when they do fail they are utterly destroyed, and consequently seldom require repair, but often require renewal. As the tubes are continually being renewed, the boiler never gets worn out. Where heavy or intermittent firing has to be resorted to, there is always a greater tendency to priming, as in any other boiler; but owing to the sediment being kept in mechanical suspension, a great amount is carried over with the wet steam, and when easily fired it has a greater tendency to settle in the tubes, and, although not heavily worked, the tubes burn through.

The firegrate being a large external one, lined with firebrick, the conditions are certainly more favourable to a complete combustion, and the cost of maintaining fireplace in working condition is only such as is experienced with other external fireplaces, while the cost of brickwork surroundings must be added to cost of boiler. A short flame coal is certainly best for this class of boiler. That the steam is wet very few (except the makers) attempt to deny, but perhaps the results of two trials will suffice, both of which were carried out by disinterested parties, and with the greatest possible care. The Philadelphia tests by Mr. E. H. Hugentobler and the American Government officials showed an English-made "Galloway" boiler to give steam containing ·57 per cent of water, while the "Babcock" gave 3·24 per cent, the steam of the "Root" not being tested.

It may be argued that these, being taken in 1876, are old, but I will come to a recent date. Mr. M. Longridge, in 1887, carried out a series of tests, with the degree of exactness and impartiality for which he has justly become noted, and a very detailed account is given in his 1887 report, where he shows the five Lancashire boilers to give 3·00 per cent of water in the steam, and the Babcock and Wilcox gave 10 per cent of water in steam; while the water evaporated "under actual conditions" was—Lancashire boilers, 8·497lb. per pound of fuel; Babcock-Wilcox, 5·93lb. per pound of fuel. I may here add that several trials have been made in Lancashire by water-tube boiler-makers, but the results have not been published. Why? Patent after patent has been taken out to overcome the difficulties of circulation and wetness of steam, but to little good.

The worst feature, however, is leakage from joints of caps, and it is a common saying that where one boiler is wanted two should be laid down, and an extra man per boiler kept to make joints, and in my experience I have never yet found an engineer who has had them three years who could give them a good name. These boilers are often known by the name of "patent safety boilers," but whether there is that element of safety to be found in them or not is open to doubt.

In 1871, when pressure was going up and coal was dear, great efforts were made to introduce this class of boiler as "safe," "efficient," and "economical," it being prophesied by some that it would in a short time supersede the Lancashire boiler. They were so well pushed, and at first sight, on paper, the arrangement was so very taking, seeing the tubes were so small, and consequently strong, that several owners were induced to try them even against the advice of the principal authorities on boilers, some of whom practically refused to insure them. One firm put in over thirty of them, but in ten years not one of them was used except as economisers, and they did not do well at that.

What appeared a success on paper was soon found to be practically a failure. Lavington E. Fletcher, in one of his reports, says: "But though it appears to be strong, and adapted for high pressure constructively, that is not the only point of view from which a boiler must be regarded; it may be equal to withstand most satisfactorily a high cold-water pressure while under test, and yet suffer distress from the action of the fire when set to work as a steam generator, more especially if the feed water be sedimentary. The boiler certainly promises to meet these difficulties by an active circulation, but how far it will stand the tests of actual and prolonged trial, especially in the pipes immediately over the fire, under the various difficulties that are met with in actual practice, can only be shown by experience. Should one of the pipes burst, the damage to the surrounding property would in all probability be small; but the unfortunate experience derived from the bursting of the pipes in the Howard patent safety boilers show that the loss of life may be considerable." Mr. Hiller, also, in his reports, says: "The failure of these boilers is evidently due to the imperfect circulation of the water, which induces overheating and rupture of one of the tubes over the furnace." And again: "A water-tube boiler of the patent safety class, but a few years in use, was on inspection found fractured in five of the vertical tubes, and in a dangerous condition. These defects were due to the defective construction of the boiler. During the last three years I have had to report on the explosion of nine of this class—a very large proportion, compared with the total number in use."

Opinions such as these, after years of experience, must be considered reliable. From 1870 to 1880, no less than 22 of these boilers exploded, very few of which could be more than five years old, defective and burnt tubes not being considered explosions. Of course, advocates for this class of boiler will argue that great progress has been made during late years. This may be so, but I cannot see where the original principle is affected. They may also offer the results obtained in America; but do boilers in America use the vile pollutions we have to put up with here as feed water? and do they get anything like the horse power that we do per yard of space covered with steam-producing plant?

Trusting you will excuse this long letter, but its importance stands as my apology, I am, yours truly, CHALKLINE.

Manchester.

LEAKAGE IN BOILER.

To the Editor of "The Practical Engineer."

Sir,—"Chalkline" may make himself easy so far as regards the boiler-maker. The work is first-class in every respect, and the boiler-maker tells me, as a matter of fact, there is a man put to every seam to caulk it, where, if one man caulked one side, as suggested by "Chalkline," he would only caulk every alternate seam; but we are troubled with *every* seam leaking. I am satisfied it is not the workmanship or the design of the boiler which is at fault; so we will let the kettle-and-pan business drop, and get to work. Our feed water contains 23gr., according to the apothecary, per gallon of various substances, chief of which is carbonate of lime. Do you consider this much or little? I think our boilers are kept fairly clean. So much for the feed. Our draught is first-class. Now, suppose the bottom flue to contain 200 cubic feet; when the fire door is opened cold air is rushing over the fire with a velocity of at least 40ft. per second. Now, taking the area over the bridge at 2 square feet, we have 80 cubic feet of cold air passing over the bridge in one second, or in three seconds more than sufficient to empty the bottom flue, which, owing to its cramped size, will not allow of this cold air forming a separate current, and consequently allows the boiler to receive very great variations in temperature; and the side flue, where the leakage is, is the most direct route to the chimney. Such is the boiler-maker's theory. Now, what are we to do? I wish to advise my employers rightly in this matter. When doctors disagree, it is difficult for me to decide. There are two courses open, viz., first to make the bottom flue deeper, thereby increasing its capacity; and secondly, applying a cleaner of the Hotchkiss type, as advertised in these pages.

Whichever of the two is adopted makes no difference to me; it is only a question of my employer laying out his money to accomplish the end for which it is spent.—Yours, &c.,

Bolton. ENGINE-MAN.

QUERIES AND REPLIES.

16. Setting Corliss Valves.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—Engineer.

22. Antimony.—Will any reader kindly inform me of the best way to melt ground antimony? The only means at my disposal for doing so are in a ladle over gas or over a large stove, and this is not effectual, as the powder simply cakes.—H. P. S.

23. Light Mixing Mill.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—Eastern.

26. Cavities in Siemens Cast Steel.—Can any reader explain the cause of the hollow cavities occasionally met with in Siemens cast-steel ingots? I mean hollowness so bad as to completely destroy the ingot.—W. P.

27. Forging Mushat Steel.—Will some practical reader kindly inform me of the best way of forging Mushat steel? I can forge ordinary cast steel, but Mushat steel seems to fall to pieces under the hammer.—Steel Bar.

28. Yacht Engines.—What is the greatest I.H.P. I would get out of compound engines $\frac{9\frac{1}{2}\text{in.} \times 16\text{in.}}{10\text{in.}}$ and boiler (horizontal) 6ft. 3in. by 5ft. 6in., and what should the areas of ports, and separate parts, and diameter of steam pipe be, so as to get the greatest power of them?—S. J. M.

29. Cementing Rubber to Metal.—Can any reader give me information as to the best cement for fastening a rubber stamp to metal. The cement must stand frequent pressure upon the rubber without being loosened.—J. A. L

30. Metallic Piston-rod Packing.—Who are the makers of Cruikshank's metallic piston-rod packing, and what is their address? Also where is the United States Metallic Packing Co.'s packing to be had?—J. W.

31. Setting Slide Valve.—The slide valve of my "Fowler" traction engine does not admit steam evenly to both sides of the piston head, and although it seems to be set fair, yet steam enters for three-fourths of the forward stroke and only for one-third of backward stroke when in last notch of reversing lever. If I alter the valve rod so that valve works evenly, then, by putting reversing lever in second notch from centre, one port opens altogether, and the other one not at all, during a revolution of flywheel. Will some reader kindly point out where the mistake is?—Traction Engine.

32. Could any of our practical readers inform me how to calculate the thickness of liners to be put under a bearing next to a paddle wheel? Suppose a crank shaft of a paddle boat and the bearings next to the wheels in paddle box had dropped, I require the thickness to put under them so as to only have to lift them once or so. Centre of crank pin to centre of shaft, 2ft. Distance from face of crank cheek, 5ft. Difference the crank shows top and bottom centres, $\frac{7}{16}$in. Hints will much oblige.—Dummy.

33. Protected Bearings.—Could any reader inform me of a maker of protected lubricated bearings arranged for protection against dust, such as coal dust.—W. G.

34. Weight on Chock on Colliery Incline.—What is the weight resting on a chock placed across the rails of an incline which has a vertical rise of 1 in 12? Set of 30 tubs, each of which weighs 12 cwt. The chock prevents the downward movement of those tubs.—Student.

35. Locomotive Driving Wheels.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

TO CORRESPONDENTS.

H. M., Dover.—There is nothing novel in the use of a die and plunger for briquette making machinery. Such contrivances have been described and patented many times in brick-making machinery. Your invention must have something novel other than mere variation and alteration of proportions to entitle you to a valid patent. You should make a careful search through the hundreds of patents upon the subject.

G. J., Rotherhithe.—The word "adiabatic" is derived from the Greek, and is the name given to the curve of the expansion of a gas within a cylinder, behind a piston, when the gas is doing work upon the piston, and when there is no loss or gain of heat from the gas to the cylinder, or from the cylinder to the gas. It is also applied to the curve of compression when the piston compresses or does work upon the gas. The indicated diagram from a rapidly-moving compressing air pump gives a curvevery nearly that of the true adiabatic for air. The word really means "no transmission," and the curve is the curve of no transmission of heat. "Isothermal" means equal temperature, and an isothermal curve is a curve when the expanding or compressed gas maintains the same temperature throughout its whole course. Read our articles commenced this week—Vacuum Condenser—on steam engine matters, where we shall treat such questions in a simple way.

Vertical, Chorley.—Write again and give more particulars of your engine. State style of governing gear, whether automatic cut-off or throttle, size of cylinder, &c. Your letter contains too little information for a definite reply.

H. J. R., Watford.—The spirally-welded steel tubes are not made or sold in England to our knowledge; they are only recently introduced in America. Write to J. C. Bayles, Esq., care of The Franklin Institute, Philadelphia, U.S.A.

M. E., Newport.—There is no technical dictionary covering the civil, military, mechanical, and electrical professions. There are several good technical dictionaries on the separate sciences and professions.

Valve Gear, Cheltenham.—We have not yet seen the prospectus of the proposed German floating exhibition. The official patent offices of Germany, France, and the United States are in their respective capitals, Berlin, Paris, and Washington, which addresses will find them. You will require to apply through a patent agent, so many formalities have to be attended to. Letters on their business must be in the language of each country. The patent laws of foreign countries vary, but speaking generally inventions must be worked, or rather manufactured, in those countries where a patent is granted. An English patent only covers Great Britain, Ireland, and the Isle of Man. Separate colonial patents are required, and in Australia several patents are necessary to cover the different divisions. Your engine query is not sufficiently clear to answer. What kind of a cut-off do you use, or is steam carried the whole stroke?

Engineer.—Siemens-Martin mild steel, and many brands of basic steel, are good for boiler purposes.

MISCELLANEA.

The rival to the Zalinski pneumatic gun invented by a Mr. Hicks, of the United States, is being exhibited in this country in the shape of a model, and is, we understand, about to be submitted to the inspection of the Admiralty authorities. Centrifugal force is the only power relied upon, the projectile being discharged from a steel disc revolving at a high velocity.

The scheme for constructing a new canal from Birmingham through the Potteries to Winsford to join the river Weaver, and so connect Birmingham with Liverpool by boats of 300 tons burden, is to be shortly laid before the district at meetings to be addressed by members of the Birmingham committee who have the matter in hand. The strong feeling at present existing as to the necessity for cheaper transit of heavy goods, which has been deepened by the Railway and Canal Traffic Bill legalising terminable charges, is an important element in favour of the probable success of the project.

We have received from the International Patent Agency, 27, St. Martin's Lane, London, their pamphlet upon patents and patent laws. It contains much information of value to inventors, both upon British and foreign patents, together with full particulars of the various expenses incurred in procuring such patents through them, which expenses, we observe, are all unusually low.

Production of Quicksilver in Russia.—*La Nature* points out that quicksilver was discovered in Russia in 1879, close to Nikitowka. In 1885 a company was established to work a mine, and this company began its labours in 1886. During the first year, 1887, the mine produced 3,911 pouds of mercury, that is to say, 141,187lb. It is estimated that the whole quantity of ore in the mine amounts to about 12 millions of pouds, of which 1·2 per cent is mercury.

Egyptian Tramways.—The *Revue de l'Orient* says that the Egyptian Government has agreed to lay down two new lines of tramways, one from Old Cairo to the Limoun Bridge, with an extension over the Abbasleh, and two branches to Boulak, one from the Abou-Lela Bridge, and the other the Limoun Bridge. The second line will proceed from the Kasrel Nile Bridge to the Pyramids, with a branch to Boulak-Dakrour. Tenders are to be received at the Ministry of Public Works until the 15th of April next.

Development of the Jute Trade in Germany.—The Belgian *Bulletin du Musée Commercial* for the 16th February last states that the attention of Hamburg traders is drawn to the extraordinary development in Germany of the weaving of jute *(corchorus olitorius)*. The German merchants are too impatient to allow themselves to be supplied with this product through England, and two steamer services have recently been established for the special purpose of bringing jute from Bombay to Bremen and Hamburg direct.

The Newport-Pagnell authorities are having a tube well driven down into the lower greensand formation, in search of a supply of water for the town of Fenny Stratford. The site selected by Mr. John Eunson, of Northampton, under whose directions the work is being carried out, is near Little Brickhill, about three miles from the town. The contract has been entrusted to Messrs. Le Grand and Sutcliff, hydraulic engineers, of London, and the first 100ft. has been bored in fourteen days.

The copper output of the United States in 1888, as estimated by Mr. C. Kirchoff, jun., of the U.S. Geological Survey, was 230,403,581lb., of which 225,494,425lb. were domestic copper, and the remainder from imported ores and pyrites. The output of 1887 was exceeded by nearly 46,000,000lb. The total production of spelter in the United States in 1888 was by the same authority 55,913 tons of 2,000lb., against 50,340 tons in 1887, and it was larger than any year since 1882.

The proposed Winner Bridge over the Missouri river at Kansas City is thus described by the *Times* of that city. It will be built of iron and steel, have two 270ft. and four 420ft. spans, with 57ft. headway above high water under the bridge. In width it will provide for one standard-gauge railroad track, two street or motor lines outside the main trusses, and two foot ways. The total length, including approaches, will be 7,050ft. The piers will be of masonry, founded on pneumatic caisons, carried down 50ft. to 88ft. below the water surface. Rumour has it that this bridge will be utilised by the Chicago and North-Western R. R. as an entrance to Kansas City, and also used by a dummy line leading to land of Mr. Winner, located fourteen miles north of the city. The estimated cost of the bridge is 1,000,000 dols., and the engineers are Messrs. Waddell and Jenkins, of Kansas City.

Engineering Society, King's College, London.—At a general meeting of this society, held on March 19th, the president in the chair, Mr. Barratt read a paper on Gas Engines. The paper commenced with a brief review of the progress of the gas engine since Robert Street's invention in 1794, and several inventions were named which introduced features still retained in modern gas engines. Gas engines were then divided into three classes by the author, viz., (1) Single-cycle Engines; (2) Double-cycle Engines; (3) Three-cycle Engines. The Stockport and Robson engines were then briefly described, illustrating the first class; a description of a gas generating apparatus, shown at Nottingham in connection with the former engine, was also given. Atkinson's cycle and differential engines, and also the Clerk engine, were then described, and the great advantages arising from the differences in the length of strokes of the Cycle engines, and also from the quick expansion of the gases due to there being four strokes per revolution, were pointed out; and the action of the link-motion by which this is obtained was explained. The "Otto" engine was taken as an example of class 2, and described in detail with the various forms of governors, &c. The "Beck" and "Griffin" engines were then described in illustrating class 3, and the advantages of using a scavenger charge of air to cleanse the cylinder of the products of the former explosion was pointed out. The author then concluded with some remarks on compression and on the economy of the gas engines (efficiency tables were given of all the engines described). The great economy arising from the use of Dowson gas was discussed after the reading of the paper.

The Bore of Hangchow Bay.—Captain Moore, of H.M.S. Rambler, has lately described—in a paper read before the China Branch of the Royal Asiatic Society—the appearance and effects of the remarkable "bore" which often occurs in Hangchow Bay. This dangerous visitor is the result of the struggle between the advancing tide in the great estuary and the current of the river. Captain Moore and his officers on several occasions observed the progress of the wave, and their investigations may be summarised as follows: The rate at which the bore travels varies from ten to about thirteen miles per hour. The height of the bore rarely exceeds 12ft. or 14ft., and broken water, in which no small boat could live, follows it for some distance. With the passing of the wave the tide rises many feet in a few seconds; in one instance, observed by Captain Moore, it rose from 9ft. 4in. below to 4ft. 7in. above mean level. The rush of the bore was so strong that the force of the waves breaking against the broadside of the Rambler sent the water into the mizzen chains and the spray on to the poop. The junks in that region are protected by platforms, with narrow steps cut in the sides. To the north of the estuary is a great sea-wall, built to protect the surrounding country from being flooded by these great tidal waves. It is thirty-five miles long, and it is strengthened, where the bore strikes most strongly, by an elliptical stone buttress, 253ft. long by 63ft. wide. Behind this the junks are drawn up for shelter.

Development of Coal in Canada.—It is well known to geologists that in many parts of Western Canada there are extensive coal deposits, the successful working of which must be of great importance in the development of the Imperial traffic through the Dominion and on the Pacific. A large block of land, in which are thick and extensive seams of anthracite coal, has lately been worked by a Canadian company (The Canadian Anthracite Coal Company, Limited), in the Cascade district of the Bow River Pass, and with excellent results. This land covers the croppings of the veins, which dip from 32 deg. to 60 deg. in the side of the mountains, which rise from 500ft. or 600ft. to 2,000ft. above the croppings. A tunnel 209ft. long has been driven, and this is 45ft. above the water level, and cuts through 22 seams of coal. Three of these seams are being worked. The overlying seam measures about 9ft., of which 7ft. are coal; the middle seam has from 3ft. to 3ft. 6in of clean hard coal; and the underlying seam is about 5ft. 8in. with 10in. of slate near the centre of the seam. These are the only seams as yet practically tested, but from them about 15,000 tons of coal have been taken and shipped to the Pacific coast. The coal has been taken to San Francisco, where it has been graded as No. 1 free-burning white ash anthracite. As yet the work which the local Canadian company have been able to do has been more of a prospecting character than mining for the market, and so an endeavour is being made to open up the whole of this extensive coal-field by the employment of British capital.

ILLUSTRATED PATENTS.

15,316. Locomotive Engine Guards Applicable as Ramps, C. A. Noble, East Ham, Essex.

The construction of the guard or obstruction remover is such as to adapt it for use also as a ramp, and it is attached to the buffer beam or engine frame so as to be easily disconnected. Fig. 2 is a front view of a suitable form of the apparatus attached to the engine, and fig. 3 is a plan showing the ramps in position on the rails. Each guard consists of a plate, 1 having two flanges, 2 and 4 for bolting to the engine, and a flange 3 which serves to strengthen the guard and also to guide the wheels on to the rails when the apparatus is used as a ramp. The lower end of the guard may be provided with points 5 which bite into the sleeper, as shown in fig. 3. The apparatus is fitted to each end of the engine so that there will be a pair of right-handed and a pair of left-handed ramps.—November 9, 1887. [8½d.]

FIG. 2.

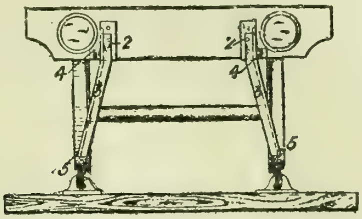
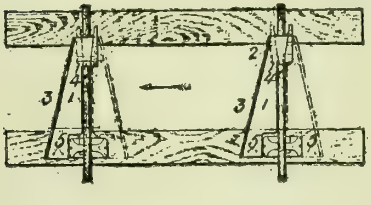
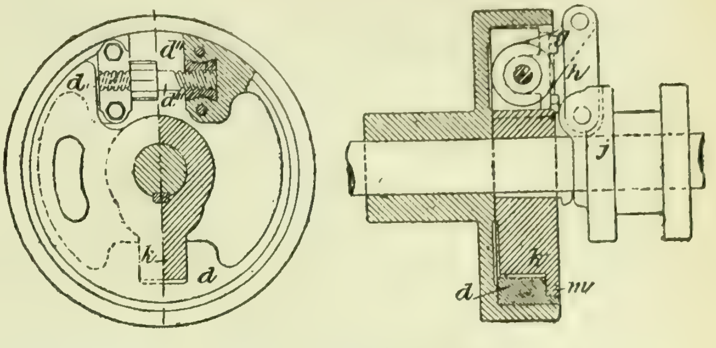


FIG. 3.



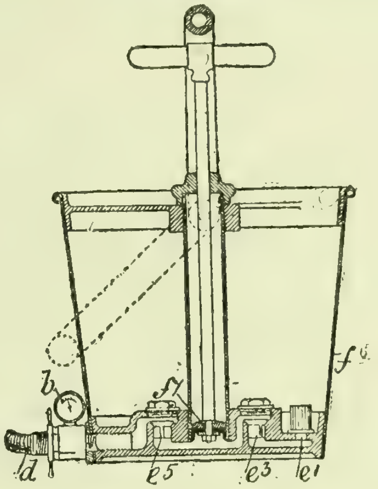
15,339. Friction Clutch, T. O. Arnfield, New Mills, Derbyshire.

The expanding friction ring d is cast separately from the driving arm k, which is provided with a lip m to keep it in position. It is expanded and contracted by a screw d^{111}, with right and left-hand threads engaging in nuts d^{11} in the ends of the ring and operated on by a lever g, link h, and sliding collar j. Adjustment for wear: The lever g is mounted on a polygonal boss on the screw so that when removed, and the screw turned to expand the ring through the angle corresponding to one of the sides, it may be again replaced.—November 10, 1887.—[8½d.]



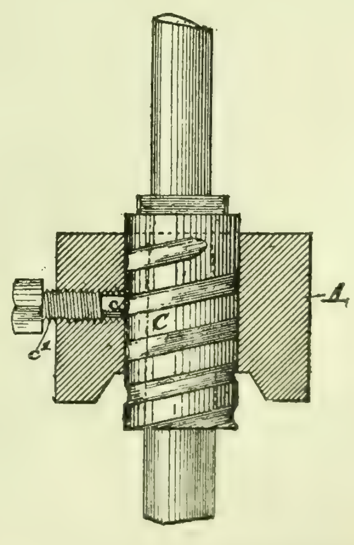
15,373. Vapour and Oil Burners for Lighting and Heating, R. Wallwork and A. C. Wells, Manchester.

Relates to means for supplying oil under pressure of types of burners described in Specifications Nos. 15,382, A.D. 1884, 15,228, A.D. 1886, and 3,543, A.D. 1887. In order to dispense with a separate pump for each lamp, the pump is combined with the oil tank or reservoir, which is carried or wheeled to the lamp to be charged. In the figure the oil is forced by the pump f^7 from the reservoir f^6 through the channel e^1, valves e^3, e^5, and flexible connection d to the lamp to be charged, the pressure being indicated by the gauge b. The pump, instead of forming an integral part of the reservior, may be secured to the outside thereof. The pump may be used to force oil into a vessel filled with air, or the desired pressure may be obtained by pumping air in a vessel partially filled with oil. With oil of greater or less specific gravity than water a fixed reservoir is used, the pressure being obtained by connecting the reservoir with the water main.—November 10, 1887. [8½d.]



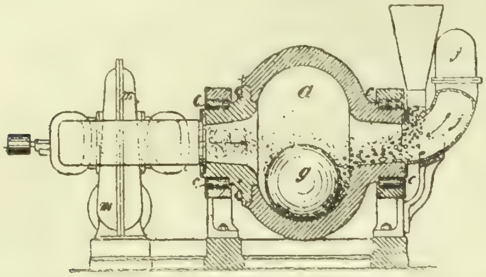
15,446. Adjustable Bearings for Spindles, T. K. Hattersley, Leeds.

Step and coned collar bearings. The exterior of the bearing C is provided with a helical groove into which takes a stud c forming the end of the binding screw c^1 passing through the rail A The upper part of the bearing is squared to receive a key for turning it.—November 11, 1887. [8½d.]



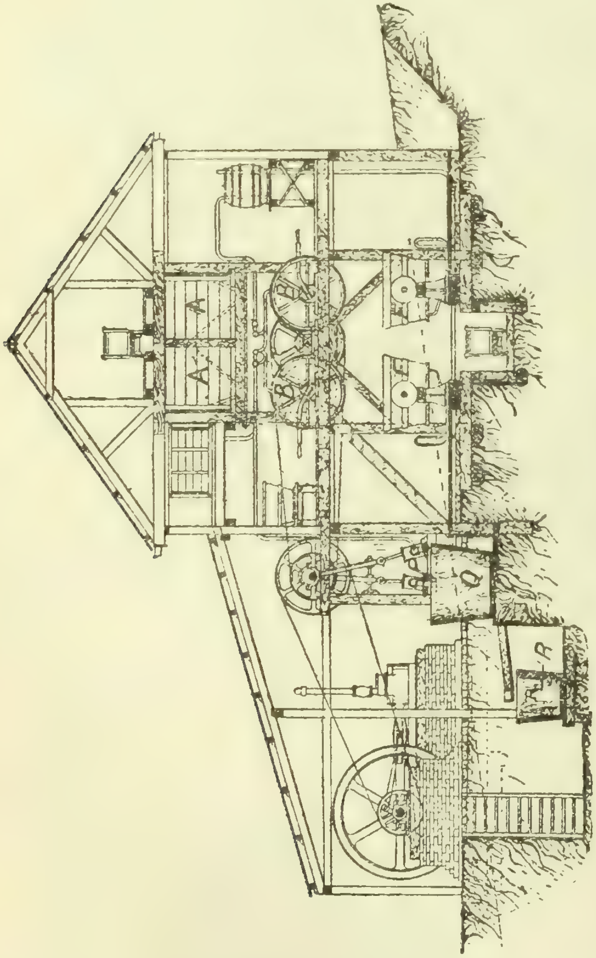
15,474. Pulverising Minerals, &c., H Hobson, Stoke-on-Trent, Staffordshire.

Ball and ring apparatus. The drum a has hollow trunnions which may run on roller bearings c, c; it may be driven by belt, spur, or friction gearing. The ball, bowl, or roller g may be hollow and loaded with lead or other heavy substance; it, as well as the interior of the drum, may be covered with hard plates, or be chilled or case-hardened. Its diameter varies from $\frac{1}{3}$ to $\frac{2}{3}$ that of the drum, which is formed with a removable end to allow of its introduction. For dry grinding the drum is connected up in a closed circuit with the fan m and a settling chamber. e feeding hopper k, which may be fitted with a vibrating shoe, delivers into the air pipe j leading from the settling chamber. For wet grinding the internal diameter of the outlet trunnion is larger than that of the inlet, so that the water overflows at that side, carrying with it the pulverised material.—November 12, 1887. [8½d.]



15,574. Extracting Gold, C. T. J. Vautin, London.

Relates to apparatus for the extraction of gold by the wet process. The pulverised material is agitated in a rotary vessel with chlorine under pressure or other similar reagent, the solution filtered off and decomposed. The drawing shows the general arrangement. A, A are hoppers whence the ores are delivered into the rotary vessels B, B, which are of iron lined with lead and with an inner lining of earthenware or similar hard material; chlorine is forced into the vessels and then air at a pressure of four or five atmospheres. The vessels are now rotated for a suitable time, and the contents run off into a special filtering vat F, from which the liquid is drawn off by a special pump P, described in Specification No. 15,575, A.D. 1887, which is arranged to produce a pulsation for the purpose of keeping the filtering medium clear. The solution is passed into the vat Q and agitated with steam or air to remove free chlorine, then into a filtering vessel R containing charcoal, which reduces it, and the gold can be obtained by burning, &c. November 14, 1887. [8½d.]



Patent, No. 15,574.

Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

16th November, 1888.

15,681A Multiplex Telegraphy, F. J. Patton, London.*

March 18th.

4663 Mortising Chisel, R. W. Little, London.
4664 Propelling Ships, J. G. Millwaters, Liverpool.
4667 Looms, W. Jackson and F. Jackson, Manchester.
4669 Pulleys, J. Wilson, Keighley.
4676 Furnace Fire Bars, Isaac Shaw, Chesterfield.
4679 Gas Engines, W. F. Bowen, Bolton.
4682 Furnace Bars, B. D. Healey, Bamber Bridge.
4694 Motor, C. Wells, Middlesex.
4702 Detaching Screw Propellers, J. Bower, London.
4704 Meters for Measuring Fluids, A. Goodwin, London.
4708 Gear Wheels, C. Lock, London.
4710 Gas Engines, W. Von Oechelhaeuser, London.
4729 Utilising Exhaust Steam, oseph Wright, London.*
4731 Purification of Iron, W. C. Roberts-Austen, E. J. Ball, and A. Wingham London.
4732 Type-writing Machines, H. H. Lake, London. (H. E. Tileston, United States)
4736 Steam Boilers, A. J. Boult, London. (Otto Mentzel, Germany.)

March 19th.

4742 Axle Boxes, W. A. Prestwich, Tottenham.
4745 Gas Regulator, J. Smyth, Bristol.
4750 Lubricators, J. J. Day and T. I. Day, London.
4753 Prismatic Compass, F. J. S. Cleeve, London.
4757 Looms, S. Walker and G. Leek, Radcliffe.
4758 Carding Engine, W. Lawton, Huddersfield.
4785 Steam Engines, W. O. Worth and J. D. Worth, London.*
4788 Bearings, J. B. Hardwicke, Lee.
4789 Pumps, J. C. R. Okes, London.
4795 Belting, T. Cudlipp, London.
4796 Superheating Steam, G. Schimming, Holborn.
4800 Electric Conductors, H. H. Lake, London. (A. A. Brooks, United States.)*
4802 Lubricants, W. T. Hicks, London.
4803 Engines, M. P. W. Boulton, London.
4815 Steam Engines, H. Knight, London.

March 20th.

4836 Steel Ingots, T. Doughty, Coatbridge.
4837 Valves, J. McAnelly, Gateshead.
4841 Rolling Trains, W. Bansen, Berlin.
4842 Gas Lamps, W. A. Fourness, Manchester.
4843 Elevators, W. G. Herbert, Liverpool.
4846 Electric Light Fittings, C. K. Falkenstein, E. Rosseau, and C. K. Falkenstein, London.
4847 Turn Tables, W. Williams, Cornwall.
4855 Flue Ventilators, G. Connell, London.*
4858 Purifying Coal Gas, J. Grossmann, Manchester.
4868 Steam Engines, G. W. Baker, Hoxton.
4869 Extracting Ammonia from Coal Gas, D. Irving and A. Cochey, Bristol.
4872 Colliery Cages, T. Morris, Pontypridd.
4875 Electrical Transmission of Power, M. Immisch, London.
4887 Breech-loading Cannon, C. B. Wharton and W. H. Topham, Essex.
4888 Screw Propellers, E. E. de Facien, London.
4898 Engines, M. P. W. Boulton, London.

March 21st.

4904 Furnace Feeding, T. Andrews, Sheffield.
4909 Riveting Machines, A. Purvis and W. Purvis, Glasgow.
4928 Warping Machines, W. G. Bywater and T. B. Beanland, Leeds.
4937 Furnaces, J. R. Fothergill, London.
4953 Railway-wagon Coupling Apparatus, A. H. de Wind, Belfast.
4956 Treatment of Steel, C. Jones, London.*
4957 Bridges, W. Lindsay, London.
4969 Manufacturing Gas, P. Tarrington and D. S. McDonald, London.*

March 22nd.

4970 Screws and Nuts, D. Gracey and R. N. Gracey, East Finchley.
4972 Engines, A. Gough, jun., London.
4973 Taps or Valves, W. Asquith, Halifax.
4974 Steam Engines, G. Holcroft and J. Grundy, Dolgelly.
4976 Valve Gears, R. Middleton, Leeds.
4980 Riveting Machines, W. F. Gilmer, Glasgow.
4989 Indicating Speed of Machines, H. S. Barron, Lewisham.
4990 Steam Generator Furnaces, P. McGregor, jun., London.
4992 Steam Pipes, J. Yates and G. Kay, London.
4993 Metallic Pipe Joints, H. Coulthurst, J. Coulthurst, and A. Coulthurst, London.
5003 Shearing and Punching Machines, A. F. Pasquier, Liverpool.
5005 Tube Stoppers, W. Dover, Liverpool.
5010 Galvanometers, F. V. Andersen, London.
5011 Gas Engines, J. Atkinson, London
5018 Steam Steering Gear, W. H. Harfield, London.
5028 Lubricating Compound, J. Annall, London.

March 23rd.

5047 Wind Motors, W. J. S. Barber-Starkey, Manchester.
5060 Lubricator, H. Pott and W. C. Readhead, Sunderland.
5063 Measurement of Electric Currents, E. H. Hungerbuhler and J. T Todman, London.
5070 Motor, C. Wells, Middlesex.
5072 Motor Engines, J. Southall, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE
PRACTICAL ENGINEER,
APRIL 12TH, 1889.

COMBUSTION.

A THOROUGH understanding of the nature of combustion is of the first importance to practical engineers and inventors, as in nearly all engineering industries at least part of the operations depend upon the successful burning of fuel in some form. In all types of commercial motive power engines the heat evolved by burning is the primary source of energy, and the apparent driving fluid, together with the necessary mechanism for its generation and action, are merely intermediate. Notwithstanding the great practical importance, and the pressing need for exact and exhaustive measurements of all constants relating to it, much yet remains to be done before it can be said that we thoroughly understand all the actions proceeding in a boiler furnace. The total amount of heat evolved by the complete burning of various fuels has been carefully determined and is known with a sufficient degree of accuracy; but the nature of the intermediate processes occurring during combustion, the highest temperature produced, the relative properties or characteristics of the various kinds of flame, and the best means of obtaining with certainty certain effects due to temperature, combined with chemical action, are all more or less undetermined. As a consequence of imperfect knowledge, it is impossible as yet to predict with accuracy the result which will be produced by detail alterations in boiler or metallurgical furnaces, and, unless previously tried, such differences in arrangement are necessarily experimental.

The chemical actions accompanying the burning of ordinary solid fuel are exceedingly complex. Coal consists of a combination, or rather many combinations, of carbon, hydrogen, and oxygen, together with some nitrogen. The first action of the heat is to cause a decomposition, or destructive distillation, similar to that proceeding in an ordinary coal gas retort. The gaseous and liquid hydrocarbons are driven off in several forms, including marsh gas and ethylene, which in burning produce the bright flame seen in firing with a flaming coal. This cokes the fuel, and the carbon itself then burns off, giving the clear, transparent, and non-luminous flame which is observed when a fire is red throughout, and the destructive distillation has ceased. If the layer of incandescent fuel be deep enough, a blue flame will be produced, due to the formation of carbonic oxide by the action of the hot carbon particles upon the carbonic acid, which is first produced when the air comes in contact with it, and unless sufficient air be supplied above the firegrate considerable loss will result. Carbonic oxide contains—or rather can evolve on burning completely—about two-thirds of the heat which the carbon it contains could do if burned directly; that is, about one-third of the whole heat which carbon can produce on burning completely is absorbed in forming carbonic oxide gas. This reaction forms the foundation of the action of all gas producers of the well-known Siemens and other types.

The question of the exact temperatures produced by the combustion of such gases in air and oxygen is still unsettled. Some few years ago, writers upon combustion, fuel, and furnace work unwarrantably assumed that the maximum temperatures of flames could be easily determined without actual experiment, and introduced the terms "calorific power" and "calorific intensity" to distinguish between the total amount of heat due to burning some particular fuel and the highest possible temperature it produced. The calorific power of a fuel is measured by the number of heat units evolved by a unit weight of it, such as one pound, while the calorific intensity is the heat evolved divided by the specific heat and weight of the products of combustion. Thus in the case of pure carbon one pound weight upon completed combustion to carbonic acid gas evolves as much heat as would raise 14,500lb. of water through 1° F., which is 14,500 heat units. This number is the measure of the calorific power. In the same way, one pound weight of hydrogen evolves 61,500 heat units, and its calorific power is 61,500. But these numbers do not express the calorific intensity or temperature produced by combustion.

It is obvious that the maximum temperature possible by combustion depends on the amount of heat produced, and on the capacity for absorbing heat possessed by the products formed. If the capacity for heat, for instance, of carbonic acid gas was the same as that of water, then the temperature would be given by the heat of combustion of one pound, but its capacity, or specific heat as it is called, is about one-fourth that of water. The heat necessary to raise one pound of water through one degree would raise one pound of carbonic acid gas at constant pressure of the atmosphere through four degrees. It is therefore necessary to divide by four to get the possible maximum. By calculating in the same manner for hydrogen, and allowing for the specific heat of the steam produced, the maximum possible temperature is 4250° F. Now, these are the temperatures usually given in the text books, and it was assumed that, if no loss occurred by conduction, such temperatures would be possible in actual work. Measurements of the temperatures of flame have been made by Bunsen, Berthelot, Mallard, Le Chatelier, and others, which most conclusively prove that numbers so high are quite erroneous, and that no flames in actual use attain any such great intensity.

In most cases only half these intensities have been attained under the most favourable circumstances; thus the maximum temperature of the combustion of hydrogen in air is 3,000° F. nearly, and of carbonic oxide in air 3,000° F. nearly.

During the past few years great additions have been made to our knowledge of the nature of flame, and considerable discussion has arisen on many interesting points closely touching practical matters, some relating to points in connection with gas-engine practice, and others bearing on combustion in boiler and other furnaces. All the observers are agreed upon the fact of the difference between calculated and real results, but all are not agreed upon the causes of the difference. Several theories have been raised which it is important that we, as practical men, should clearly understand.

According to the French observers, the specific heat of air and of the products of combustion changes with change of temperature, and increases enormously above the temperature of 2,000° F. The cause of the difference between calculation and reality is the increase which prevents the heat of combustion, completed at the highest temperature, from being manifest as increased temperature. The combustion is supposed to be quite complete at once, and, therefore, all the heat is really evolved at the highest temperature.

The German and English experimenters, on the other hand, do not believe in this increase or change in the properties of gases, but consider that combustion is not completed at once, even in the case of carefully-mixed gas and air, but that the carbon and hydrogen take a measurable time to burn, and therefore continue burning long after the highest temperature has been attained. One method of explaining this continued burning is the theory of dissociation. It has long been known that if steam be heated highly enough, it decomposes into its constituent parts, hydrogen and oxygen, by the mere influence of the heat, without the presence of any other substance chemically acting upon the hydrogen or oxygen. Carbonic acid gas in like manner decomposes into carbonic oxide and oxygen. The temperatures required are very high, and their exact values are not accurately known, but when the gases are cooled it is well understood that they combine again. The chemical decomposition by heat when recombination occurs during fall of temperature is called dissociation.

Dissociation, according to one theory, prevents chemical combination at the highest temperatures, and thus prolongs combustion by postponing it until some cooling can occur. Another English theory also supposes imperfect combustion at the beginning of the burning, and a continued combustion as time elapses. In furnace and gas-engine work it is of considerable practical importance to know which is the correct explanation, as the direction of future progress and improvement in results depend to some extent upon proper understanding of the point. Werner Siemens, for example, holds that in steel furnaces it is a great disadvantage to allow the flame burning within a furnace to strike directly upon the molten metal, and that great improvement results from preserving the flame free from contact with its enclosing surfaces, and allowing it to impart its heat by radiation; while other authorities hold the opposite view. Some consider close contact between flame and metal of a boiler, for instance, an advantage, while others fear too rapid cooling down of the burning gases as tending to cause imperfect combustion.

In our opinion, it is absolutely necessary, if the best is to be made of fuel in any form, that a sufficient free space be given clear of the close contact of small enclosing surfaces in which the combustion can occur, and when tolerably completed the hot gases may impinge upon cool metallic surfaces, but not till then. In gas-engine work, it is absolutely necessary to give sufficient time for the combustion at the beginning of the stroke, otherwise a most unsatisfactory diagram will be produced. In the discussion upon Professor Kennedy's recent paper at the Society of Arts, this point came up in connection with one of the gas engines decrisbed, and it seems to us that too high a piston speed is an undoubted disadvantage. What is gained by diminishing loss of heat to the walls is lost in heat discharged with exhaust gases, because of incomplete burning.

Further experimental work is still required upon the laws of combustion, and much good will doubtless follow a more intelligent understanding of the complex actions which go on in every flame or furnace. The specific heat theory of the French seems to us exceedingly improbable, even although emanating from experimenters so distinguished as Mallard and Le Chatelier, corroborated by Bertholet and Vieulle.

THE EIFFEL TOWER.

Amid considerable jubilation on the part of the Parisians, the great tower was finished last week, and the French now possess the loftiest edifice in the world. There still remains considerable work in fittings and decoration, and the hoists have to be erected, but as a structure it is practically complete. The design is by no means so inartistic as was at first feared; indeed, it is stated to be quite an ornament, instead of a blot, on the exhibition and its surroundings. Although interesting from an engineering point of view, yet its comparative uselessness detracts somewhat from our admiration for a well-planned and excellently-constructed work in which very considerable difficulties were most ingeniously conquered.

The height of the tower is 984ft. (300 metres), and it is built of wrought iron of a total weight of 6,500 tons. It consists of three parts: first, a base having four legs, forming a square of 340ft. each side. The legs slope up to the first gallery, and then at a steeper angle to the second, where they unite into one, and are carried to a third gallery at about 900ft. from the ground level. Springing from this there is a campanile, carrying the upper platform, which is of small size.

The foundations are built of massive masonry, and the booms rest upon them through hydraulic rams. Each boom, or leg, consists of four square tubes of wrought iron 1in.

thick, terminating on a hydraulic ram, upon which a pressure of 800 tons can be exerted. There are 16 of these rams, so that they could together lift 12,800 tons, or about double the actual weight of the whole tower. They were used in adjusting accurately the position of the booms while building, and are also intended to compensate for any slight settling of the foundations tending to cause departure from accurate verticality.

Compared to the Forth Bridge, either as an engineering feat or as a work of public utility, the Eiffel Tower is insignificant; but still it has an interest of its own, and doubtless it will be mounted by millions of visitors, who will be enabled to enjoy a delightful and unequalled panoramic view of Paris and its surroundings.

MILL GEARING.

At the monthly meeting of the Leeds Association of Engineers and Draughtsmen, held on Thursday, March 28th, at the Wheat Sheaf Hotel, Leeds, the president, Mr. J. C. Moorhouse, in the chair, Mr. Alfred Towler, M.I.M.E., read a paper on Mill Gearing. He introduced his subject by describing some of the earlier methods for the transmission of power. The old millwrights, he said, were possessed of great ability and ingenuity, and were the pioneers of modern engineers, civil and mechanical, but this fine old race to which we were so much indebted was rapidly passing away and being succeeded by men of scientific culture, who have less of the instructive faculty as the result of increased theoretical knowledge. The invention of the steam engine and the development of machine tools gave mill gearing a great impetus, and wood, which was almost the sole constructive material used, had been superseded by iron and steel. Mr. Towler proceeded to describe various forms of teeth, their proportions and properties under various conditions, and also the effect of high speeds and shocks. Backlash, he said, was due to varying angular velocity caused by irregularities in the shape of the teeth pitch and pitch circle. This was attributable chiefly to the difficulties in approaching perfection. Some have been surmounted by cutting the teeth by machinery. This was being carried out to a very great extent in America, and there was undoubtedly a growing tendency in this country in the same direction. Backlash increased with the velocity, and ultimately we reached a velocity at which it was unsafe to run toothed gearing, the backlash becoming so great that the teeth literally hammered each other off. The maximum speeds at which it was possible, under favourable conditions, to run toothed gearing safely, were as follows:—

Ordinary cast-iron wheels	1,800ft. per minute.
Helical " "	2,400ft. " "
Mortice " "	
Ordinary cast-steel wheels	2,600ft. " "
Helical " "	3,000ft. " "
Special cast-iron machine-cut wheels,	

The horse power of toothed gearing could be determined by the following formula:—

$$\text{N.H.P.} = \sqrt{(D\ R)}\ P^2BM$$

$M = \cdot 15$ for cast steel
$M = \cdot 043$ for cast iron
$M = \cdot 05$ for wood
$P =$ pitch in inches
$B =$ breadth in inches
$V =$ velocity in feet per minute
$R =$ revolutions per minute

Main driving by belts, Mr. Towler said, originated in America, and it was in that country that the effect of the atmosphere on a broad flexible belt running at a high velocity on large drums was first ascertained and taken advantage of. The conditions favourable to belt driving were then considered together with the materials used in the manufacture of belts, their breaking and working strength. Leather, he said, had depreciated in quality and strength as the result of the more rapid process of tanning, and although it was possible for it to attain as high a breaking strain as 8,000lb. per square inch of section, the ordinary leather strapping was not more than half that strength. Chain belts for high speeds over small pulleys were highly recommended, especially where it was desirable to have a uniformity of speed and pressure on the bearings, as is the case with dynamos and modern corn-milling machinery.

Mr. Towler went on to say that the most modern form of main driving was by rope gearing. Previous to its introduction, a want had long been felt for a means of transmitting and distributing power noiselessly at higher speeds than it would be safe to run toothed gearing. Strap gearing, although well suited for the transmission of power at high speeds, was equally unsuitable where the power required to be distributed to several shafts, on account of the room taken up. In this respect rope gearing had achieved all that could be desired. The various proportions of grooves for ropes of different sizes were given, and the standard angle was stated to be 45 deg. Of the two materials used for ropes, viz., cotton and hemp, the former was decidedly the best for mill-gearing purposes, because it was the least affected by atmospheric changes. Ropes gave the best results which were made with a central core, and had a working strain from 1 to 2 per cent their actual breaking strength.

The author concluded his paper (which was illustrated with diagrams and templates) by generally comparing the first cost, efficiency, durability, and maintenance of the three systems.

Messrs. Moorhouse, Brayshaw, Atkinson, Elsworth, and Tempest took part in the discussion.

COUNTER-BALANCING MACHINERY.

By Francis Campin, C.E.

Almost, if not quite, the only destructive force acting upon machinery which defies calculation is that which in various forms is called into action by vibration. When we come to deal with vibration, theory is at a loss, for practically no data can be fixed upon which to construct a definite hypothesis, and those vibrations which are of the nature of tremors are the least susceptible of measurement.

It is for this reason that the greatest attention should be bestowed upon this question, for although we may not be able to estimate the amount of detrimental action with any approach to accuracy, yet its nature and mode of operation may be ascertained, and hence, in some cases, it may be entirely suppressed, and in others reduced to a minimum.

The great danger to be dreaded from vibratory action is that the impulses causing it may become isochronous with the vibratory periods of the matter acted upon, in which case ultimate failure becomes a matter of time only. A little explanation will render this obvious. If a bar is subjected to a transverse force it will be deflected, and if deflected beyond some fixed amount it will bend permanently, if malleable; if otherwise, it will break; and to cause such a result at one application, a force of an ascertainable amount must be applied. Our present object is to show how a very much smaller force, repeatedly imposed, may lead to a similar end. If a body is deflected, and instantly released from the acting pressure, it will not merely resume its original form, but will pass beyond it to a distance somewhat less than the deflection originally caused, and thus vibration will be set up that will continue to diminish until it ceases, when the work upon it has been absorbed by internal molecular friction, and, to be strictly exact, external atmospheric resistance. Let the force be regularly applied at such intervals of time as to accord with that occupied by one vibration, then each incidence will fall so as to increase the amplitude of the vibrations already set up, and if continued for a sufficient time, this extension will outstep the limits of the safe deflection of the element so treated. The most striking way in which this can be illustrated is by supposing a case of a heavy body standing on end, which cannot be upset by the united efforts of several men, but which, nevertheless, can be set rocking by one man, and by his repeated efforts at proper intervals ultimately overturned. In such an experiment there is sufficient time between the oscillations of the mass for the regular application of the recurrent impulses; but the vibration of materials under stress is far too rapid to admit of such manipulation. For this reason the experiments that have been made upon repeated loads upon bars, up to the number of some millions, have not helped us to any data that can be applied to calculations connected with vibration, and the engineer is still left to rely upon his judgment in these matters, and that will lead him to make sure of being on the safe side, and therefore, if he errs, it will be in the direction of using more material than is absolutely necessary, thus increasing the cost of the work he has in hand beyond the limits of strict economy; but so long as those limits cannot be defined he is certainly not much to blame, especially as an error in the opposite direction would be far more serious in its results.

A great deal is to be done in the arrangement of the framework of a machine, which should be so ordered that all the stresses, where possible, are met by direct and not by transverse resistance of the material of which it consists, and when the stresses produce compression ample lateral stiffness must be supplied. Beyond the framing of the machine, however, the effects of vibration command attention—in the marine engine in regard to the results produced upon the hull of the vessel, and in the locomotive in respect to wear and tear of permanent way.

The vibration of machines being due to unbalanced forces developed in connection with the movements of their parts, it is to some equilibration of these forces that we must look for a remedy, and to that end the nature of the necessary movements of the machine must be studied with great care, for it occasionally happens that by counter-balances improperly applied the evil which was intended to be mitigated has been aggravated instead, the material added having given rise to additional disturbance instead of counteracting that originally existing.

The balancing of revolving elements such as cranks and eccentrics is very simple, as the same weight which balances them when at rest will serve equally when in motion, the centrifugal force of the counterbalance equilibrating that of the crank, although their centres of gravity may not be equidistant from the axis of rotation. This appears from the formula $\frac{w v^2}{g r}$ where w = weight; v = velocity, and r = radius of circle passing through the centre of gravity of the mass. The weight of the crank and that of its counterpoise when at rest must vary inversely as their distances from the axis of rotation, and the velocities will vary directly as those distances, which also are the radii of the circles of revolution, hence the proportions which obtain equilibrium in the one case apply equally in the other. When, however, the reciprocating parts are involved, the results are different. When the engine is at rest the connecting-rod is supported on the crank pin and the guide blocks in proportions dependent upon the position of its centre of gravity between those points; now the weight thus resting on the crank pin can be balanced by a fixed counter-weight, but the forces produced by the motion of the connecting-rod cannot be equilibrated by a load moving round a fixed centre, for the motion of the centre of gravity of the former is not in a circular path, and its centrifugal force will be proportionately less as the path of its motion is of greater radius. From these considerations we draw that if the crank-counterbalance is to be increased in order to modify the vibrations due to the connecting-rod, the additional weight should not be equal to that brought upon the crank-pin when at rest, otherwise when in motion, there will be an unbalanced centrifugal stress upon the main shaft. The proportion of the counter-weight must be determined for each particular case. Of course the connecting-rod could be balanced by a similar piece moving in an opposite direction, but such an arrangement would be far too costly and cumbersome for adoption.

All large wheels and heavy revolving pieces should be accurately made and carefully balanced, otherwise there will be a constant tendency to bell out the bearings, and so bring a cross strain upon the shaft and set up a continuous tremor throughout it. It is highly important to keep the bearings close up to heavy wheels, as, if they are far enough off to allow of the shaft becoming sensibly deflected, very considerable cross strains will occur, compounded of the weight of the wheel and centrifugal force arising from the deflection of the shaft below its true alignment to the bearings; and the cross strain must be varying in intensity, if not also in character, throughout each revolution, perhaps subjecting the material to constant alternation of strain between tension and compression.

Rocking or oscillating elements should always be balanced in order to relieve the bearings or dead-centres, as the case may be, from unequal strain, and no bearings in the case of fixed machines, except they are for very light work or for the shafts of regulating levers, should be so placed as to overhang the foundation if it can be avoided. Cams and eccentrics should also have counter-weights. By attending to these matters, although some extra trouble and expense may be incurred in the first instance, yet it will be found profitable in the end, and the machines will not only be more durable and require fewer repairs and adjustments, but they will work more satisfactorily and with less lubricant than others of ruder design.

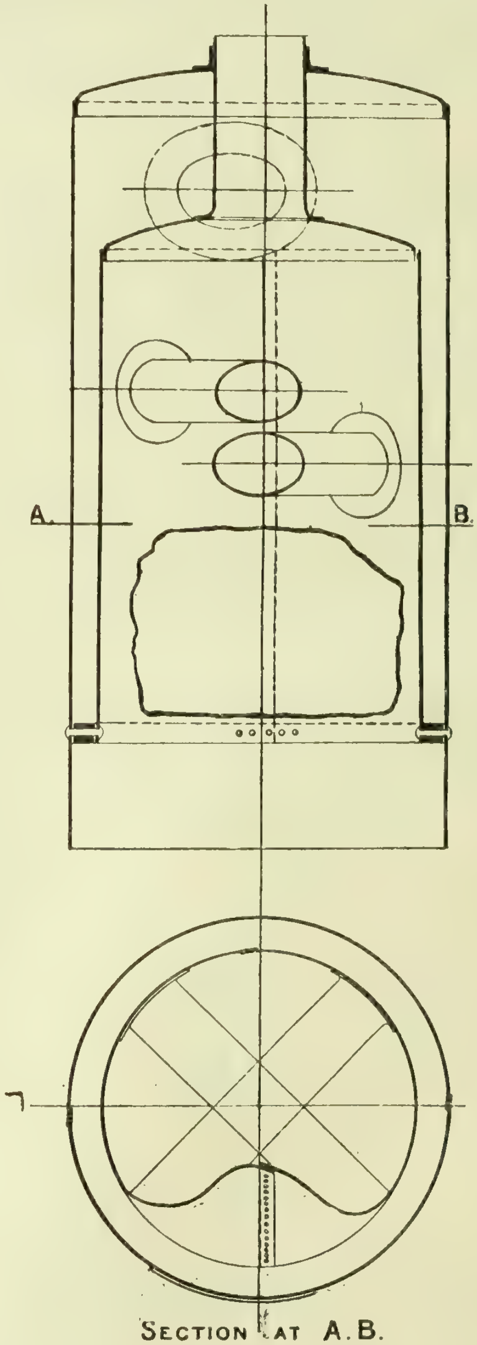
MELBOURNE EXHIBITION.—We are informed that Messrs. W. and J. Galloway and Sons, Knott Mill Ironworks, Manchester, have been awarded the first order of merit, with special mention, for their well-known "Galloway" boiler, tubes, &c. This boiler has furnished steam for the exhibition, and has given great satisfaction.

BOILER EXPLOSIONS.

BOARD OF TRADE REPORTS.

(Continued from page 194.)

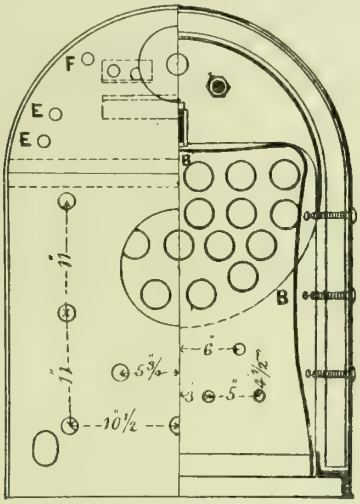
REPORT NO. 296 refers to an explosion which occurred on board a small launch at Beverley, in Yorkshire, on October 25th last. The boiler was of the ordinary vertical type, but the firebox, as will be seen from the accompanying illustration, which is taken from the Board of Trade Report, was abnormally high for the size of the boiler, and the surrounding water space exceptionally deep and narrow. The explosion arose from the collapse of the firebox, which was bulged in from top to bottom at one side, and torn open as shown in the sketch. The reaction of the issuing steam and water tore the boiler from its fastenings and projected it into the river, while three men on board at the time were more or less scalded and otherwise injured. The report attributes the explosion to the weakness of the firebox, which was seriously wasted by corrosion, coupled with the overheating which would be sure to arise from the defective circulation resulting from the narrow water space. The boiler, it should be observed, was under the inspection of the Boiler Insurance and Steam Power



SECTION AT A.B.

Company, and was examined by one of their inspectors on June 5th, 1888, and reported to be in satisfactory order. From the defective condition of the plates, however, revealed by the explosion, it would appear that the inspector was deceived with regard to their thickness.

Report No. 297 refers to the blowing off of the cover of a bleaching kiln at Heaton Mersey, near Manchester, on September 20th. The kiln itself was seriously damaged by the explosion, and the cover in falling smashed through the roof of a shed some distance away, but no person was injured. The kiln measured 5ft. in length by about 4ft. in diameter, and the cover, which consisted of a dished plate riveted at its outer edge to a cast-iron ring, was hinged to another cast-iron ring riveted to the cylindrical body. Apparently it had been intended to secure the cover by means of eight bolts, but at the time of the explosion one of them was left out, while two others adjacent were in a defective condition, in consequence of which the plate was incapable of withstanding the ordinary working pressure of 50lb. on the inch, and was blown off in the manner stated.



END ELEVATION.

Section through Firebox showing where it was forced off the stays

Report No. 298 deals with an explosion that occurred near Folkingham on the 18th of October. The boiler, which was of the locomotive multitubular type, and employed for grinding grain, gave way at the right-hand side of the firebox, the flat plate being forced over the ends of six of the screwed stud stays, when the issuing steam and water so severely scalded the owner that he died a few days afterwards. From the report it appears that the failure of the stays was due to the wasted condition of the firebox, the plate at the stay holes being barely one-eighth of an inch thick, while the riveted heads of the stays were completely eaten away. Indeed, looking at the wasted condition of the plate, it is a matter for surprise that the boiler should have withstood the ordinary working pressure of 45lb. so long as it did. It should be mentioned that the boiler was not under the care of any inspection or insurance company, while it is also worthy of note that the safety valve, as is so often the case with boilers of this type, was loaded with a spring balance, unprovided with any stop ferrule to prevent overloading, so that it could be locked fast by simply giving the regulating nut a few extra turns.

Report No. 299 deals with the fracture of the cast-iron cover of a stop valve on board the steamship Bryn Glas, at Newport, on August 4th. The casualty, which was of a comparatively trivial character and confined to the fracture of the cover and three of the studs, was caused by the wheel of the valve being forcibly turned the wrong way through an act of inadvertence on the part of the engineer.

THE Addyston Pipe and Steelworks, at Addyston, Ohio, is said to be the largest pipeworks in the world. The pipe foundry is 1,000ft. long by 168ft. wide, and nine other buildings are 225ft. by 150ft. each. The company makes its own gas, and uses gas as fuel to operate the hydraulic machinery used in handling the pipes. The pig iron comes from Alabama, Tennessee, and Georgia, and the capacity of the works is now 85,000 tons of manufactured material per annum. The works cover 110 acres, and practically support a town of 6,000 inhabitants.

THE TRANSMISSION OF POWER BY ELECTRICITY.

(Continued from page 237.)

THUS far I have considered the distribution with a practically constant potential at the motors, and the parallel method of distribution, as distinguished from the constant current method, where the motors are in series. This last, for large powers and many machines, is a limited and unnatural method, the former a comprehensive and natural method, which facts are entirely independent of the question of relative electrical potentials or currents, because, on constant potential circuits, we can work at 100, 1,000, or 5,000 volts if we choose.

Among some of the special cases of power transmission I will briefly note the following :—

6. The transmission from one point to another, using two series wound machines, where the motor has a constant torque or a load per turn. The motor being at rest, as the electro-motive force of the generator is raised by increasing its speed, or by increasing the resistance of a shunt around its field with any given speed, the current, which may be expressed by

$$\frac{E}{K}$$

will increase until the torque is great enough to start the motor against its load, when the current will become stationary. A motor electro-motive force being now created, the current is expressed by

$$\frac{E' - e}{K} = \frac{E}{K}$$

Any increase of the electro-motive force of the generator will be followed by an equal increment in the motor electro-motive force, the difference between the two, and hence the current, remaining perfectly constant. The speed of the motor being known for one electro-motive force and load, its speed for any other electro-motive force may be determined, and fast or slow hoisting be regulated entirely at the generating station.

7. The transmission to one point from another, with a single generator and a single motor with variable loads, presents two solutions. The first is the use of the compound dynamo and differential motor ; but a far more interesting solution is the use of two series machines, which, when properly proportioned, become perfectly self-regulating. I will briefly touch upon the theory of this method of transmission. We have the condition that the same current passes through each field and armature, and also the condition that the speed is constant, while the work is variable. Since work may be expressed as a product of speed and torque, and since the speed is constant, it follows that the motor torque must vary directly as the work. Again, we have as an expression for the work done the product e C. Since the speed of the motor is constant, e must vary directly as the strength of the field, which, where the magnetisation is low, will vary directly as the current, and when more highly magnetised in a much less degree. E being E . m . f of the generator and K the resistance of the circuit, we have—

$$C = \frac{E - e}{K}$$

and, as we have already stated,

E varies as e, as E—e, as C,

and work—

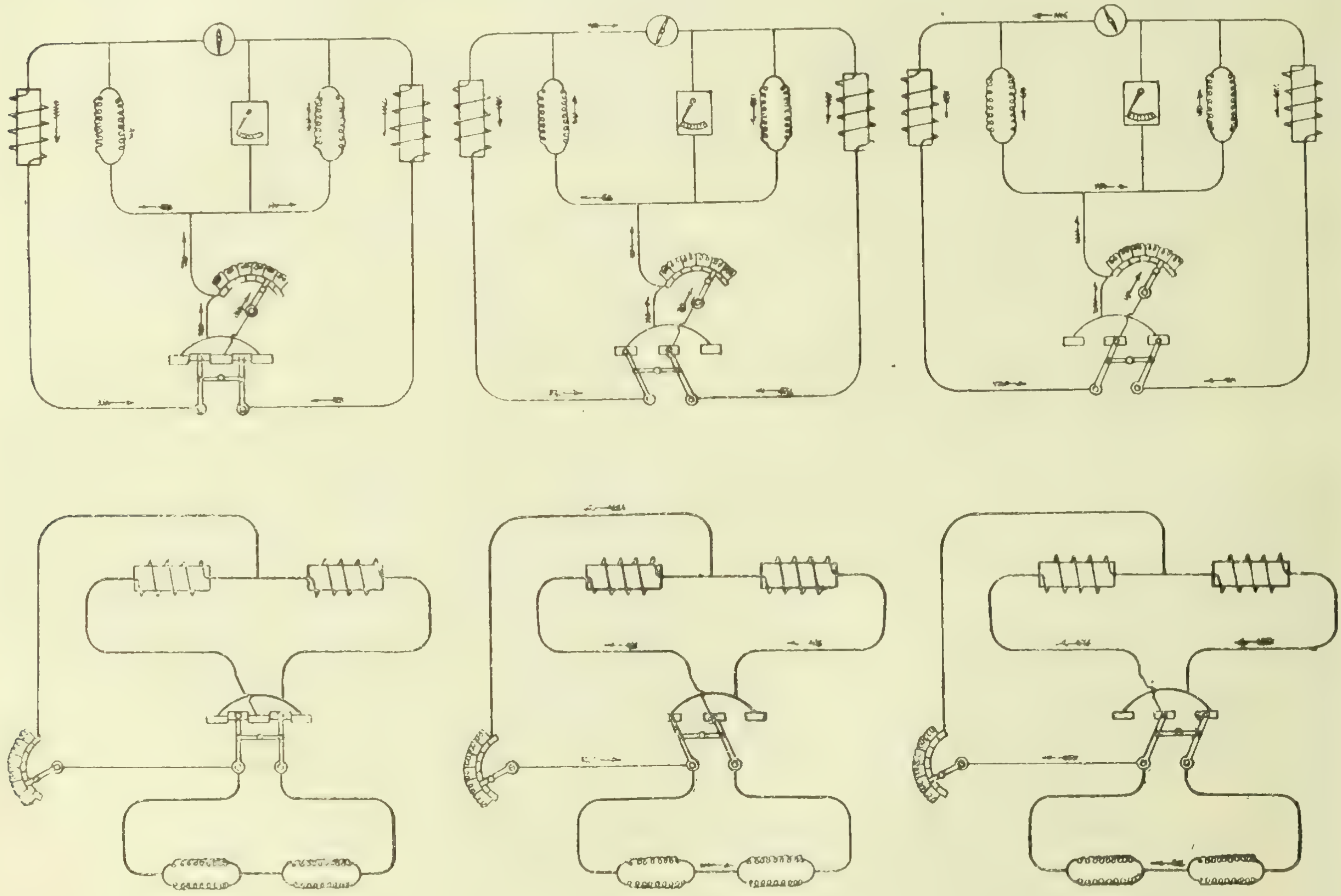
varies as e C, as C^2, as e^2, as E^2.

The dynamo likewise being driven at a constant speed, E likewise varies as the strength of its field. If m equals the number of turns of wire in the dynamo field, and n those in the motor field, then the ampere turns or magnetising forces are expressed by m C and n C. It follows from what proceeds that the magnetisations due to m C and n C should vary in the same proportion ; in other words, the characteristics of the generator and the motor must be similar between the limits of the variation in load. Should the machines used be improperly proportioned, then the regulation can be largely determined by putting a resistance in the line circuit, or shunting one or other of the fields with a resistance. The electrical efficiency of the circuit being

$$\frac{e}{E}$$

we have the following fact : That the electrical efficiency is a constant for all loads with the limit of automatic regulation. If the machines are of the same general type, then, when correctly proportioned, the ratio of their weights and watt capacities should be the same as the electrical efficiencies of the circuit.

8. As a modification of the preceding, especially where large powers, long distances, and necessarily high potentials are used, it is advisable to divide the generators and motors into a battery of machines of identically the same weight and character, the number of the machines being the ratio of the electrical efficiencies, the generators all to be driven from the same line of shafting, and the motors to drive on to a common line, and the current to pass through all the machines in series. This I consider the only sound method when dealing with large powers and high potentials and single units of generation and recovery, especially where automatic regulation is required. Its advantages are manifest. One of the greatest difficulties which we have in dynamo-electric construction in closed-circuit machines, especially where using the drum system of winding, is the difficulty of securing perfect insulation when high potentials are used.



One thousand or 1,200 volts seem as high as it is now advisable to go in machines of this type, where currents of any magnitude are to be used. In the transmission of electricity reliability is an essential, and a potential of 3,000 or 4,000 volts, distributed over three or four machines in series, is, despite the increased number of machines, far less liable to cause failure than where put into one machine of the aggregate size of the four; and in the event of the breaking down of one machine, the units may be so proportioned that by a corresponding change in the units at the other station, or a proper variation of the regulating shunt to the fields, it becomes quite possible to continue automatic operation. As an illustration of this distribution of machines, if wishing to use dynamos and motors of an electrical efficiency of about 95 per cent, a commercial efficiency each of about 90 per cent, and with about 60 per cent as the total commercial efficiency of the circuit, I would, with a distance of about nine miles, use five series machines identical in construction, each wound for about 1,200 volts, three of which machines would be driven by a common line of shafting at the generating station, and two driving on to a common line of shafting at the receiving station. It will be noticed that both in the single and multiple unit series system the electro-motive force and the current vary equally. I hope at an early date to be able to show this last system in practical operation.

The indirect methods of transmission, such as through a secondary battery of generators, motor generators, and secondary batteries, I will not here discuss.

I come now to the consideration of some new, interesting, and very practical formulæ for determining the elements of a single transmission of a given amount of power. Before entering upon its discussion, it is necessary to state why I differ somewhat from the methods which have hitherto been published.

Those who have followed with any particular interest the progress of the development of the transmission of power by electricity must be more or less familiar with the early experiments of Deprez and the papers by Professor Lodge and Mr. Gisbert Kapp. The experiments of Deprez have not had that practical result which had been hoped for them, and it seems to me as if an attempt had been made to go further than commercial demands warrant. We must avoid the consideration of the subject from a purely theoretical light. No system of transmitted energy can be made profitable unless the cost of the same at the far end, including not only the actual cost of production, but the capitalised value of the possibility of accident due to the fact that the prime source of energy is not under immediate control, shall be less for the transmitted energy than the price that would have to be paid for its production there by water, steam, or some other agency. As attractive as the use of water power appears as a prime source of energy, its uses are very limited, and every year will become more and more so; and unquestionably the great future of the transmission of power by electricity will depend upon the fact that in a large proportion of cases it will be cheaper to carry energy in the shape of electricity on a wire by the shortest cut between two points than to pack it up in the shape of wood or coal on the back of a mule or behind a horse. I have no sympathy with the theoretically possible but really impracticable consideration of the transmission of power from Niagara to New York; for Niagara has a far greater value as a sublime spectacle than as a commercial factor in metropolitan affairs. I will then in my estimates confine myself to that which is practical and possible, and will consider the conditions under which power shall be so transmitted. Messrs. Lodge and Kapp have deduced some very interesting formulæ, but one of the conditions which was taken into account by them was that of leakage. In a purely theoretical study this is as it should be, but the transmission of power by electricity, to meet the demands of actual life, must above all things be reliable; and by this I mean, not merely certain to supply power at the end of the line, but to deliver a definite percentage under perfect regulation and a known cost. This cannot be done with the uncertain and variable element of an unknown but material leakage; for if this leakage exists, then it must be a variable quantity, depending not only upon the condition of weather, but likewise upon the continual variation which exists in the electro-motive force when the load is not constant. We meet them with the condition that in the successful installation of a plant for the transmission of power we must be free from material leakage; that is, the leakage must be so small under all possible conditions of service as to never interfere with the efficiency and reliability of the transmission. Hence in the formula which I in practice adopt to determine the elements of my work, I shall assume a line of practically perfect insulation. I am justified in this, because the additional expense to secure this desirable result is more than compensated for by the reliability of the service. We can only accomplish this by the most careful line erection and choice of insulators. It can be materially aided by running the positive and negative leads each on an independent line of poles, and perfectly clear of all trees, and of course a well-covered wire can be used. When a double line of poles is used, it is advisable to wrap the lower ends with bare wire for a distance of about six feet above the ground, and to connect these bases together; or, if the poles are close together, a galvanised iron or copper wire should be taken around each pole at the distance given, and joined together. This is to avoid the possibility of a serious shock in wet weather, which might be received by a person leaning against a wet pole if any accident should occur to the line insulators when very high potentials are used.

In the formulæ which are given, I shall make use of the term "couple efficiency." As long ago as the spring of 1888, Drs. John and Edward Hopkinson made tests of efficiency of double conversion with the Edison-Hopkinson and Manchester dynamos, the efficiency of the former rising at times to over eighty-seven per cent, and of the latter to nearly seventy-eight per cent. No others have made so thorough an analysis of the action of dynamo-electric machinery, and my own experience warrants me in assuming, for the purpose of this paper, a commercial efficiency of double conversion, where two machines are connected by a metallic circuit of no appreciable resistance, or what I have called the "couple efficiency," of not less than eighty per cent, which is only allowing about ninety per cent commercial efficiency for the dynamos and motors. It will oftentimes rise higher than this, but I think it advisable in a specific formula to adopt a perfectly safe figure. This couple efficiency for either single, shunt, or series machines, or nests of machines, is easily determined with considerable accuracy and small expenditure of power. The method I prefer was one independently proposed, but similar to that first put into practice by Dr. John Hopkinson, that English scientific investigator to whom we all owe so much. It may be termed the variable differential method, and depends upon the use of an electro-mechanical couple. The first diagram illustrates the testing of two shunt-wound machines. Two such machines are belted to a common line of counter-shafting having three pulleys, each being given its proper speed. To the third pulley is connected a motor of about one-third the capacity of one of the machines to be tested, this motor being one of a perfectly well known commercial efficiency, and provided with means for varying its speed; or, if desired, the power can be transmitted through a good dynamometer. The like terminals of the large motors are then connected together, an ampère meter put into this circuit, and a potential galvanometer connected across the terminals. One terminal of each field is likewise connected to its proper line, and the other terminals of these fields are brought to the movable levers of a two-way circuit changing switch. One contact is carried to the main line, and between it and the other two is inserted a variable resistance, which in the middle position of the switch is short circuited. We have, then, the two large motors connected in an electro-mechanical couple, and to the same shafting is connected a third motor. The main dynamo being started, the switch set in the middle position, the motor is speeded up, which sets the counter-shafting in operation and drives both the machines as dynamos, each exciting its own field. If the machines are symmetrical, no current whatsoever will pass over the branch connecting the two; they are simply in the position of two dynamos in parallel circuit with each other, with no external circuit and no path over which the current can flow except that through their field magnets; consequently, very little power, save that of friction, is taken. The switch being moved in one direction, the resistance is thrown into the field of one machine. The electro-motive force which it develops at this particular speed is now reduced; it becomes a motor, and current will flow over the connecting mains from the other machine, which is still a dynamo, which current is roughly expressed by the quotient of the difference of the electro-motive forces of the two machines, divided by the resistance of the circuit. By varying the resistance in the fields this current can be made of any value up to the limit. We have here, then, one machine acting as a motor, and driving on to the counter-shafting with a certain number of horse-power, this countershafting driving the other machine as a dynamo with a certain greater amount of horse-power, this second machine furnishing the current which operates the first as a motor. The deficit, or loss of efficiency between the two machines and the friction is supplied by the third. By reversing the switch the resistance is first cut out of one field, and then thrown into the field of the other machine. This machine now becomes a motor, and the other machine becomes a dynamo. This reversal is not instantaneous, because it takes time for the field magnets to charge and discharge. The ampère metre will drop to zero, and will then rise again progressively.

This method of testing can be used for two purposes, one for testing the actual horse-power developed and the couple efficiency, which can be done by measuring the current, the electro-motive force between the machines and the horse-power delivered to the shafting by the third motor, and for the other purpose of testing simply the heating capacity of the armature coils with a given number of ampères. For this latter purpose it does not matter practically whether the machines are run at their normal speed and generate their normal electro-motive force, or whether some lower electro-motive force is used. If a lower electro-motive force is present, it simply means that there must be a greater ratio of difference between the field magnet strengths and a larger resistance used with the reversing switch.

When desiring to test the two series machines, the connections are somewhat different, and are illustrated in the second diagram; the machines, of course, being mechanically connected as in the first instance. We can similarly test a multiple unit series system; and in all these cases, by the introduction of an artificial resistance into line, we can produce all the phenomena of an actual long-distance transmission. This method of testing, where there can be an immediate variable and controllable reversibility of the dynamo and motor, and test of the efficiency of transmission under widely varying conditions, illustrates in one of the most beautiful ways the flexibility and utility of electric transmission.

Assuming then, that we have no leakage, and that our dynamos and motors have a definite known efficiency, we will take up the consideration of a few formulæ.

Let l = distance between the generating and receiving stations in feet, plus the sag.
n = number of effective horse-power to be delivered on the motor shaft.
E = electro-motive force at the terminals of the motor.
v = number of volts fall of potential on the line.
$E + v$, or E', being, of course, the electro-motive force at the beginning of the line or the terminals of the generator.
a = efficiency of the motor.
CM = circular mils of conductor.

An electrical horse-power is 746 watts, watts being the product of current by electro-motive force. Then for any horse-power n, a motor efficiency of a and an e. m. f. of E at the motor terminals, we have the number of ampères equal to—

$$\frac{746n}{Ea} \qquad (1)$$

Allowing m ohms as the resistance per mil-foot of copper, the total line of resistance would be

$$\frac{2\,m\,l}{CM}$$

for a complete metallic circuit. From the above we have for the drop or fall of potential on the line.

$$v = \frac{746\,n}{E\,a} \times \frac{2\,m\,l}{C\,M} = \frac{1492\,n\,m\,l}{E\,a\,C\,M}$$

or

$$C\,M = \frac{1492\,n\,m\,l}{E\,v\,a} \qquad (2)$$

substituting for m its approximate value, 10·5,

$$C\,M = \frac{15666\,n\,l}{E\,v\,a}$$

(*To be continued.*)

CLIFFORD'S NEW MINERS' SAFETY LAMP.

We now illustrate in detail Mr. Clifford's new patent safety lamps for mines, described generally in our issue of March 22nd, and which was recently exhibited at a meeting of the Manchester Geological Society. The Phœnix Lamp, as it is to be called, is very novel in construction, and is designed with the object of providing great resistance to the passage of flame, even at the highest velocities of current, while its construction enables it to give a good light, capable of sufficiently illuminating the roof as well as the sides of the workings. To this end, ordinary lamp types, having glass cylinders surmounted by cylindrical gauzes, are entirely departed from. Fig. 1 is a vertical section; fig. 2, a transverse section upon the line AB; fig 3 is a plan of the oil vessel and attachments, with the upper portion of the lamp removed. A glass cylinder surrounds the flame, and is firmly held in position by asbestos washers. The upper portion is contracted in diameter, and is covered by a metal hood, which forms part of a segmental pillar or box E, cast in one with the base portion F, or attached to it in any other substantial manner. This base is fitted tightly against the oil vessel by means of the shackle hinges L and O, which are of special construction, and jointed in a thoroughly safe way. The gauze is a flat sheet G, bent to fit the segmental portion (fig. 2) of the box pillar E, and protected by the shields or bonnets C, H, K. The main bonnet C hinges at D to the pillar portion E, and when unhinged the gauze is open for inspection and cleaning, if need be. The gauze is forced between the segmental surfaces of the bonnet and the pillar E.

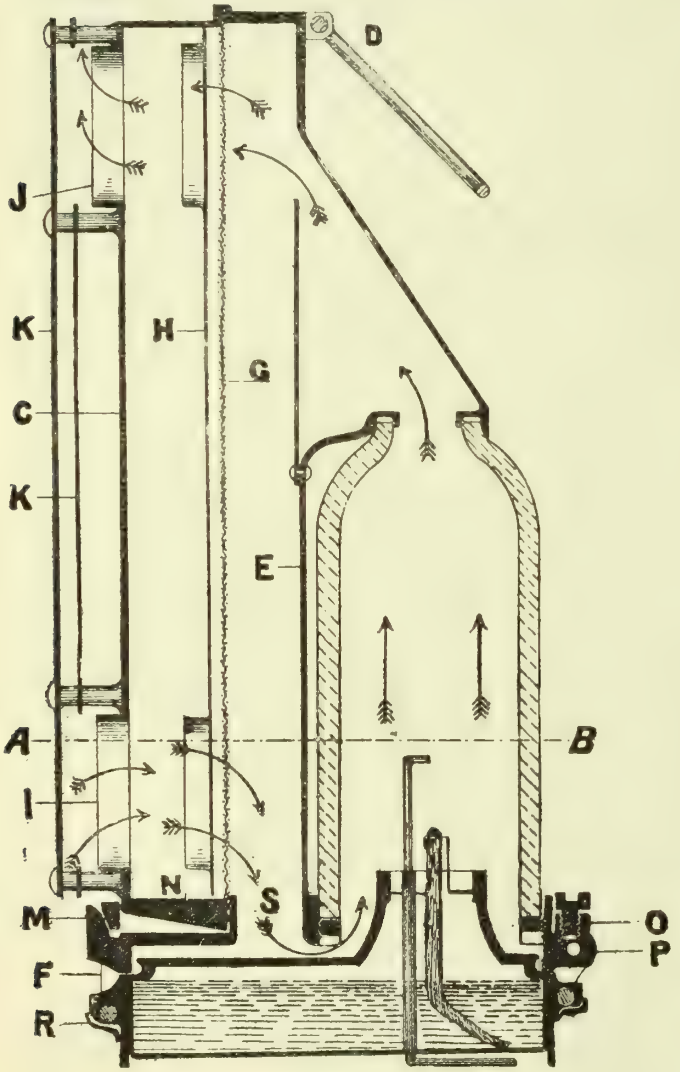


Fig. 1.

The action is as follows: When lit, the oil vessel is safely fastened in position by the shackles or yokes, and the air supply enters the bonnet at a passage I, which is shielded by a metal plate K. It then finds itself in a space within the bonnet, but still separated from the gauze by the internal shield H, which has two apertures opposite to I, but not in direct line with it. The air reaches the gauze by these apertures, and passes through it into the space S; from thence it flows under the glass by the annular space shown, and passes upwards to the flame to supply the combustion. The hot products then ascend, and flow out at the top of the glass by the hood into the upper portion of the space enclosed between the gauze G and the pillar E; then, as shown by the arrows, through apertures in the shield H and the passage J in the bonnet C, which is protected similarly to the air inlets. By this method the light from the flame is free to strike upwards with but little obstruction above, and although the air supply is from below the flame, the gauze is not placed under the wick, and is free from chance of clogging by spilling the oil. A plentiful supply of air thereby enters the lamp, and it is not sensitive to tilting or movement. The complete arrangement of shields and bonnet prevents the possibility of any current of whatever velocity from impinging directly upon the gauze, and thereby renders the lamp safe in explosive currents.

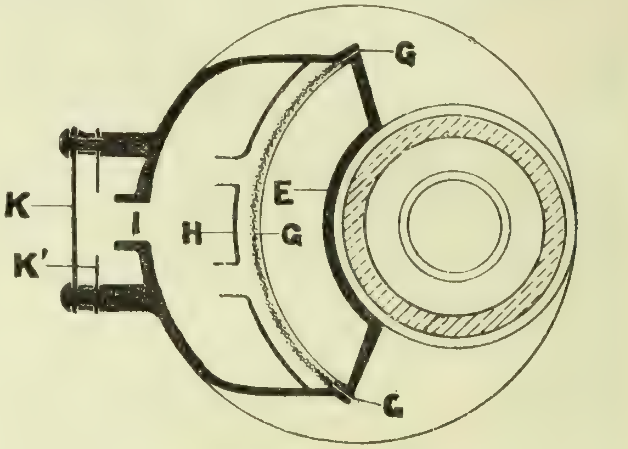


Fig. 2.

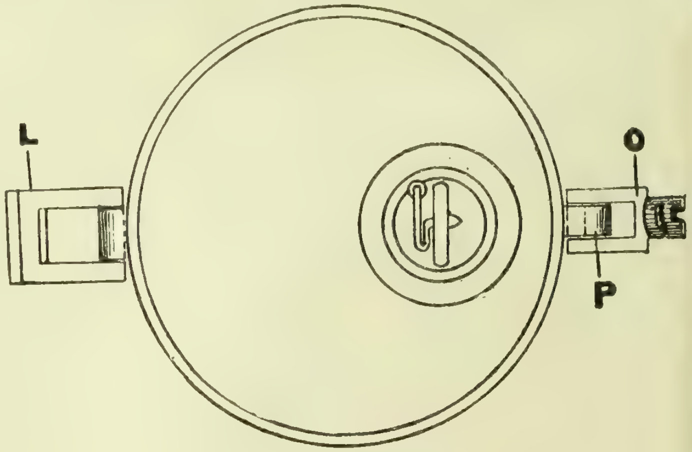


Fig. 3.

The shackle L is made with an inclined face to press against the projecting inclined piece or wedge M, so that when closed by hinging from R the portion N of the bonnet will be firmly pressed against the gauze to make a joint. The gauze may be fastened to the segmentary edges of the box E in various ways, but in any case it is exceedingly easily got at for inspection. When the yoke O is slipped over P, it may be strained up by screw or fastened with a lead rivet. Mr. Clifford's lamp is most ingenious, and we shall be much interested in the results obtained with it in daily practical work. In principle it seems to us sound and capable of giving very good results, both as to safety and all-round illuminating power. It might be advisable, however, to make the glass conical, and to protect it with suitable rods.

We understand that the lamp has successfully withstood an exceptionally high velocity test.

A seam of natural gas, with a daily flow of 14,000,000 cubic feet, has been struck near Columbus, Ohio.

THE INSTITUTION OF CIVIL ENGINEERS.

At the eighteenth ordinary meeting of the session, held on Tuesday, the 26th March, Sir George B. Bruce, the president, being in the chair, the paper read was on "The District Distribution of Steam in the United States," by Dr. Chas. E. Emery, M.Inst.C.E., of New York.

The author stated that in the United States the comparatively new industry of the transmission of steam underground from a central source of supply for a distance of a mile and upwards, and its distribution to buildings "on tap," the same as gas or water, had already been developed to an extent and had achieved an importance not generally known. The paper referred to the distribution of steam with imperfect apparatus to detached buildings in the United States Naval Academy at Annapolis, as early as 1853; and cited the patent of Mr. Birdsill Holly, in 1877, which provided for a series of stuffing boxes separately anchored at the ends of pipe sections of about 100ft., with service outlets in the stuffing boxes, from each of which steam could be delivered from a stationary point as readily as from a steam boiler. The author had designed and constructed the steam plant of the New York Steam Company, which had in use a length of about five miles of main steam pipes, much of which was 15in. and 16in. in diameter. The steam was distributed at the high pressure of 80lb. per square inch from a boiler station in which the boilers were arranged in four stories at the sides of central fire rooms, and the products of combustion were discharged into two chimneys. The plant was designed for boilers of 16,000 H.P., 12,000 H.P. being in position. The coal was carried by machinery to the top of the boiler-house, emptied into a bin, and distributed through shoots to each boiler floor at the sides of the furnace doors. The ashes passed from the ashpits through suitable shoots to the basement, and were discharged into cars, which were raised by a lift to the roof of a building in the rear and emptied into carts for removal. In constructing the street work the author dispensed with stuffing boxes, which were undesirable on account of the constant attention required to prevent leakage, and designed and applied a special expansion joint for which the word "variator" had come into use. This joint was provided with diaphragms of thin corrugated copper, supported on radial backing-plates spanning the annular space represented by the exposed radial length of the diaphragm. The fatigue of the metal in the diaphragms of this joint had been thoroughly tested in advance by experiment, and the device had proved entirely successful in practice, providing for expansion without leakage, and not needing attention. This system was, after its introduction, adopted by the original Holly Company for all subsequent plants, and many of the older installations were altered to use it. Steam plants on this plan were in regular use in 23 cities in the United States. Two companies started in opposition to the Holly Company had failed, and three others, licensed under the patents of that company, had been suspended on account of financial difficulties. The paper was accompanied by illustrations showing full details of the improved expansion joints and of the various connections to enable the work to be carried on without stopping for special arrangements. Ball joints were used at every street corner, and finally on the back of each expansion joint provided with a single diaphragm, whereby slight changes in line or grade could be readily made even with the large pipes, and all strain prevented in connecting them. The pipes, in lengths of about 16ft., were generally provided with flanges, whereby they were readily lowered into and adjusted in the trenches; and the joints, both flat and ball, were made with gaskets of thin corrugated copper covered with a coat of paint, and squeezed flat in place by the use of heavy flange bolts. A duplicate system of pipes for return water was laid in the same trench with the steam pipes. The larger pipes were supported by piers capped with stone placed about 15ft. apart; independent brick walls were built at the sides; the space between the pipes and walls was then filled with mineral wool, and the conduit thus formed covered with cross planks and roofing paper. At the dips in the pipe traps were placed to carry off the water of condensation, and there were traps for draining the pipes and blow-offs, to which access was obtained from manholes. The expansion joint developed considerable thrust, which was received on large castings anchored in the brickwork. The main outlets, which were placed in the stationary bodies of the expansion joints, were each 3in. in diameter, and generally closed with a screw plug, which could be removed through an ordinary gate valve, while steam was on, by a special tool; and a steam supply for 80 to 100 H.P. could be obtained in a few minutes. Most of the large pipes were made of lap-welded wrought iron tubing ¼in. thick, which was rolled into flanges with an improved boiler-tube expander. Losses by condensation in this system of steam distribution were, contrary to general belief, very small. The principal difficulty was with leakage, as every one of the numerous valves leaked a little, and there were occasional leaks such as occurred in all steam work; but they could be kept under control with a properly organised force. The largest volume of steam was consumed during ordinary business hours, but there was an appreciable use in newspaper offices, eating-houses, and for some manufacturing operations, during the night. The consumption in summer for power was about one-half that during the winter. The double pipes of the average size cost, under the conditions in New York, $12·34 per foot, although such cost was charged at about $19·00 per foot on the books, to cover incidental expenses, engineering developments, and financial expenditure, incident to the establishment of a new undertaking. The company had expended, independent of work on another station, about £440,000; but of this a large amount could be properly assigned to other stations, provided the system were extended throughout the entire city. The author believed that similar plant could be constructed complete for about £240,000; and, where land was cheaper and the conditions less exacting, for £200,000. From a comparison of the increase in receipts year by year, he thought that, with the prices obtainable in New York, a handsome dividend could be paid on these amounts. A formula was given for calculating the sizes of pipes. The causes of the prevention of "water rams," which were injurious to under-ground steam pipes, were discussed, and the system used for settling with the consumers was explained. To avoid the confusion of a pound pressure with a pound weight, a pound of water evaporated into steam was called one kal, the price of which was charged from 30 to 70 cents per thousand kals to the consumers, according to the quantity used by each. The general introduction of steam enabled steam engines of any size to be worked in any part of a building, to drive machinery of any kind, to furnish electric light, and to pump water, &c.; and a building might be heated either with live or with exhaust steam on any scale. The introduction of steam thus supplied to dwellings would not only furnish heat when required, but reduce the cost and discomfort of laundry and culinary work. At any time of the day or night, by means of suitable vessels, the usual operations of domestic cooking could be carried out. The temperature of steam at ordinary pressures was insufficient for broiling and baking; but, with these exceptions, a family in a city with steam laid on could live comfortably in summer and winter without fire, and the attendant disadvantages resulting from smoke and the handling of coal and ashes.

MINING IN CHINA.

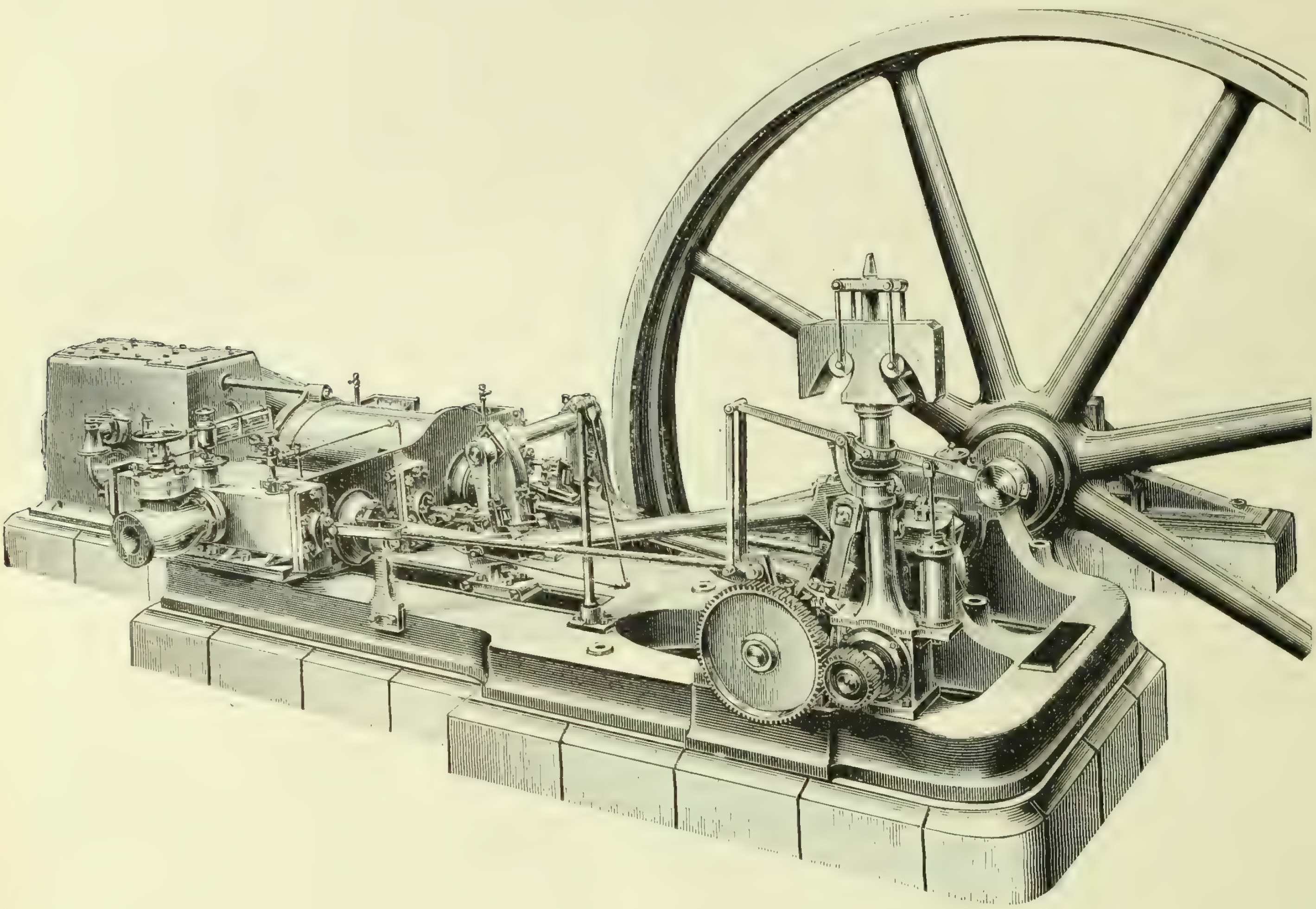
There are at present two collieries working with English machinery, the Kaiping Colliery, which is a very fine place, drawing over 1,100 tons per day, and the Keelung Colliery, in Formosa. No doubt China possesses vast mineral wealth, especially coal, which, it is said, is found in every province in the empire. But no coalfield has been much explored, except, perhaps, that in the northern part of the Province of Chili, in the centre of which are situated the Kaiping mines. This valley will undoubtedly in the near future be studded here and there with collieries, as the railways and other large engineering works are introduced and extended. But the collieries will probably be always in the hands of the Chinese companies, with English engineers superintending. The Chinese Government dislikes foreign companies having large works out of the Treaty Ports. The coal from Kaiping, some of which is of excellent quality, is used chiefly by the northern steamers, the Tientsin arsenal, the Chinese northern naval fleet, the city of Tientsin, and the country people; none of it is exported, except to Chefoo and Port Arthur. The seams worked vary from 2ft. to 54ft. thick. Coal, in this district, over a distance of some 200 miles, has been worked by the natives for two or three centuries, if not longer. Their shafts are never sunk deeper than fifteen fathoms (90 feet), and are generally about six feet in diameter. They are sunk a little to the dip of the outcrop of the seams, which lie at a gradient from 25 degrees to vertical, but, as the Chinese are ignorant of the principle of ventilation, the works never extend more than 150ft. from the shaft. The air then becomes short, and the native miners prefer to sink a new shaft, which is done at a very small cost. At the top of one shaft they set up a hand windlass, by means of which they draw water out of the mine in baskets containing about four cubic feet of water. The same method is adopted for lowering and raising the miners, and for bringing the coal to bank. The daily output at these native pits varies from 5 to 50 tons per day, and is chiefly all small slack and inferior outcrop coal. About twenty miles to the north of Pekin, anthracite coal is worked in the hills by the natives, and is carried to the city by camels. It is said that more than a thousand tons a day in winter time are brought into the city in this way. At a few places Chinese companies work, with varying success, lead, copper, silver, and gold mines with English plant and English and American supervision.

It is stated that all fast trains in Bavaria are now equipped with the Westinghouse brake. The Heberlein brake will be used on mail trains.

Bridge over the Indus.—The girders of the railway bridge over the Indus at Sukkur have been placed in position, and the bridge will be opened for public traffic early in April.

TWIN COMPOUND ENGINE.

Constructed by Messrs. W. & J. Galloway & Sons, Engineers, Manchester.



We illustrate above Messrs. Galloway's well-known twin compound engine, which is largely used in mill work, and gives admirable results in steadiness and economical consumption of fuel. In it the high-pressure and low-pressure cylinders lie parallel to each other and close together, communicating by a direct passage, and practically without intermediate reservoir of any considerable capacity. All the valves are of the slide type, and the admission valve, which is separate from the exhaust, to the high-pressure cylinder, is governed automatically from the governor by the well-known link gear, which secures an instantaneous cut-off. From the high-pressure to the low-pressure cylinder the steam passes also by slide valve, and after doing duty in the low-pressure cylinder it is discharged into the condenser by independent exhaust valves. The arrangements secure the minimum of clearances and smallest length, and therefore resistance, of ports, while the cooling action of the exhaust steam is reduced to the lowest point by diminishing the surface upon which it can act. It is not an uncommon belief among engineers that the evils of long ports and large clearance spaces can be entirely suppressed by sufficient cushioning, but this is a mistake. Far better reduce clearances to the smallest possible than seek to remedy the losses caused by excessive cushioning.

A careful test of one of these engines was made some years ago by the chief engineer of the Boiler Insurance and Steam Power Company, Manchester, at the mills of Messrs. H. Bazley and Co., Manchester, which it may be interesting to recall in these days of triple-expansion engines and increasing pressures. The engine had a high-pressure cylinder of 18in. diameter, low-pressure cylinder of 30in. diameter, strokes 3ft., and working speed 65 revolutions per minute. During the test, which was continued over two complete days' work, a consumption of 1·97lb. of fuel per I.H.P. per hour was easily obtained as an average result. As the engine was too lightly loaded, had 250 horse been taken out of it, the consumption per I.H.P. would have been considerably less. Still, this is a very favourable result, and one which we believe could not be readily excelled under like conditions of proportionate load, even with triple-expansion engines. The triple-expansion engine has great advantages, but we very much doubt if it could give greater economy at light loads than the simpler compounds. The boiler supplying steam during the tests was a Galloway, 24ft. long by 7ft. diameter, fitted with a Green's economiser, and the pressure varied from 70lb. to 80lb. per square inch.

PATENTS IN JAPAN.

A despatch, dated the 7th January last, has been received from the Hon. P. H. le Poer Trench, Her Majesty's Chargé d'Affaires at Tokio, enclosing copies of the new Japanese regulations respecting patents, which were issued on the 18th December under the authority of the sign manual, and which replace the regulations of a similar character published in 1885. Mr. Le Poer Trench in his despatch says:

"The new regulations provide for granting of letters patent to all inventors whose discoveries are beneficial, or calculated to improve existing processes of manufacture, articles of food or drink and medicines being, however, excepted.

"Sole property in an invention is secured by letters patent for a term of 5, 10, and 15 years, according to the fee paid. A provision is inserted with regard to the lapse of a patent, should the patentee fail to make public use of the patented article within three years of the date of the patent, or should he withdraw it from public use for a period of three years. The Bureau of Patents is placed under the supervision of the Minister for Agriculture and Commerce, and he has special power either to refuse a patent or to impose conditions upon its employment where the nation, from a military or a political point of view, is interested in the unrestricted use of the invention, or in keeping it secret. Foreign patents and foreign trade marks remain, as before, without protection in Japan, and they cannot receive protection as long as the provisions of Japanese law are not effective in respect of foreigners living in Japan.

"These regulations came into force on the 1st of February, 1889.

TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

(Concluded from page 242.)

As the added feed was not directly measured, it cannot be expected that it would be possible to obtain a complete heat balance from this trial. It is possible, however, to obtain one in which the error must be very small. The actual quantity of feed-water supplied from the weighed tank amounted to 407·5 pounds per hour. This quantity was raised from 63 deg. to 115·7 deg. F. by the addition mainly of condensed steam from the feed-heater. From various measurements made during the trial, it is possible to calculate (the details of the calculation need not be given) the amount of condensed steam added to the weighed feed. It must have been very closely 41·2 pounds per hour, making the total feed-water 448·7 pounds per hour. In the following account of the heat disposed of in the boiler (Table XV.) this quantity is taken as correct. Calculations similar to those made for Trial A_2 show that the quantity of air used per pound of coal was 20·8 pounds, so that, approximately, 21·8 pounds of furnace gases passed up the chimney for each pound of coal put on the fire. The complete analyses of the furnace gases are given in Mr. Wilson's report, and a summary of them is given in Table XIV.

TABLE XIV.

Constituent.	Percentage by volume.	Percentage by weight.
CO_2	9·98	14·60
CO	0·00	0·00
O	9·70	10·30
N	80·32	75·10
	100·00	100·00

It will be seen that on no occasion was any carbonic oxide found to be present. The mean chimney temperature was 355 deg. F., which, although higher than in Trial A_2, is still less than the temperature of the steam, owing no doubt, as before, mainly to the action of the coil as a feed heater.

The error of *plus* 1·6 per cent is, perhaps, not more than might be expected for a calculation in which one important item has had to be estimated.

Taking as correct the quantity of feed water per hour given above, namely, 448·7 pounds, the feed water per indicated H.P. per hour was 20·28 pounds, and per brake H.P. per hour 23·88 pounds, results a little better than those of Trial A_2. On the same basis, the heat turned into work is 12·26 per cent of the whole heat taken up by the water in the boiler, which is just 60 per cent of the quantity which would be turned into work by a "perfect" steam engine working between the same temperatures, and receiving the same amount of heat per hour. The heat taken up by the water amounts to 20,850 thermal units per indicated H.P. per hour, as against 21,350 thermal units in Trial A_2.

TABLE XV.

	Thermal units.	Percentages.
Calorific value of 39·7 pounds of coal (the quantity used per hour.................. }	564,000	100
Heat expended in raising 488·7 pounds of water from 201° to 384° F., and evaporating it at that temperature........................	462,000	82·0
Heat expended in raising temperature of furnace gases..............................	59,400	10·5
Heat lost by radiation (as before).............	51,070	9·0
Heat expended in evaporating moisture in coal (as before)..............................	570	0·1
		101·6

The steam shown by indicator cards (figs. 11 and 12) as present in high-pressure and low-pressure cylinders respectively, at the pressures already given (see Trial A_2), amount to 65·0 and 80·2 per cent respectively of the weighed feed water.

Trial B.—This trial took place on October 1st. Its nominal duration was three hours, and its object to test the working of the engine at about half its full brake power. It has not been thought necessary to work out the thermal results of this trial in so much detail as those of the full power trial. The speed of the engine was 138·1 revolutions per minute, and brake horse power 9·76, or almost exactly half of the brake power of the former trials. The weight of fuel used was 85 pounds, and the trial lasted 3 hours 7 minutes.

The mean boiler pressure was kept lower than before, namely, at 120·1 pounds per square inch, in order to avoid an extremely early cut-off. The quantity of feed-water was completely measured, as in Trial A_2. It amounted to 329·21b. per hour, and the coal per hour having been 27·25lb., the evaporation per pound of coal was 12·08lb. Reduced to standard, this amounts to 12·76lb. per pound of coal, or 13·09lb. per pound of carbon value. The mean temperature of the chimney gases was 369·1 deg. F.

The indicated H.P. on this trial was 12·32 (fig. 11), so that the mechanical efficiency of the engine reached 79·2 per cent working at half-power. The indicated H.P. expended in driving the engine itself—that is, the difference between the indicated H.P. and the brake H.P.—was 2·56 as against 2·61 and 2·68 in Trials A_2 and A_1 respectively, the revolutions having been very nearly the same in all three cases.

Trial C.—This was a short experiment of half an hour's duration, to determine the power necessary to run the engine alone without any load. The speed was 144·2 revolutions per minute, the indicated H.P. 2·32. The trial lasted half an hour, and six sets of indicator cards (fig. 11) were taken in that time. In nearly all of these the power shown on the low-pressure cards was negative.

Fig. 12 shows the indicator diagrams for Trials A_1, A_2, and B, expanded in the usual way. The diagrams in dotted lines are so drawn that their horizontal breadths at any pressure show the amount of *steam* of that pressure present in the cylinder, while the corresponding ordinate of the saturation curve shows the volume as steam of the same pressure of the whole feed-water per stroke.

SPEED TRIALS.

Attempts were made to obtain accurate records of the speed of the engines at every part of their stroke. Although these attempts were not so far successful as to justify a record of the results here, it may be well to describe the instrument used, as it has given perfectly consistent and satisfactory results elsewhere. This instrument was designed by Mr. H. B. Ransom, in the engineering laboratory at University College. It consists of a drum covered by a prepared and blackened (smoked) paper, which drum revolves with the shaft whose velocity is to be measured. Near to the drum a tuning fork is kept in vibration by means of an electric current. This tuning-fork is carried on a slide-rest, and is actuated by a screw in such wise as to travel parallel to the axis of the drum. One limb of the tuning-fork carries a light style of sheet brass, which rests in light contact with the drum. As the drum revolves, and the tuning fork vibrates, a wavy line is traced upon the paper. The number of waves in any length is a measure of the time taken by the drum in turning through a corresponding angle.

Observations were also made of the speeds at which the engine ran continuously with various loads, to determine the sensibility of the governor, the governor remaining untouched between the experiments.

Atkinson.—The speeds taken by the counter for one minute, in each case, were as follow :—

Revolutions per minute.	Load.
128·5........................	Full
128·5........................	Full
130	One-third
130	One-third
130·5........................	Light
130·75	Light

The difference between maximum and minimum speeds is thus only 1·75 per cent of the latter.

One feature about the working of this engine is particularly worthy of commendation, namely, its comparatively very quiet exhaust, which is due to the low pressure reached at the end of the expansion.

Crossley.—The dynamo was in all cases driven from the counter-shaft.

Observations were made for successive periods of five minutes, and the means taken, with the following results :—

	Revolutions per minute.	Explosions per minute.
Light, without counter-shaft..	164 9	10·5
Light, but drriving counter-shaft	162·3	19·0
With dynamo fully loaded :..	152-3	70·5
Dynamo, part loaded	153·2	53·6
Dynamo magnets only........	160·6	34·0

The difference between the maximum and minimum speeds is here 8·27 per cent of the latter, or 6·57 per cent if the running without the counter-shaft be neglected.

Griffin.—Observations were made with the full load and no load, with the following mean results :—

Loads.	Revolutions per minute.	Explosions.
No load.....................	204	14·3
Full load	199·6	118·0

The difference between the maximum and minimum speeds is here 2·2 per cent of the latter. It has already been mentioned that in this case we were able to ascertain that the engine was practically free from all cyclic variations of speed.

Paxman.—The following are the results of observations made with varied loads :—

Loads.	Revolutions per minute.
No load	148·5
Driving dynamo, light	140·8
Full load..................................	140·2

Appendix I.—Mr. Wilson's Report on Gas and Coal Analyses.

Coal Gas.—During each trial three samples of the gas supply were taken, at the beginning, middle, and end of the trial.

In each case the three samples were mixed together, and duplicate analyses made.

	Volumes of Dry Gas.		
	Crossley engine trial, Sept. 19, 1888.	Atkinson engine trial, Sept. 21, 1888.	Griffin engine trial, Sept. 27, 1888.
Oxygen .... Carbolic Acid	0·51	0·52	0·36
Carbonic Oxide	3·96	4·19	4 58
Olefines	3·77	4·07	4·04
Marsh gas	37·34	37·73	36·14
Hydrogen	50·44	48·56	50·94
Nitrogen	3·98	4·93	3·94
	100·00	100·00	100 00

Average composition of olefines : 1 vol. = 1·81 vols. $C_2 H_4$.

Flue Gases.—Paxman steam engine. In each trial six samples of flue gas were taken at nearly even intervals throughout the trial, and analyses of each sample made.

September 26, 1888 (Trial A_1).

	Volumes Dry Gas.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.*
Carbonic acid	8·42	10·07	9·29	9·73	12·41	7·01
Carbonic oxide	0·00	0·00	0·00	0·00	0·00	0 00
Oxygen	10·96	9·65	10·64	9·91	7·33	12·98
Nitrogen	80·62	80·28	80·07	80·36	80·26	80·01
	100·00	100·00	100·00	100·00	100·00	100 00

* This sample of gas was collected within one minute of the end of the trial, when the grate was very far from being in its normal condition. It has, therefore, not been reckoned in with the others in finding the average composition.

September 28, 1888 (Trial A_2).

	Volumes Dry Gas.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Carbonic acid	11·64	11·40	11·28	13·82	9·34	13 66
Carbonic oxide	0·00	0·00	0·00	1·90	0·00	1·46
Oxygen	8·26	8·24	8·67	3·99	10·19	4·26
Nitrogen	80·10	10·36	80·05	80·29	80·47	80·62
	100·00	100·00	100·00	100·00	100 00	100·00

Coal.—The coal employed for the Paxman steam-engine trials was carefully sampled, and gave on analysis :—

	Parts by weight.
Moisture	1·21
Carbon	84·54
Hydrogen	3·65
Nitrogen	0·84
Sulphur	0·81
Ash	4·48
Oxygen, &c. (by difference)	4·47
	100·00

HULL AND DISTRICT INSTITUTION OF ENGINEERS AND NAVAL ARCHITECTS.

The members of the above institution held their sixth meeting of the session on Monday evening, March 20th, at the Mechanics' Institute, George Street, Hull, the President (Mr. Geo. Bohn) in the chair. A very interesting and instructive paper was read by Mr. J. Harrison Leitham on the subject of "Boiler Construction, Past and Present," in which the history of boilers was traced from the beginning of this century up to the present time. The paper was copiously illustrated by drawings, some of which were over 50 years old. One of the most interesting features of the paper was a description and drawing of a steam boiler constructed of wood, which had done duty for a period of 14 years, with a steam pressure of 2½lb. above that of the atmosphere. Amongst the many marine boilers illustrated were some which were of special interest to Hull and district engineers, more particularly those of the Pacific steamers Victoria, Monarch, and Transit, and the original drawings of the boilers of the first-named steamer created great interest because of their explosion on the Thames over 50 years ago, which had then occasioned great consternation. At the close of the paper the writer drew particular attention to a number of points in boiler construction, as applied to present day practice, which were afterwards discussed exhaustively by the President, Messrs. J. Spear, R. Carson, J. R. Smith, F. H. Pearson, M. Allen, J. Jamieson, F. Brentano, T. Thompson, T. Smith, M. Stirling, H. F. Fourny, and — Harrison.

THE CHINESE AS ENGINEERS.

The Chinese are not great as mechanics, although some have a large idea of their own importance in this respect. Soon after steamships came to be much used off the coast, a Chinaman believed that he could not only build boats to be mechanically propelled, but that he could improve upon the steam productions of the people of the West. He induced a wealthy Chinaman in Shanghai to advance him a sum of money, to assist him in designing and constructing a boat, which was to be better than anything of ours. The Shanghai river has a very strong and rapidly-running tide, and it struck this ingenious Chinaman that he might use this tide for the propulsion of his new boat. So he had the boat built under his own supervision, with large side wheels, which were to be driven round by the force of the running water. These wheels were to be connected with two smaller wheels, and were to be the means of propelling the boat. The Chinaman had great faith in his absurd idea, and his boat, from which he and his friends expected great things, was actually launched. Much to the amusement of the various naval engineers in the port, the boat was of course merely washed down by the tide—a result that was foreseen by everybody except the infatuated Chinaman and his too confiding associates. But it is only fair to state that the working mechanics, who have learned their business in foreign shops in China, make clever and handy workmen, and often display no small amount of skill and ingenuity. They are also a most steady, sober set of men.

THE SHIPBUILDING PROGRAMME.

The return moved for by Lord Randolph Churchill of the number, tonnage, and cost of the effective ships of the Royal Navy afloat on the 1st of January, 1889, and the standard of strength required to bring the present number up to the proposed standard required in five years, has been issued. It appears that there were 62 armoured vessels, with a tonnage of 431,880 tons, costing £22,829,256; there were 29 protected (including 22 partially protected) ships, tonnage 78,540, cost £4,106,551; unprotected ships 282, tonnage 168,724, cost £8,699,912, or a total of 373 ships with a tonnage of 679,144, and costing £35,635,719. The proposed standard in 1894 will be 77 armoured vessels, 88 protected, and 336 unprotected; total, 501. The additional vessels are to cost £21,127,040. There are 128 ships required to complete this programme, costing £22,669,000. The sum of £1,546,000 is required to complete ships building, £16,150,000 for ships to be built. There are 30 vessels which, being obsolete in type or speed, are not included in the number of vessels afloat.

Germany, by the year 1894, by which time the British shipbuilding programme will be completed, will have 40 armour-clads, 14 of which, now in existence, are small coast-defence vessels, 10 protected and 52 unprotected ships, and 107 torpedo boats. The figures for France, Russia, and Italy are based on a different standard of computation, being only the programme for the current year. At the beginning of the current year, of armoured, protected, and unprotected vessels, and torpedo boats respectively, France had 30, 5, 143, and 130; Russia, 17, 3, 58, and 127; Italy, 13, 7, 40, and 117. The French Government were building 9 and had projected 3 armour-clads, and had 9 protected cruisers on the stocks, as well as 15 unprotected vessels. The Russian vessels building were 5 armour-clads and 9 unprotected ships. Italy had 5 first-class armour-clads in progress and one protected, 7 protected cruisers in course of construction and 3 more decided on, and 3 unprotected vessels on the slips, and 10 more and 16 torpedo boats set down for commencement.

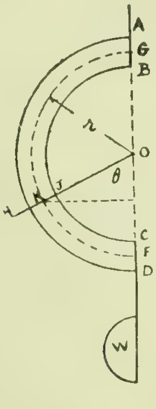
CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STRENGTH OF RING.

To the Editor of "The Practical Engineer."

Sir,—As none of your correspondents have as yet dealt correctly with the weighted ring problem, I beg to offer you the following solution, as the question is of some interest. It may, in the first place, be pointed out that it cannot be solved by pure statics, and hence the solution offered in your issue of the 22nd ult. is necessarily incorrect. There are two or three ways of treating it, but I much prefer that of the principle of work, the application of which to problems of this nature appears to be but little known to English engineers, and so far as I know there is no English text book on the subject. For those who read French and have sufficient mathematical knowledge, I can strongly recommend Castigliano's "Theorie de l'Équilibre des Systèmes Elastiques," which is published by A. F. Negro, at Turin, and is eminently practical. Taking the mean radius of the ring in question to be 11in., let this be denoted by r, and let the weight be denoted by 2W lb. If we split the ring in two, and also the weight with its supporting cord, so that half the whole rW is taken by each half of the ring, as shown in the annexed figure, then the action of the other half of the ring, which is shown removed, can be replaced by adding a moment to the face cD, and also a shearing force and a normal force. In the present instance both the shear and normal force at this section are zero, as is easily proved, and hence we have only to deal with the moment at this section. Let this moment be denoted by M_o. Then consider the moment at any other section, such as HJ. Then the moment here due to W is evidently $Wr \sin\theta$, where θ is the angle KO makes with vertical, and the moment due to M_o is M_o. Hence total moment at the section is $M = M_o + Wr\sin\theta$.



Now, it is shown in Cotterill's "Applied Mechanics," page 338, and most text books, that the resilience or work done in bending a beam is

$$\int\frac{M^2\,dS}{2EI}$$

the integral being taken over (where E = elastic modulus, and I = moment of inertia) the whole length of the beam. Hence if l is equal to the length of the mean fibre between F and G, we have in our case resilience

$$= V = \int_o^l \frac{M^2\,ds}{2EI.}$$

and substituting for M we get

$$V = \int_o^l \frac{(M_o + Wr\sin\theta)^2 ds}{2EI}$$

Now, by the principle of work as applied to elastic beams, this quantity must be a minimum with respect to M_o. Hence, differentiating with regard to this quantity, we get

$$\frac{dV}{dM_o} = \frac{I}{EI}\int_o^l (M_o + Wr\sin\theta)\,dS = 0 \text{ for a minimum.}$$

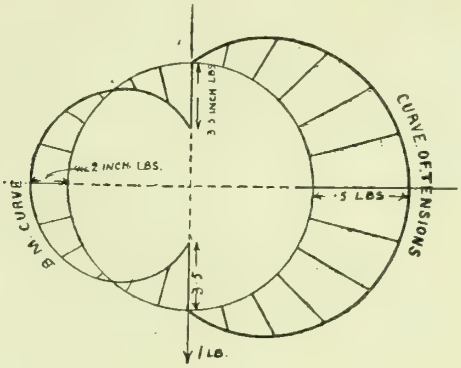
Putting $ds = rd\,\theta$, and changing the limits accordingly, we get

$$\frac{r}{EI}\int_o^\pi (M_o + Wr\,sin\,\theta)\,d\,\theta = 0.$$

Hence $$M_o\,\pi + 2Wr = 0;$$

or $$M_o = -\frac{2Wr}{\pi} = -\frac{2\times W\times 11}{3{\cdot}1416} \text{ inch lbs.} = -7W \text{ very nearly.}$$

Having obtained M_o, it is easy to obtain the moment at every point by the formula $M = M_o + Wr\sin\theta$, or $M = W(11\sin\theta - 7)$ inch lbs. Similarly, the normal tensions can be obtained from the formula $T = W\sin\theta$. Both moments and tensions are obviously the same for the two half rings, and in the annexed diagram the bending moment curve for the ring is drawn on the left half, plus the curve of normal tensions on the right half; by combining these, the stress can be found at any point. In the diagrams, W is taken as 0·5lb., or 2W = 1lb.



The above solution is practically exact within the elastic limit, and can therefore be made use of in determining the working strength of the ring; the two curves of moments and tensions being combined in the usual way to find the stress on the metal. With regard to the breaking strength, however, there is no method of obtaining it save by actual experiment, as, owing to the plasticity of the metal, the distribution will be completely altered long before the breaking point is reached. Some light on this point is now being obtained by the study of autographic diagrams.—With apologies for the length of this letter, which, however, could hardly have been condensed without sacrificing clearness, I am, yours, &c.,

P.

To the Editor of "The Practical Engineer."

Sir,—I trust that "Orion" will, without prejudice, allow me to point out a slight defect in his method (as given on page 208 in your issue of March 22nd) of arriving at the ultimate strength of a ring made as in the sketch there given. I do not wish to underrate the importance of his reply to the query, but I have not the least doubt that he will agree with me that the question of knowing the ultimate strength of such a ring is one of very slight importance compared to the knowledge of the weight necessary to produce permanent set, and I therefore speak with special regard to the breaking or ultimate strength. However, as "Orion" merely offered his calculation as an approximate one only, I have taken the liberty of pointing out where the defect in the formula lies. "Orion" is, I feel sure, perfectly aware that some length of time before the application of the load necessary to produce rupture the shape of the ring will have been altered. This being so, it is evident that the element of length, or mean diameter of the ring, which he has applied in his formula, will be a source of error; and again, it is very probable that under some particular load, short of the ultimate load, the sides of the ring may approach one another until the load or weight is in an almost direct line with the axis of the bar of which the ring is made. This may be readily proved by an experiment with a ring of wire. If this happens, then the stress in the two sides will be in proportion to the square of the diameter of the section, and not as the cube, as stated. I must confess that I am unable to solve the problem to my own satisfaction, otherwise the question would not have remained so long without an answer; and I will admit that I see no objection to the use of the method given by "Orion" in cases where the load does not alter the shape of the ring, as it would then be of some service for determining the approximate stress induced by such a load; that is to say, the formula might be used with comparative safety if the value assigned to k was such as to represent the working strength instead of the ultimate strength. At least, such is the opinion of OMICRON.

ECONOMY OF EXPANSION.

To the Editor of "The Practical Engineer."

SIR,—In your issue of March 29th, "Economy" wishes to know if he would save anything by cutting off steam, presumably in a single-cylinder engine, at quarter stroke, with 80lb. pressure, instead of using steam at 40lb. pressure, and cutting off at half stroke. In answer thereto, I should say that there is not the least doubt that the engine, with the higher steam pressure and greater number of expansions, would be the more economical of the two, as the following figures will show:—

Data:	1st case.		2nd case.
Absolute pressure ......equals	95lb.	......	55lb.
Cut-off	$\frac{1}{4}$-stroke	......	$\frac{1}{2}$-stroke
Ratio of expansions	4	......	2
Ratio of theoretical mean pressure to absolute initial pressure equals	·5965	.. ...	·8165
Theoretical mean pressure in a condensing engine cylinder, allowing 3lb. back pressure, absolute ....equals	53lb.	(23% Approx)	43lb.
T.M.P. in a non-condensing engine cylinder, allowing 18lb. (absolute) back pressure ......equals	38lb.	(35% Approx)	28lb.
Relative densities of steam	95	to	55
Relative consumption of steam...	(95 × 1)	to	(55 × 2)
Relative consumption of steam...	$86\frac{1}{3}$	to	100

For simplicity I have assumed that the expansion of steam follows Boyle's law—*i.e.*, "that the pressure is inversely as the volume." From this we may see that in a condensing engine we may obtain (theoretically) an increase in the power developed of about 23 per cent, and in a *non*-condensing engine an increase of about 35 per cent, by using the high-pressure steam expansively, while at the same time it may be noted that the consumption of steam will be reduced more than 13 per cent.

Of course, in practice, these figures would in each case be somewhat reduced—as, for instance, the initial condensation would be higher in the engine which cut off the sooner, and the loss of heat by radiation, &c., would also be materially increased.

And, finally, before "Economy" finally makes up his mind to adopt the higher pressure, he should for the sake of the engine satisfy himself that the initial strains caused by such pressure are not too great, as he will no doubt be aware that when first starting the initial strains in the one case will be double that in the other.—Yours, &c.,

OMICRON.

LEAKAGE IN STEAM BOILER.

To the Editor of "The Practical Engineer."

SIR,—I am sorry to find my attempts to inform "Boiler" in his difficulty should have led him to think I suspected imperfect workmanship in his boiler. My reference to the construction was merely a suggestion as to a *possibility*, and was not intended to point to a *probability*. He has been correctly informed as to each man doing one side, and consequently each alternate seam; but where men are accustomed to work either hand, as in most shops (right or left), and where they have not the best appliances for turning over, it would be *one man one side*, as I have already said; but, as he justly says, "to business." Now, I have again looked over his dimensions of flues, and cannot see a probable cause for such a peculiar defect—all leakage in one flue and corresponding flue perfectly tight. An inrush of cold air, such as he alludes to, would certainly be felt in furnaces if felt anywhere; but he can soon prove this by getting a good reliable pyrometer, with stem about 4ft. 6in. to 5ft. long, and making holes into his flues at different points of each of his flues, and I think I can foretell, within a few degrees, what difference of temperature he will get with door open, say one minute (which time is generally long enough for a man to fire), and with fire door closed. As regards fire cleaning, the proper way is to push back to bridge as much fire as possible, and not, as is occasionally done, work fire almost dead and then clean them perfectly bare from end to end, a course not generally followed at our Bolton cotton mills; and if he will not take more than one minute to fire, and clean fires as I say, with the dampers down, or nearly so, he will not find a greater difference than 50deg. Fah. during a full day's regular work. This will not be likely to cause the trouble which is so very peculiar. Twenty grains per gallon is enough to cause trouble in furnaces under severe working, if not occasionally blown out and cleaned, but many boilers are working well with much more. Again I ask, do the flange seams or hoops touch the shell side? If he will only go on working a short time, he may find leakage disappear as mysteriously as it appeared. Can he not arrange for an expert, say an old experienced man, to see his boiler?—Yours, &c., CHALKLINE.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

SIR,—"Chalkline's" letter is certainly to the point, and the information therein is not only valuable but thoroughly reliable.

My experience in this type of boiler is, like "Chalkline's," rather limited, but in the main his statements tally in almost every respect with my own experience. I recently inspected a water-tube boiler of about 75 H.P., and put down to work at 100lb. per sq. inch, and fired by the aid of a mechanical stoker, on the endless fire bars system. I watched the steam gauge ascend from 20lb. to 60lb., and then, with a little run, fall down to 15lb., and thus it acted, the engineer said, from first thing in the morning till stopping at night, and that the steam was no sooner up than it was down; it required twice as much attention as the Lancashire, and burnt more coal per H.P. than its rival. Like the gas engine, they are suitable for small power, and are only to be recommended for such purposes, or for being fired with the waste gases from puddling or other furnaces; but for other purposes they, in my opinion, should never be put down.—Yours truly, R.

QUERIES AND REPLIES.

27. FORGING MUSHET STEEL.—Will some practical reader kindly inform me of the best way of forging Mushet steel? I can forge ordinary cast steel, but Mushet steel seems to fall to pieces under the hammer.—STEEL BAR.

Answer.—If "Steel Bar" will heat his Mushet steel slowly and thoroughly until it becomes a cherry red, he may then work it into the required shape in a similar manner to ordinary tool steel, but he must take particular care not to work it when it is losing its colour, as it may fall in pieces under the hammer. He must not on any account dip it in water, but allow it to stand until cold, when it will be found sufficiently hard for all purposes.—OMICRON.

Answer.—Before Mushet steel can be forged, it is necessary that it should be annealed. This operation should continue from twenty-four hours upwards, according to the size of steel employed. After it is perfectly cold, the forging may be proceeded with at a dark red heat, care being taken that the heat is well soaked through the whole body of the material, for if there is any sudden variation in the temperature, it is liable to fly off at that part when under the hammer. The principal point to be observed is, that the forging must not be done hurriedly, as this steel draws very slowly. It is on account of this fact that the heat requires to be uniform, so that the drawing may be spread through the whole body while being worked. If these particulars are adhered to, the necessary forging for tools and similar objects can be satisfactorily performed. Water must on no account be used, but oil.—ORION.

28. YACHT ENGINES.—What is the greatest I.H.P. I would get out of compound engines $\frac{9\frac{1}{2}\text{in.} \times 16\text{in.}}{10\text{in.}}$ and boiler (horizontal) 6ft. 3in. by 5ft. 6in., and what should the areas of ports, and separate parts, and diameter of steam pipe be, so as to get the greatest power out of them?—S. J. M.

Answer.—As the querist "S. J. M." has not stated the pressure of steam which he intends to adopt, it would be impossible to give the greatest I.H.P. that an engine of this size would actually develop, but I should say that with a working pressure of 80lb. per square inch, he might readily obtain from 60 to 65 I.H.P.

With respect to the area of ports:—

Make the *area of steam ports* in the high-pressure cylinder equal to about 7 square inches, that is 7in. by 1in.
Area of exhaust port equal 7in. by $2\frac{1}{2}$in.
Area of steam ports in the low-pressure cylinder equal to about 17 square inches, say $12\frac{1}{2}$in. by $1\frac{3}{8}$in.
Area of exhaust port in low-pressure cylinder *equal to* $12\frac{1}{2}$in. by 3in.
Diameter of steam pipe $2\frac{1}{2}$in.
Cut-off in high-pressure cylinder $\frac{5}{8}$in. stroke.
Cut-off in low-pressure cylinder $\frac{9}{16}$in.

If "S. J. M." will state more clearly what he means by "separate parts," I will endeavour to assist him. OMICRON.

30. METALLIC PISTON-ROD PACKING.—Who are the makers of Cruikshank's metallic piston-rod packing, and what is their address? Also where is the United States Metallic Packing Co.'s packing to be had?—J. W.

Answer.—The address of the United States Metallic Packing Co. in this country is 43, Exchange Chambers, Liverpool.

31. SETTING SLIDE VALVE.—The slide valve of my "Fowler" traction engine does not admit steam evenly to both sides of the piston head, and although it seems to be set fair, yet steam enters for three-fourths of the forward stroke and only for one-third of backward stroke when in last notch of reversing lever. If I alter the valve rod so that valve works evenly, then, by putting reversing lever in second notch from centre, one port opens altogether, and the other one not at all, during a revolution of flywheel. Will some reader kindly point out where the mistake is?—TRACTION ENGINE.

Answer.—The ordinary link motion will not give an equal cut-off at both ends (owing to obliquity of connecting rod) unless the leads are very disproportionate, which is undesirable. Even with a ratio of leads front to back of one to three, the difference will amount to about one-fifteenth of the stroke. If the valve was originally set with unequal leads, and "Traction Engine" makes them equal, he will thus see that the variation in the cut-off will be considerably increased, and may account for the condition of things cited. On the other hand, if he alters the valve so as to get equal cut-offs, he may have negative lead at the front (cover) and too much lead at the back; then by linking up the travel of valve is decreased to such an extent that it is insufficient to open the port, while the excessive lead at back, together with the half travel, may give a full port opening. Perhaps this will assist to a solution of the difficulty.—ORION.

32. COULD any of your practical readers inform me how to calculate the thickness of liners to be put under a bearing next to a paddle wheel? Suppose a crank shaft of a paddle boat and the bearings next to the wheels in paddle box had dropped, I require the thickness to put under them so as to only have to lift them once or so. Centre of crank pin to centre of shaft, 2ft. Distance from face of crank cheek, 5ft. Difference the crank shows top and bottom centres, $\frac{7}{16}$in. Hints will much oblige.—DUMMY.

Answer.—From the particulars given in this question, I take it that the shaft is out of line by an amount equal to half the difference between the measurements taken top and bottom in a length of two feet (length of crank); in other words, to seven sixty-fourths of an inch per foot of length. If this is so, then in a length of 5ft. the shaft will be $5 \times \frac{7}{64} = \frac{35}{64}$in. lower than it should be, and hence a liner a little less than $\frac{9}{16}$ thick will make matters all right again.—OMICRON.

Answer.—This is calculated on the principle of the lever. Half difference crank shows : thickness of liner :: crank to shaft : face to bearer; *i.e.*, liner $= \frac{(\frac{7}{16} \div 2) \times 60}{24} = \frac{7 \times 60}{32 \times 24} = \frac{35}{64}$ inch.—MARINE ENGINEER.

Answer.—If "Dummy" has not yet got his shaft set, perhaps the following may be of use to him. In the first place, it is quite possible through various causes that the two shafts have not dropped by the same amount at their outer ends. "Dummy" should test this by placing his crank on the top centre and taking a line through to the centre of his cylinder, by which means he may detect the difference, if any. This done, and working from the line to one cheek, suppose that he finds a difference of $\frac{7}{16}$in. between the face and the line when on top and bottom centres, the thickness of the line required will be in this proportion:—

Crank centres.		Distance to outer bearing.		Half the difference.	
2	:	5	::	$\frac{7}{32}$	$= 1\frac{3}{8}\frac{1}{4}$in.

I take it that "Dummy" has tested the crank at 2ft. from its centre, and that the distance from the inside cheek to the inner edge of outer bearing is 5ft. Of course, to find the difference due to the length of bearing, he will require to make another calculation, using the extra length instead of 5ft.—COMPOUND.

34. WEIGHT ON CHOCK ON COLLIERY INCLINE.—What is the weight resting on a chock placed across the rails of an incline which has a vertical rise of 1 in 12? Set of 30 tubs, each of which weighs 12 cwt. The chock prevents the downward movement of those tubs.—STUDENT.

Answer.—The total weight of the 12 tubs is 12 × 30 = 360 cwt. If the vertical rise is one foot per 12ft. length of incline, then by the principle of work (neglecting friction) the weight on the chock will be $\frac{1}{12}$ the total weight of the tubs; that is to say, 30 cwt.—OMICRON.

Answer.—The force required to hold the tubs, or say the tension on a rope to hold them, acting in the same direction as the inclination, will be in proportion to the weight of the tubs as the vertical rise in the 12ft., viz., 1 is to the hypothenuse of a triangle which has a base of 12 and a perpendicular of 1.

$$1 : \sqrt[2]{12^2 + 1^2} :: 360 \text{ cwt. to the force required.}$$
$$1 : 12{\cdot}04 :: 360 \quad ,, \quad ,, \quad ,,$$
$$29{\cdot}9 \text{ cwt.} = \text{the force.}$$

This is supposing there is no friction on the rails, but as this may be taken at $\frac{1}{120}$ of the weight, the force required would be less by this amount, that is:

$$29{\cdot}9 \text{ cwt.} - \frac{360 \times 1}{120} = 26{\cdot}9 \text{ cwt.}$$

For demonstrations of this, and similar cases, I would refer "Student" to Todhunter's "Mechanics," &c.—COMPOUND.

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16. SETTING CORLISS VALVES.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—ENGINEER.

22. ANTIMONY.—Will any reader kindly inform me of the best way to melt ground antimony? The only means at my disposal for doing so are in a ladle over gas or over a large stove, and this is not effectual, as the powder simply cakes.—H. P. S.

23. LIGHT MIXING MILL.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—EASTERN.

26. CAVITIES IN SIEMENS CAST STEEL.—Can any reader explain the cause of the hollow cavities occasionally met with in Siemens cast-steel ingots? I mean hollowness so bad as to completely destroy the ingot.—W. P.

29. CEMENTING RUBBER TO METAL.—Can any reader give me information as to the best cement for fastening a rubber stamp to metal. The cement must stand frequent pressure upon the rubber without being loosened.—J. A. L.

35. LOCOMOTIVE DRIVING WHEELS.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

36. NUT CAST ON IRON SCREW.—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and $\frac{3}{8}$in. pitch.—SUBSCRIBER.

37. STEAM JOINTS.—Which is best for steam joints, such as valve box covers and steam pipes, indiarubber, asbestos, or thin wire gauze? Is there any reason for preferring any one of them in special cases?—SUBSCRIBER.

TO CORRESPONDENTS.

J. C., Oldham.—We shall be very pleased to draw a Zeuner's valve diagram for you if you say what the cut-off is to be. You have given the other points, but not that. Write again.

T. A. H., Birmingham.—The nuts upon the crank shaft bearings of marine engines are generally locked by means of a collar and set screw; while in connecting rod ends the nuts are often locked in this way for the larger engines, with the addition of a split pin through the bolt. Smaller engines have simply the usual double lock nut and split pin; there are several disadvantages common to all form of self-locking nut which have prevented them from coming into general use. For connecting rod ends it is unsafe to depend upon any single lock nut; as yet no method answers so well in all circumstances as the ordinary double lock nut.

EXPANSION, Darwen.—At the time you mention, when the vacuum was the principal feature of the steam engine, cylinders were made very much larger in diameter than they are now for a similar power. The power obtained from the same size of cylinder is many times greater now than it was then. Read our articles on subjects such as vacuum condenser. Friction in engines is much less now than then, but cylinders are smaller.

MISCELLANEA.

THE electric railway, three miles long, to be erected at Negaunne, Michigan, will be worked by water power ten miles away.

THE boring of the long tunnel on the Rhondda and Swansea Bay Railway, between Treherbert and Abergwynfi, in Glamorganshire, which is to connect the Rhondda Valley coalfield with Swansea, has been completed by the contractors, Messrs. William Jones and Co. This tunnel is 3,400 yards in length—being, we understand, the seventh longest in England—and although from the great height of the mountains no intermediate shafts could be sunk, when the advanced headings met the lines were so perfect that no divergence could be detected, and the levels agreed to within half an inch. Mr. Yockney, the engineer, is to be congratulated on this result.

SERVIAN ACTIVITY IN RAILWAY ENGINEERING.—The directors of the Servian railways intend to construct extensive engine works at Nisch. The traffic on those lines has increased to a very considerable extent, and has resulted in converting Nisch into a practical grand junction. Hitherto there have always been workshops at the place, where repairs could be and were executed, but if the new buildings and works are completed, as anticipated, not only will additional facilities be afforded to all the Eastern lines to have their engines repaired there when necessary, but even new engines will be constructed and supplied in complete working order.

NEW LEEDS FORGE COMPANY.—Contracts have been signed with Messrs. Andrew Handyside and Co., Derby, for the erection of new iron-built sheds, lighted from the roof and sides, which are required by the New Leeds Forge Company, Limited, for the extension of the hydraulic press flanging department. The sheds are to cover an area of 11,000 square yards. The foundations are now being dug out, and the work of erection will commence immediately. The whole of this space, it is stated, is to be filled with hydraulic presses and the necessary furnaces, together with new and improved special machinery for the rapid manufacture of pressed flanged steel plates required in the construction of all classes of Fox's patent rolling stock.

A NEW SYSTEM OF OPTICAL TELEGRAPHY.—A French optician, named M. La Cour, has devised a new system of spectro-telegraphy, founded on a novel system, which seems to present considerable advantages over the methods hitherto employed. Instead of availing himself of interrupted rays of light, the inventor sends a signal which can be read at the receiving station like an ordinary letter. The transmission is effected by means of a luminous beam, refracted through prisms, and deprived at its departure of certain coloured rays. The spectrum obtained on the arrival of the signal is interrupted by one or more black bands which correspond to the rays absorbed at its departure. The luminous beam may be made to assume the form of the letters of the Morse alphabet, and a special contrivance serves to modify the light emitted after each signal. The transmission of the signals is accomplished with considerable rapidity, and it is probable that this system will be applied in many ways, especially at sea. Four or five signals can be despatched simultaneously from the same lamp, which will allow signalling to be carried on at night in a corresponding manner to that of flag signalling by day.

GASEOUS FUEL.—This formed the subject of a lecture recently delivered in the Association Hall, Peter Street, Manchester, by Mr. B. H. Thwaite, under the auspices of the Manchester and Salford Noxious Vapour Association. Mr. H. Fletcher, of Bolton, presided. In introducing Mr. Thwaite, he urged those present to assist the association by supporting candidates, whether municipal or Parliamentary, who would take measures to prevent the pollution of the atmosphere. Mr. Thwaite, proceeding with his lecture, described the uses of gaseous fuel, as distinguished from solid fuel. He was materially assisted by a number of illustrations which were thrown upon canvas by means of a lantern which was operated by the Rev. C. G. K. Gillespie. Mr Thwaite gave an interesting description of the natural gas regions of America, and explained the process of drilling wells. In the United States no less a sum than £10,000,000 was invested in natural gas undertakings, a figure which formed a splendid monument to the enterprise of our American cousins. He referred to the respective merits of natural and artificial gas, and traced the improvements made in the manufacture of the latter. He concluded an instructive lecture by a series of interesting experiments.

The Mint, Birmingham, Limited.—The share capital consists of 16,000 shares of £5 each; there is also £40,000 in 5 per cent debentures, redeemable at the option of the company after five years at 5 per cent premium. The debentures will be of £25 each. The company has been formed to take over as a going concern, as from 1st January, 1889, the business of Messrs. Ralph Heaton and Sons, Birmingham. In addition to the manufacture of complete coinages in gold, silver, nickel, copper, bronze, and other alloys, and the supply of metals for coins in the rolled bars or in blanks finished ready for the coining press, the firm are large producers of various classes of brass and copper goods.

A Large Wire Rope.—There has been despatched from the old-established works of Dixon and Corbitt and R. S. Newall and Co., Limited, Teams, Gateshead-on-Tyne, one of the largest, if not the largest, wire ropes used in the United Kingdom. Its length is 4,560 yards, and is five inches circumference, weighes over 23 tons, and occupied three large railway trucks. This rope has been made to the order of the North British Railway Company, and is to be used for drawing the trains from their Queen Street Station, Glasgow, to Cowlairs. A wire rope has been used for this purpose for some years, but this is the first one made on Lang's patent, of which the firm are licensed manufacturers. This make of rope has been proved to be superior to any other for haulage and incline works, and, we have no doubt, will do credit to its makers. We understand that this firm, with a view to extend their business in the South Wales coalfield, have recently established a manufacturing branch at the Windsor Ropeworks, Cardiff.

Severe Test for Consett Steel.—A Steel-built Vessel on the Rocks.—There was in the public graving dock at West Hartlepool a vessel, the condition of which is believed to be an undeniable proof of the value of the use of steel as a shipbuilding material. The vessel is the steamer Merida. She is a little over eighteen months old, was built at West Hartlepool, we believe, by Messrs. E. Withy and Co., and when in the far East got on the rocks on the Indian coast. She had been brought to West Hartlepool to repair; and docked in the place and by the firm named, the extraordinary damage done is apparent on inspection. Those only who look at the steamer from the bottom of the dock can have an adequate conception of the extent of the damage done, or of the strain that must have been endured before such injuries could have been inflicted on the keel and bottom of the ship. The keel is bent and distorted, and driven aside and upwards; at various parts the bottom is bulged in; and from stem almost to stern the bottom is "buckled up" in a number of places in a manner and to an extent that few can have previously seen in a steamship. With all this damage, there is practically no breaking of the plates. And, as bearing on the question of the use of iron or steel, we may quote the opinion of two competent judges, who believe that "iron would not have borne one-fourth of the knocking about." We are informed, and it is satisfactory to learn, that the steel plates which have given such proofs of their quality are locally made—they are from the Consett Iron Company's works. The cellular double-bottom of the vessel has proved its use in the long voyage home for the extensive repairs needful, and the makers of the steel plates and the builders of the Merida may be congratulated on the proof thus unexpectedly furnished of the excellent workmanship. It may be added, as to a point regarding which there has been some local discussion, that the Merida shows no signs of any excessive corrosion.

Engineering Society, King's College, London.—At a general meeting of this society, held on March 12th, the president in the chair, Mr. C. C. Jones read a paper on "Refrigerating Machinery." The author confined his attentions to machines based (1) on the compression system, and (2) on the cold-air system. In the compression system vapour was drawn off from a volatile liquid into a pump and compressed, the heated compressed vapour was cooled in coolers or condensers, and thereby liquefied; it was then ready to be re-evaporated. One of Siebe, Gormon, and Co.'s ether machines, which works with a vacuum of 12lb., was then described. Ammonia machines, an installation in Leadenhall Market, on the De la Vergne system, and a 26-ton ice-making plant, were also described. The latter machine was made by the Pulsometer Engineering Co. under the Puplett patents. The leakage of ammonia from the compressor pump was entirely prevented by a circular chamber in the stuffing box filled with oil. In the De la Vergne system the same result was produced by pumping oil into the compressor pump below the ammonia. The principle of cold-air machines was that, when air is compressed, cooled after compression, and allowed to do work as it expanded, cold was produced. The author described in detail one of Lightfoot's universal refrigerators, capable of producing 80,000 cubic feet of cold air per hour, worked by a compound condensing steam engine. Two of these machines, on board the sailing ship Fifeshire, were alluded to in connection with the frozen-meat traffic. In referring to some of the Haslam machines, the author pointed out the special features of the interchanger system, and dwelt especially on the application of cold-air refrigerators in bringing fruit from the colonies to England by Mr. Haslam's regulating process. Special mention was made of the employment of a Puplett ammonia machine on board the Iceking for cooling barges which convey the frozen meat from the ships to the stores. Several photographs, and a model of a cold-air machine, kindly lent for the occasion, were shown.

Material in a Steamer.—The amount of material necessary in the construction of a 1,200-ton steamer is simply astonishing. It takes 40,000 lineal feet of timber, 25 tons for hog chains, and in all 50 tons of iron, 120 bales of oakum to caulk the seams, and fully 5,000 dols. worth of paint. The cost of such a boat at the yards runs about 80,000 dols., to which an additional 25,000 dols. may be added for furnishing. It takes generally about five months to put up a 1,600-ton boat, and it should last ten years with ordinary care. When the hull of a boat is finished, every nook and corner is filled with salt, about 100 barrels being used for a 1,200-ton boat. This is done to prevent the rotting of the timber, and, strangely enough, the cabins and upper works usually decay much sooner than the hull. This refers to American river steamers.

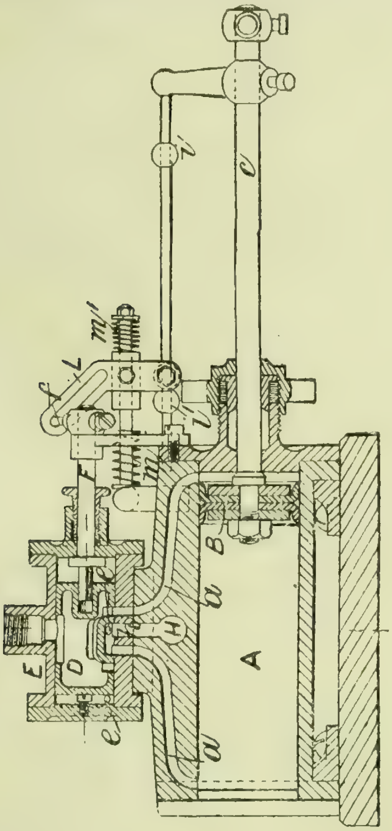
The Armstrong Gun.—Under the auspices of the Newcastle and District Association of Foremen Engineers and Draughtsmen, Major Jones lectured in the Literary and Philosophical Institute, Newcastle, on "The Action of Fired Gunpowder in the Bore of Guns, as ascertained by the use of instruments described in his former lectures." There was a good attendance. The lecturer dealt mainly with the results of experiments, conducted under the direction of the Committee on Explosives, which led to the development of the new and heavy types of naval guns. The diagrams and tables he had shown, he thought, spoke for themselves. It was a circumstance to be regretted that there were still old guns in some of our warships. There was not, he continued, a shadow of a doubt that the first new type of gun was produced and fired at Elswick long before any such gun was produced elsewhere. He took that opportunity of stating the fact publicly and emphatically, because some doubt had been thrown upon it, and people—some of them in high places, persons who ought to have known better—had been attributing the step to foreign progress. The results of the firing of the first 6in. and 8in. guns were published in the *Times* a year before Herr Krupp tried what might be termed the new type of gun. Possibly the German makers got ahead of the English makers, and that might be the reason why some people believed the idea originated elsewhere. Where they had had work of that kind done and a revolution of that sort carried out in the armaments of the navy, they would be aware that it was not the work of one individual only, but the work of many, though the many were always directed by one. That directing spirit was Capt. Noble. He (Capt. Noble) and Sir Frederick Abel were the two members of the Ordnance Committee who sat on that committee from beginning to end, and, in addition to that, Capt. Noble had now the direction of the work at Elswick. Sir F. Abel, as his name implied, had been rewarded. He did not think Capt. Noble's services had been sufficiently recognised. There had been an omission, and it ought to be corrected. He thought the correction might very well be spelt with a K. On the motion of Mr. M. W. Swinburn, seconded by Mr. W. Mayer, and supported by Mr. Dalrymple, a vote of thanks was accorded to Major Jones.

Launches.—Recently, Messrs. Schlesinger, Davis, and Co. launched from their shipbuilding yard, Wallsend, a large steel screw steamer, named the Benwick, built to the order of Mr. Joseph Hoult, of Liverpool, the managing owner of the Ben line of steamers of that port. The vessel is of the following dimensions: Length, B.P., 302ft.; breadth, moulded, 40ft.; depth, moulded, 23ft. 2½in.; and is designed to carry a dead-weight cargo of 4,000 tons. She is constructed on the cellular bottom principle throughout for water ballast, and has a poop, long raised quarter-deck, long bridge extending beyond foremast, and a topgallant forecastle. Shifting boards and trimming hatches will be fitted to each hold in order to comply with the Grain Cargoes Act. She will be rigged as a two-masted fore and aft schooner. Maginnis's patent steering gear will be fitted in the engine-room, with shafting running along the deck, acting direct on the quadrant, thus dispensing with all chains, rods, sheaves, &c. Messrs. Emerson, Walker, and Thompson Brothers' patent steam windlass will be fitted on the forecastle. The vessel will also be fitted with four powerful steam winches for the rapid loading and discharging of cargo, special arrangements being made on deck for the stowing of all cargo gear. The accommodation for the captain, officers, and engineers is amidships in houses on the top of the bridge deck, the forecastle being fitted up in a substantial manner for the crew. The Benwick classes 100 A1 in steel at Lloyd's, and been built under special survey. The engines, of the triple-expansion description, are of 190 nominal H.P., having cylinders 22in., 34in., and 56in., and 42in. length of stroke. The boilers are of steel, two in number, working at a pressure of 160lb. per square inch. The machinery has been constructed by Messrs. Black, Hawthorn, and Co., Gateshead, and, together with the hull, has been erected under the superintendence of Mr. A. C. Hay, of Liverpool, the owner's superintendent engineer. The vessel was named by Miss Dora Hoult, the little daughter of the owner. Messrs. Wigham Richardson and Co. have just launched from their Neptune shipyard a smart spar-decked screw steamer, which is an addition to the fleet of the Compagnie Anonyme de Navigation Mixte, of Marseilles, and is intended to trade between that port and Algiers. Her dimensions are 260ft. by 32ft. by 25ft. There will be accommodation provided for first, second, and third class passengers, and the engines, which will be triple-expansion (Tweedy's patent), are by the same builders. The vessel was named Felix Touache by Miss Ernestine Chubb.

ILLUSTRATED PATENTS.

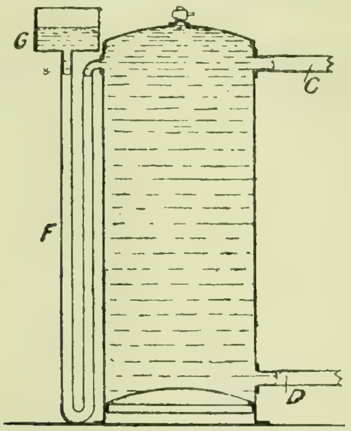
15,657. WATER-PRESSURE ENGINES, W. Tee, Middlesex.

Applicable particularly to engines used for working the feeders of organ bellows. Distributing valve gear: The valve D which regulates the distribution of the fluid to the working cylinder A is itself actuated by the fluid pressure. The distribution to A, through the ports a, a, is effected by a sliding motion of the valve D as in the ordinary slide valve of a steam engine, p H being the exhaust port. The distribution to actuate the valve D itself is effected by a reciprocating rotary motion of the valve D on its own axis. Port e, e, and a corresponding port not shown, make communication between the inside of the valve D and the spaces at the end of the cylinder E in which D works, the admission and exhaust of the fluid at the proper time being determined by the rotary motion of the valve D. This partial rotary motion is imparted to the valve by tappet gear i, i^1 attached to the piston rod c of the working piston B. The knobs i, i^1 strike the end of a slotted cam L, which is supported between two springs m, m^1, and acts upon an arm f connected to the rod F, which is so connected to the valve D that it imparts to it a partial rotation, and at the same time allows it to receive the reciprocating sliding motion necessary for distributing the water to the main cylinder. Automatic stop valve: A lift valve is fitted on the exhaust pipe, which is actuated by a rack and pinion, so connected to the organ bellows that the stop valve closes and stops the engine when the bellows are full.—Nov. 15, 1887. [8½d.]



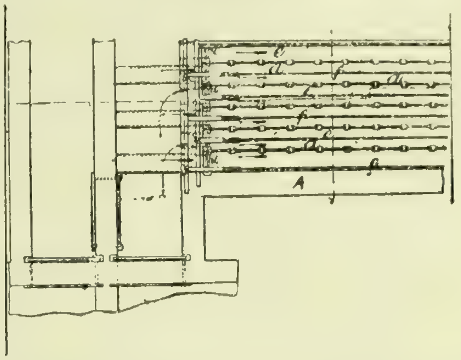
15,658. GAS ENGINES, C. Davy, Ranmoor, Sheffield.

To maintain a comparatively high mean temperature in the cylinders of gas engines, a fixed oil, such as olive oil, is circulated through the cylinder jackets instead of water. The oil circulates by connection, and is cooled by passing through pipes in contact with the air, through a vessel traversed by air pipes, or through a vessel corrugated to produce sufficient cooling surface. The corrugated vessel allows of the expansion of the oil, while in the case of the other vessels to provide for this, and at the same time prevent the exposure of the hot oil to the atmosphere, a long bent tube F terminating in a vessel G is used. The vessel G may stand on the floor and be entirely closed, the tube F passing through the top and dipping into the oil; the latter compresses the air in G on expanding. The vessel G may contain a floating piston. The pipes C and D lead from and to the cylinder jacket.—November 15, 1887. [8½d.]



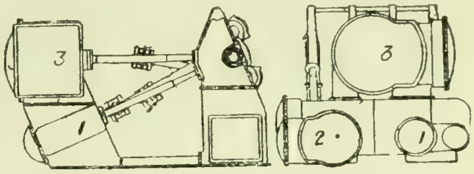
15,760. ELECTROLYTIC TREATMENT OF SEWAGE AND SEA-WATER, W. Webster, jun., Blackheath, Kent.

The object is to decompose sewage and sea-water, more particularly with a view to obtaining ammonia from the former or a disinfecting fluid containing chlorine from either. The liquid to be treated is introduced into a series of compartments of a tank A, separated from each other by porous partitions a and containing alternately positive and negative electrodes e, f connected to the poles of a suitable generator of electricity. The liquid contained in one set of the compartments traversed by the electrodes of the same sign is retained therein for a length of time for the accumulation therein of the desired product, while that in the other set of compartments is constantly renewed. When it is desired to obtain ammonia from sewage, the liquid in contact with the negative electrodes is left undisturbed for a time; while in obtaining chlorine from sea-water, the sea-water in contact with the positive electrodes is retained there for some time. Various arrangements of the compartments, and a form of apparatus for use on a small scale, are described.—November 17, 1887. [8½d.]



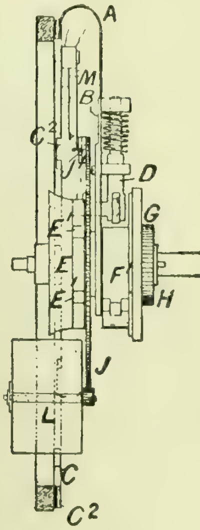
15,788. STEAM ENGINES, A. Laing, Partick, Lanarkshire.

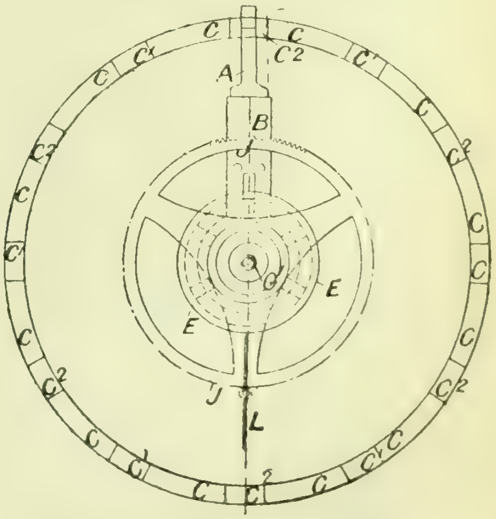
Consists in the arrangement or disposition of the cylinders in several ways for triple and quadruple expansion marine and other engines. In one arrangement the H.P., and intermediate cylinders 1, 2 are placed at an angle to the horizontal, with the L.P. cylinder 3 horizontally mounted above them, all three working on to the same horizontal shaft, as the shaft of a paddle engine. A similar arrangement of four cylinders for triple or quadruple expansion is also shown with the later stage cylinders situated beneath. Two corresponding arrangements are shown suitable for screw engines, in which the cylinders, previously horizontal, are now placed vertically over the crank shaft, the engines otherwise being relatively similarly disposed. In the case of paddle engines, in place of all the cylinders being upon one side of the shaft, they may be situated in two groups on opposite sides, with their axes inclined like the lower ones in the arrangements first described. The shaft may be divided and furnished with a clutch, so that the two halves may be driven in the same or opposite directions, the grouping of the cylinders readily lending itself to this purpose.—November 17, 1887. [8½d.]



15,877. INDICATING POSITION OF A SHIP'S RUDDER AND FOR LIKE PURPOSES, J. B. Willis, Portsmouth.

A step-by-step electric transmitter, operated by the steering mechanism or other apparatus whose motion is to be recorded, is placed in circuit with a receiver, which may be such as described in Specification No. 800, A.D. 1887, or of any other suitable form. An arrangement of transmitter, as applied to steering gear, is shown in the figures. H is a pinion gearing with a quadrant on the rudder head, and C is a ring of conducting strips C, C divided by non-conducting strips C^1, C^1. Over this ring moves a spring contact maker A carried by





an arm B secured to a spring box, which is rotated in either direction by the spindle G^1 by one of a pair of oppositely coiled spiral springs inside. The spring box and arm B do not rotate continuously but by steps. When the contact A is over the centre of each slip C, which is usually hollowed out, as shown at C^2, a spring locking bar D enters one of the notches E^1 in the fixed cylinder E and holds the arm until, by the further rotation of the spindle G^1, and with it the disc G carrying cams F^1, F^1, the bar D is lifted out of the notch, whereon the spiral spring, which has meanwhile been coiled up, moves the arm quickly over to the next strip C, whereon it is again stopped by the locking bar D. The spring box also carries a toothed wheel J, which drives a fly L to regulate the speed of the arm. On this wheel J are pieces J^1, J^1 which make contact between two springs M, M to ring a bell and indicate to the steersman that the apparatus is in good working order.—November 18, 1887. [8½d.]

15,884. Miners' Safety Lamp, J. Ashworth, Stanley, Derbyshire.

Relates principally to improvements in the means for supplying air. Air inlet tubes *c*, *c*, are fitted to the frame of the lamp and are provided at their upper ends with an adjustable perforated non-heat conducting hood D, by means of which, on its receiving a partial rotation, the openings to the tubes are more or less closed, and the air supply correspondingly checked. Air inlets *c*, regulated by sleeves E, are also provided lower down the air tubes, or, as an alternative, openings a^1, controlled by a sliding ring F, may be employed. In order to promote better combustion a ring G, such as shown in fig. 8, may be fitted to the oil reservoir and perforated so as to direct the incoming air to the flame. The ring H enclosed by the gauze I is formed with a rectangular, annular groove around its outer circumference. The glass P, which is held in position in the usual manner, is packed at the top and bottom with asbestos *p* or other suitable material. In a modification a regulated supply of air enters the lamp through an inner shield.—November 19, 1887. [8½d.]

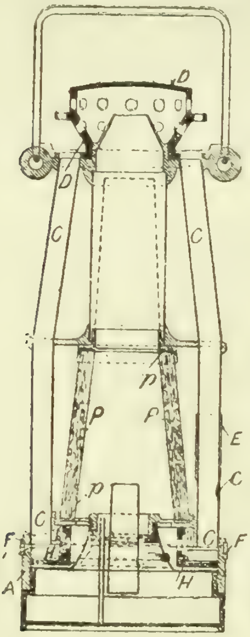
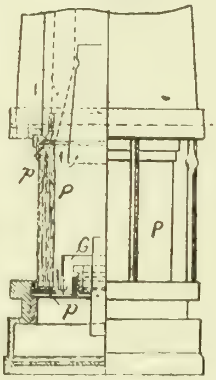
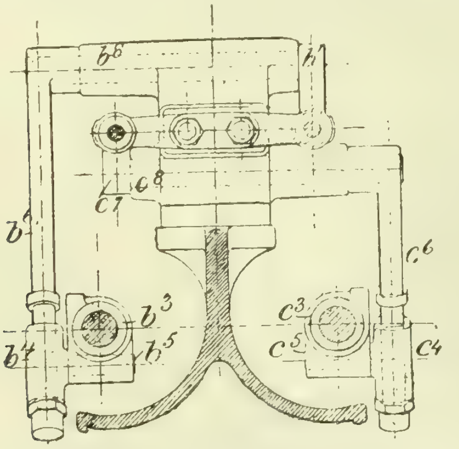


FIG 8



15,944. Duplex Steam Pumps, T. Jefferiss, Handsworth, and Tangyes Limited, Cornwall Works, Soho, both in Staffordshire.

Relates to operating the valves in steam pumps in which the valves of each cylinder are worked by the movement of the piston rod of the associated cylinder. Each piston rod (shown in transverse section) carries a block b^3, c^3 with an eye b^5, c^5, in which works a pin projecting from the side of a socket b^4, c^4. Through the socket slides the end of an arm b^6, c^6, by which a transverse spindle b^8, c^8 is oscillated. The spindles rocked by the two piston rods are situated one above the other, and have one an upwardly projecting short arm c^7, and the other a similar depending arm b^7, by which the slide valves are worked directly.—November 19, 1887. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

March 25th.

5088 Ammonia Process, J. Plummer, Edinburgh.
5089 Rollers, J. Smith, Barnsley.
5092 Railway Construction, &c., F. F. Abbey, Huddersfield.
5093 Electric Batteries, W. J. S. Barber-Starkey, Manchester.
5096 Flying Engine, J. K. Smythies, Essex.
5100 Valve Gear, W. R. Cummins, Glasgow.
5103 Flywheels, J. P. Binns and H. G. Binns, Halifax.
5105 Sewing Machines, J. Leigh and W. Ormston, London.
5108 Hydraulic Main, J. Summerville and A. Allen, London.
5111 Alarms, D. Levison, C. M. Dorman, and R. A. Smith, Manchester.
5113 Couplings, F. W. Lattermann and A. Eckhardt, London.
5116 Storage Battery, T. Pease, Liverpool.
5120 Wood Screws, A. Reid, Middlesex.
5123 Springs, E. H. R. Evans, London.
5130 Cutting Files, A. Goldenberg, London.*
5132 Mineral Oils, T. H. Gray, London.*
5135 Type-writers, E. Fitch, London.*

March 26th.

5138 Annealing Furnaces, A. W. Turner and G. Tomkinson, Birmingham.
5145 Gas, J. H. R. Dinsmore, Liverpool.
5146 Steam Generators, J. Jackson, London.
5151 Spring Accumulator, A. Gibb, London.
5154 Water Meter, F. Gutzkow, London.*
5156 Liquid Valves, J. W. Wailes, Liverpool.
5165 Gas Engines, H. H. Lake, London. (The Secor Marine Propeller Co., United States.)
5195 Buffer Iron, J. Lones, C. Vernon, E. Holden, and R. Bennett, Middlesex.
5197 Generating Steam, J. C. Mewburn, London. (La Société des Générateurs a Vaporisation Instantanée (System Serpollet), France.)
5198 Ordnance, B. T. Babbitt, London.
5199 Aerial Engines, F. T. Millitt, London.
5204 Valves, H. H. Lake, London. (T. Tripp, United States.)*
5206 Looms, S. Pitt, London. (H. Skinner and E. Tymeson, United States.)*
5215 Fire Extinguishers, O. Pierce, London.
5222 Couplings, T. Sutcliffe, Liverpool.
5223 Ores, E. B. Parnell, Middlesex.

March 27th.

5232 Vices, J. S. L. Ashforth, Sheffield.
5240 Composite Packing, O. Phalp, Cardiff.
5242 Forgings, P. M. Justice, Middlesex. (F. W. Taylor, United States.)*
5249 Tube-corrugating Machine, J. S. Taylor and S. W. Challen, Birmingham.
5252 Couplings, F. G. Gunhouse and B. Whalley, Halifax.
5256 Furnaces, W. J. Dunnachie and W. Jardine, Glasgow.
5265 Steam Trap, G. F. Ekelund, London.
5271 Centrifugal Pumps, D. A. Garcenot, London.
5284 Valve Apparatus, H. Trott, London.
5286 Crushing Ores, W. H. Coward, London.

March 28th.

5301 Motor Engines, W. P. Theerman, Manchester.*
5325 Safety Valve, A. McMaster and J. G. Tinley, Down.
5327 Boiler Tubes, A. Rollason and A. C. Chapman, Newcastle-on-Tyne.
5328 Water Motors, R. G. Morton, Glasgow.
5332 Slide Valves, T. Scanes, Forest Gate.
5333 Stamping-up Sheet Metal, P. Mallet, London.
5336 Corrosion of Propeller Blades, J. Verity, London.
5339 Purifying Sea Water, V. B. Lewes, London.
5346 Screws, &c., W. Hillman, Middlesex.
5352 Sand Moulds, J. Mees and A. B. Mees, Middlesex.
5366 Furnace Grates, T. Lineker and J. Fletcher, London.

March 29th.

5376 Pulleys, G. Hurdle, Southampton.
5380 Crystal Blue, G. R. B. Kempton, West Ham.
5381 Blowing Fans, E. Williams and W. H. Holland, Birmingham.
5382 Flues, E. R. Joicey, London.
5384 Band Saw Machines, W. Heathman, London.
5387 Belt Pulleys, W. Begg, Glasgow.
5389 Artificial Fuel, A. J. Boult, Middlesex. (H. G. Weber, United States.)*
5397 Gas Motor Engines, A. S. Nelson and J. G. McMillan, Glasgow.*
5402 Speed Recorders, E. E. Wigzell, London.
5403 Rollering Steel, W. Boyes, Birmingham.
5404 Coupling Box, V. Shervey, Bristol Bank Buildings.
5421 Cam, J. S. Bowley, London. (E. J. Way, Transvaal.)
5434 Rotary Engine, J. Holcroft, London.
5438 Casting Ingots, M. Scott, London.
5443 Liquid Meters, G. Teideman, London.

March 30th.

5451 Shield for Gauge Tubes, G. H. Wall, London.
5457 Railway Buffers, A. E. Morgan, Birmingham.
5461 Furnaces, L. R. Ingham and M. Dean, Accrington.
5466 Aerial Railway, W. Leggott, Hull.
5471 Valves, Sir W. Thomson, Glasgow.
5474 Flanging Pipes, J. Wotherspoon, Glasgow.
5484 Stuffing Boxes, R. Marshall and E. F. Gerald, London.
5500 Steam Traps, W. Watson, London.
5505 Rotary Apparatus, J. B. Stoner, London.
5509 Arc Lamps, H. E. Fenner, London.
5510 Forging Presses, C. Davy, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

The Practical Engineer,

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE

PRACTICAL ENGINEER,

APRIL 19TH, 1889.

THE PURIFICATION OF RIVERS.

A PAPER was read on Wednesday, April 10th, at the Society of Arts, by Captain Sir Douglas Galton, K.C.B., on the sanitary functions of the recently-appointed County Councils, one part of which dealt with a most important matter from an engineering standpoint—the disposal and treatment of the Metropolitan sewage. The sewage problem is one which has long waited for satisfactory solution, and has greatly occupied the energies of engineers and chemists of every type, from the most rabid theorist, ignorant of the real difficulties of the problem to be solved, and confident in proportion to the extent and intensity of his ignorance, to men of the highest standing both as practical engineers and practical chemists.

The Act of 1855 created the Metropolitan Board of Works, and imposed upon them the duty of making such sewers and works as were necessary for preventing the serious contamination of the river Thames in or near London. In 1858 the Board of Works submitted their scheme to the Government, who passed it on to a committee of referees—Captain Galton, Mr. Simpson, and Mr. Blackwell, who condemned it on the grounds that insufficient provision was made for the increase of the Metropolis, the removal of storm water, and that the scheme would allow of serious pollution of the river. Twenty-seven square miles only were drained by gravitation, and for the remaining 92 pumping had to be resorted to, in many cases twice over. They recommended an alternative plan, namely, to discharge at outfalls placed at sea reach, instead of Barking and Erith Reach, and so pump only 38 square miles, while 81 square miles were discharged by gravitation. By so doing it was held that chemical treatment of the sewage would be unnecessary, because of the rapid dilution in the open sea, and absence of tendency to return by the tide.

Notwithstanding the adverse opinion, the Board of Works were allowed to carry out their original scheme, with the result predicted by the committee, as is proved by the Report of the Royal Commission on Sewage Discharge in 1884, stating that the serious floodings of the low-lying portions of London made it necessary to construct additional large sewers, costing, as estimated by Sir Joseph Bazalgette, £1,500,000. It was also necessary to enlarge the reservoirs at Barking and Crossness for crude sewage. From a purely theoretical standpoint, it seems very wasteful to discharge, without use for fertilising land, such large quantities of ammonia and phosphates as are contained in sewage; but the difficulties of economical recovery and distribution are so great that it seems almost the only plan open to us in dealing with large cities.

The methods of treatment of effluent water may be broadly classified under two modes—(1) where the object of the process is to destroy the organic matter by oxidation or chemical change, and so purify the water; (2) where the object of the process is to remove the organic matter by precipitation or otherwise, but without destroying it, so that it may retain its ammonia and other organic compounds in a condition suitable for fertilising.

We here refer to methods of treatment of sewage where the water-carriage system has been adopted, not to methods of treating solid matter as very successfully accomplished at Rochdale. Such methods are applicable to towns of moderate dimensions, but we fear could not be used in large cities without inordinate expense and too great inconvenience.

The late Dr. Angus Smith proposed many years ago to aerate sewage by pumping air into it, and so causing the dissolved oxygen to attack the organic matter, and oxidise it by converting the ammonia to nitrates and the carbon to carbonic acid, and this is the process which always occurs in nature, without which our rivers would speedily become foul, and even the sea itself lose its freshness. The air was forced into intimate contact by means of a screw propeller arrangement which lifted the water and sucked air into it, so that it became churned up into a mass of foam, such as we see when the paddles of a steamer strike water. It was found that a very considerable oxidation was obtained in this way, and one which arrested the process of putrefactive decomposition for many hours after treatment, so that the water could flow out to the open sea, still remaining inodorous. Sir Henry Roscoe also recommends this treatment, according to Sir Douglas Galton, and states that the growth of animal and plant life is encouraged. Those plants and animalculæ absorb oxygen, and are excellent decomposing agents to burn up and render innocuous all forms of deleterious organic matter. He says: "The purification of river water is chiefly affected by living organisms requiring free oxygen for their growth. These may be said to effect the changes generally ascribed to animal life. But other organisms of a vegetable character, such as algæ, &c., are always present in river water. These evolve oxygen during their life, and they are also potent instruments in the natural purification of the river. Indeed, they are capable of oxygenating the water far above its normal amount, and thus aiding in supporting the life and growth of the former class of organisms. Both forms, therefore, assist each other in ridding water of dead organic matter, both soluble and insoluble, and therefore bringing it into a healthy condition."

In our opinion, the oxidation and destruction of the organic matters in sewage is the most hopeful and sound proceeding considered from an engineering and commercial standpoint. The numerous attempts to precipitate and utilise fertilising constituents have caused enormous outlays, and have attained but indifferent success. Indeed, we are not aware of any of them being financially successful, and many have been disastrous failures. On the other hand, the efficient supply of oxygen in some manner closely imitates Nature's methods, and by proper treatment may be made to oxidise and render innocuous vast quantities of water. It is a question, however, in what way this oxygen may be best and most efficiently supplied, as mere mechanical pumping does not cause an intimate or rapid enough absorption to be quickly efficient at ordinary temperatures, and ordinary temperatures only are within the range of practice, although we have heard sanguine inventors propose the application of heat, forgetting the enormous expenditure of fuel which would be requisite. Other more feasible proposals have been made, such as the use of spongy iron and animal charcoal, but both are too expensive and slow. Spongy iron or carbide of iron has a powerfully oxidising effect upon organic matter in water, and is used with success in the purification of water for drinking purposes on a large scale. The iron has the advantage of being capable of treatment which restores its oxidising properties when impaired by use. The action is to some extent an electrical one, similar to that of spongy copper and zinc, originally, we think, discovered by Dr. Gladstone and Mr. Tribe.

If granulated zinc be placed in a solution of a copper salt, the copper deposits in fine powder upon its surface, and when the salt is washed away the mixture of zinc and copper has remarkable properties. If pure water be placed upon it, and gently heated, hydrogen is evolved and zinc oxide is formed. Zinc alone has no power to decompose water in this way, but when covered with a finely-divided copper an electrolytic action supplements the tendency of the zinc to combine with the oxygen of the water, and it decomposes. The action of spongy iron is both reducing and oxidising, and is thus powerfully purifying.

The electrolytic process of Mr. Webster seems to us to be very hopeful. The oxygen necessary to decompose the organic matter is not required in any great quantity, but it must be in its most powerful form, and as it is well known that oxygen, in what chemists call its nascent condition, is in its condition of greatest chemical activity, at ordinary temperatures, it follows that it should be applied to its work in this state if possible.

When a current of electricity passes through water it becomes decomposed into its constituent gases, hydrogen and oxygen, which escape at the metallic surfaces placed in the water from which to pass the current. At the moment of formation the gases are exceedingly active chemically, and rapidly attack any oxidisable matter and burn it up (because oxidation is really burning, at whatever temperature it occurs) to carbonic acid water and nitrates. In sewage waters, there is always present a considerable proportion of chlorine in the form of metallic chlorides, such as sodium chloride, and here the electrical action is different from that occurring with pure water. The oxygen unites with chlorine and forms with water an acid known as hypochlorous acid, which has of itself a violent oxidising power, so that in sewage the oxidising action of electrolytic decomposition is more violent than in ordinary water. These facts form the basis of Mr. Webster's process, and we think that if the practical difficulties, which are very considerable, can be overcome, the process should be a successful one. It is, however, a very different matter to deal with millions of gallons than to treat a small quantity in a glass beaker. We shall therefore await with interest the further results of his large scale experiment at Crossness outfall.

We thoroughly agree with Sir Henry Roscoe in considering that oxidation is the proper direction in which to look for a successful system of sewage purification, but it is impossible to say whether eventually the mechanical aeration by means of pumps of some form, may not be more practicable than the electrolytic method, fascinating as its central idea undoubtedly is.

We sincerely hope that the London County Council may find engineers and chemists capable of solving practically the great and difficult problem of the purification of the Thames, as the difficulties with other rivers could then be readily conquered.

Efficient means of purifying water are urgently required to help us to abolish one hitherto unavoidable evil of our material prosperity and collection in huge cities, the pollution and degradation of our formerly pure rivers and streams.

THE DESIGNS FOR NEW BATTLE-SHIPS.

THE annual meeting of the Institution of Naval Architects, commenced on Wednesday, the 10th April, was the occasion of a remarkable and most interesting discussion. Sir E. J. Reed, formerly the director of naval construction, had severely criticised in the House of Commons and in the *Times* the designs of the new warships proposed to be added to our navy, and stated in his opinion that in battle they would be found of the most dangerous and inefficient type. Mr. W. H. White, the present chief constructor, obtained the consent of the Admiralty to read a paper upon the new types of ship, in order to discuss the matter before engineers and shipbuilders familiar with the subject. This proceeding seems to us a most admirable one, as the House of Commons cannot be considered a fit field for discussion by engineering and scientific experts. In the interesting discussion which followed the paper much light was thrown upon the difficulties and conditions of naval construction, by men who had every opportunity of forming an opinion from sound and extended experience. Mr. White's paper was long, and detailed with great minuteness the points sought in an efficient battle-ship, from which it clearly appears that, like all other machines, a warship is a compromise betwixt conflicting and sometimes entirely antagonistic conditions, all of which are separately of great importance.

The progress made of late years in the use of high explosives and the great power of recent guns has made it possible to pierce any existing armour. The limit of velocity and penetrative power of shot has not yet been reached. On the other hand, the displacement of a ship cannot be indefinitely increased, and consequently the weight of armour she can carry is strictly limited. Modern designers have, therefore, departed from the older form of completely heavily armoured ships, and adopted instead a restricted belt of the heaviest armour for the ship, heaviest armour protection for the great guns, and comparatively light armour for the other parts, and in some cases no protection for the ends. This course enables them to put greater weight in the new auxiliary armament of quick-firing guns, more powerful engines, and greater coal capacity — therefore greater speed and staying power. They have, in fact, produced ships capable of being sunk under certain circumstances, just as were our old wooden frigates, but also having immense powers of offence for sinking others. This type of ship is now largely used in foreign navies as well as in our own. Mr. White minutely described the nature of the advantages given by the construction, and the disadvantages of increasing thickness of armour unduly, which would require much larger and more expensive vessels. Sir E. J. Reed criticised at considerable length the limited armour system, if we may so call it, and stated that a battle-ship ought to be so armoured as to render it impossible to sink her by any existing naval guns. He considered the narrow armour belt as dangerously deficient.

Sir Edward's speech was an able and temperate one, much more impartial in tone than we should have expected from his previous letters to the press upon the subject, and from his point of view his arguments had considerable weight. Lord Armstrong followed, and stated that if a ship be rendered entirely safe from being sunk, we should so hamper her with protective armour as to destroy the chances of successful attack. It must be quite clear, his lordship said, that the ship designer must compromise in the best way he can, and in ships of the new barbette class we had the best compromise available with existing knowledge between offensive and defensive principles. He looked with disfavour upon the completely armoured class, which could not be made invulnerable, even at a cost enormously in excess of other types. Our navy should contain many ships of comparatively restricted cost rather than a few of the most costly ships.

Lord Charles Beresford then spoke, and agreed with Lord Armstrong that to make a ship perfectly safe you must greatly limit her powers of offence, and, in his opinion, the true problem was to decide upon the rival claims of armour v. armament. He, as a sailor, entirely condemned ships which were not fighting ships, and in this he was at one with his brother officers.

Sir Nathaniel Barnaby defended the Admiral and Inflexible class of vessels, and agreed in the main with the two former speakers in their view of high offensive power and limited armour.

Several naval officers spoke, including Admiral Hornby, Captain FitzGerald, Admiral Colomb, and Admiral Lord Clanwilliam, all viewing favourably the new designs.

It seems undoubted that Sir E. Reed's main point—more extensive armour protection—was pressed too hard by him, and that for efficient fighting the ships should have heavy armament, high speed, and considerable coal endurance; and to obtain this it is necessary to restrict the armour to some extent. It is exceedingly valuable and interesting to have the opinion of experts upon new designs discussed openly, so that all may understand the points at issue in matters of such national importance as our navy.

THE PETROLEUM EXHIBIT AT THE PARIS EXHIBITION.

The petroleum industry is to be represented at the Paris Exhibition in a novel and interesting manner, which takes the external form of a circular petroleum tank of about 59ft. diameter, and 26ft. high, constructed of sheet iron and riveted together. Contrary to the usual method, the structure was commenced at the timber work of the roof, and each ring, about 3ft. 3in. high, was riveted together on the ground, and then elevated to position by hydraulic jacks; then another was built up after underpinning the first in position, and forced on the one above it similarly by jacks, and then riveted in position. Finally the bottom was put together and riveted. By this method the floods which passed over the ground occupied by the exhibit did not damage the work in any way.

The interior of this tank building is arranged as a panorama, the circular walls being utilised for this purpose, and painted by M. Poilpot, representing interesting views of the oil districts in the United States and the Caucasus, with geographical maps, which indicate the positions of the oil-bearing layers where the petroleum industry is cultivated. All the different uses of petroleum are represented, apparatus for lighting and heating, petroleum engines, and other applications.

The interior is divided into two stages; on the ground floor all apparatus and implements used in the petroleum industry are placed in a circular gallery for inspection, while the upper portion is devoted to the panorama.

The idea seems to us striking and ingenious, one which should convey easily to visitors a vivid idea of the magnitude and growing importance of this source of liquid fuel supply. Not only will the separate apparatus be open for inspection, but their uses will be portrayed upon canvas in such a way as to bring home to the mind the modes of use in the different processes of manufacture.

HYDRAULIC MACHINERY EMPLOYED IN THE CONCENTRATION AND TRANSMISSION OF POWER.—VI.

In our last article we described the tools used in the manufacture of ordinary cup leather packings, and their method of use. Neither the hat packing nor the U can be made in so simple a manner. Figs. 27 and 28 illustrate the formation of the hat packing from a circular disc of leather. The packing is finished by cutting out the central disc and champering the edge to an angle of 45 deg. The pressure employed in forcing the leather into the die may be supplied by means of a central screw and nut, as described in our last article, for the ordinary cup packing.

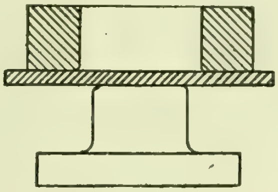

Fig. 27.

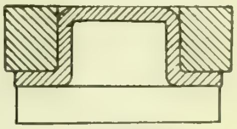

Fig. 28.

In this case, of course, a small hole must be first cut in the disc of leather for the central screw to pass through. This hole must in any case be small, otherwise it will be found impossible to make a satisfactory packing on account of the tearing and distortion of the leather. If screw clamps, or a small screw, or hydraulic press be employed, however, the central hole may be dispensed with. These remarks apply equally to the manufacture of U leathers, which indeed are frequently made by means of the press in which they are subsequently to be used.

The dies used in the production of U leathers are illustrated by figs. 31 and 32.

The pressing is effected in two stages: First the leather is pressed into a cup shape (see fig. 31), and at a second operation (fig. 32) the cup is pressed into a hat shape, with a U-shaped rim, part of the rim of the original cup going to form the internal rim of the U, as will be readily understood from the figures. The central disc is then cut out and the edges champered to an angle of 45 deg., as in the case of the hat packing.

The discs of leather used in the manufacture of leather packings are very readily and rapidly cut out of the hide by means of a knife-cutter fitted to the end of an ordinary hand-drill, and adjustable to any radius by a set screw, the discs cut out of the centre of large packings being, of course, used for smaller packings.

The formula which we gave in our last article for the friction of cup, U, and hat packing, viz.,

$$f = \cdot 04 \frac{P}{D}$$

when f is the friction of the leather packing, P the whole load on the ram or piston, and D its diameter in inches, may be conveniently thrown into a form in which the friction is given as a function of the hydraulic pressure per square inch and diameter of the packing. For if P be the pressure per square inch,

$$P = PD^2 \times \cdot 7854 \text{ ; and hence}$$
$$f = \cdot 04 \times \cdot 7854 \times PD = \cdot 0314 \times DP.$$

In this form the formula is applicable to packings used for other purposes than maintaining rams or pistons tight, the pressure per square inch and diameter of the packing alone being required to be known.

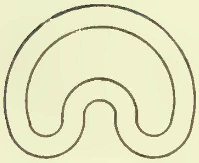

FIG. 29.

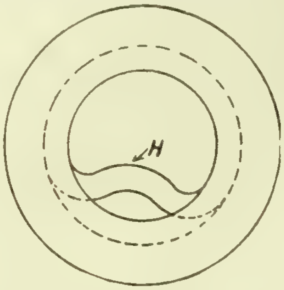

FIG. 30.

From the foregoing brief description of the method of working leather hydraulic packings, the truth of our remarks as to the inadvisability of employing an unnecessarily deep packing will be sufficiently apparent, especially as regards U packing. Fig. 33 illustrates the proportions to be recommended for ordinary U packings, which will indeed be found ample for all purposes. The internal diameter of a U packing should be about $\frac{1}{16}$in. less than that of the ram which passes through it, and the external diameter about $\frac{1}{16}$in. greater than the recess or cylinder in which it fits; the diameter being measured at A and B, fig. 33. This will ensure the tightness of the packing when first inserted. For large packings a somewhat greater margin may be allowed. It is always best to fit the mouths of cylinders in which U leathers are used with glands (fig. 34), the mouth of the ram being well rounded, so that the leather can be put in place without any injury to its shape or edges. The ends of rams should similarly be well rounded or tapered for a distance of say half an inch, with the same object. For many purposes it is, however, sufficient to simply turn a groove in the mouth of the cylinder (see fig. 35), to receive the packing. The leather, if of large diameter, is easily inserted in the groove, by first doubling it into the shape illustrated by fig. 29, but, if small, practice and care are necessary to avoid injury to the leather. A small leather is usually inserted by first suppling it by letting oil stand in the rim a short time, if the leather be at all harsh; it is then pushed into the groove as far as it can be got to go, leaving as little remaining out of the groove as possible, and a blow or two from a piece of wood struck by a hammer will then usually suffice to put it in the shape illustrated by fig. 30, and another blow at H (fig. 30) will drive it nearly into the groove.

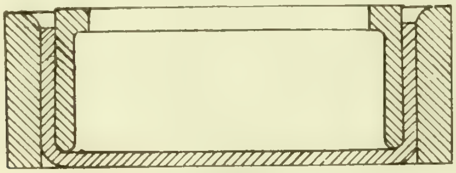

FIG. 31.

It is, however, better practice to fit the mouth of the cylinder with a gland (fig. 34). The studs securing the gland should not be subjected to a test stress exceeding 15 tons per square inch, if of wrought iron, and if this maximum be not exceeded, a sufficient margin of strength will be provided to compensate for extra stresses due to unequal tightening of the nuts, &c. The thickness of the flange of the gland, if of cast iron, may be one and a half times the diameter of the studs, and the width of the flange three times the diameter of a stud. The projecting portions of the gland should be one and a half times the stud in length.

If p be the hydraulic test pressure per square inch, d the diameter of the ram, and c the width of the packing, the whole stress on the studs due to the hydraulic pressure is

$$(d+c)\, c\, \pi\, p = 3 \cdot 1416\, (d + c)\, p\, c.$$

Hence if n be the number of studs, and d_1 the diameter of a stud at the bottom of a thread, the stress on the studs per square inch is

$$(d + c)\, c\, \pi\, p \div n\, d_1{}^2\, \frac{\pi}{4} = \frac{4\, p\, c\, (d + c)}{n\, d_1{}^2}$$

which, as above stated, should not exceed 15 tons, or 11,200lb.

We have recommended $\frac{5}{8}$in. as the most suitable dimensions for c, but if circumstances render it advisable to reduce the space occupied by the packing to minimum limits, c may be diminished to $\frac{7}{16}$in. without very greatly subtracting from the efficiency of the packing.*

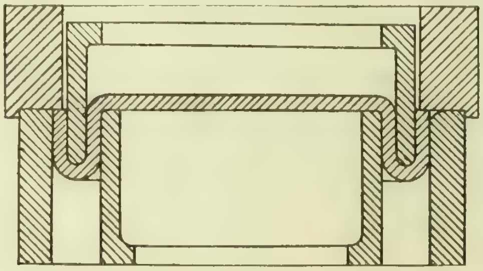

FIG. 32.

HEMP PACKING.

The first cost of leather hydraulic packings is comparatively high, and if the surfaces against which they work are not carefully looked after, and maintained in a state of perfect polish and well lubricated, the packings will deteriorate rapidly and become no inconsiderable portion of the expense of maintenance of an hydraulic plant. For these reasons hemp packings, which are thus water tightened to strong mechanical compression by means of a stuffing box and gland, are used by many engineers wherever possible; since the first cost of the hemp packing is comparatively inconsiderable, while at the same time the packing can be renewed more rapidly and with less loss of time. If the rod or plunger which is to be packed is heated, as is necessarily the case with some types of steam pumps, leather packings are altogether inadmissible, and hemp, asbestos, or some similar packing must be used.

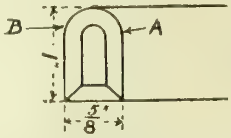

FIG. 33.

On the other hand, the friction of the mechanically compressed hemp packing is far greater than that of the self-acting leather packing; also, if the hydraulic pressure for which the packing is used be high (and hemp packing, contrary to the opinion of many, may be employed successfully for very high pressures, such as three tons or more per square inch), there is considerable risk of scoring the surfaces of the ram and plungers in actual work, owing to the necessarily intense pressure with which the packing must be forced against the sliding surface in order to secure water-tightness. A further objection to hemp packing is that the packing must be compressed with sufficient force to ensure its being tight under the highest pressure at which the machine in which it is used is intended to work; hence, although the machine may be frequently working under a comparatively low pressure, the friction of the packing is always that due to the higher pressure, and may amount to a very large percentage of the whole work done by the machine, whereas, if leather packings be used, since the pressure on the packing varies directly with the work which the machine is performing, the *percentage* of power absorbed by the friction of the packings is, within certain limits, practically constant.

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* There is a difference of practice among manufacturers of hydraulic packing leathers, some preferring to use the grain and some the skin side of the hide for the wearing surface. The latter plan makes the neatest leather in appearance, and is generally to be recommended.

It must be left, then, to the judgment of the engineer to decide which description of packing shall be employed in any given case, each type having its own special advantages and defects, which must be duly weighed and taken into consideration before arriving at a decision. The friction of hemp packings cannot be so definitely determined by experiment for any given conditions of use as that of leather hydraulic packings. We have not merely to consider the intensity of the hydraulic pressure employed, as in the case of leather, but the depth of the stuffing boxes and diameter of the packing surface, as also the degree of pressure applied by means of the stuffing box gland. Under the same degree of compression there is no doubt that a deep stuffing box will produce more frictional resistance than a short one; but, on the other hand, the deep stuffing box will not require so intense a compression as the short one, and hence in actual practice the friction of the short stuffing box may exceed that of the long one, if the packing is to be water-tight under a given maximum pressure. It is, however, very desirable in practice to have a simple formula by which to determine the probable maximum friction of a hemp packing under given conditions. If the packing be screwed up judiciously, and the stuffing box of fair proportions, the formula may take the form $cpd = f$, where c is a constant, to be determined by experiment within assigned limits as to pressure and diameter, p the hydraulic pressure (maximum) per square inch, d the diameter of the ram or rod in inches, and f the total amount of the friction. For many purposes it is sufficient to take f as equal to one-tenth the pressure per square inch, multiplied by the diameter of the ram, or $f = \frac{pd}{10}$, and the friction of a hemp packing judiciously used will rarely exceed this amount within very wide limits of pressure and diameter.

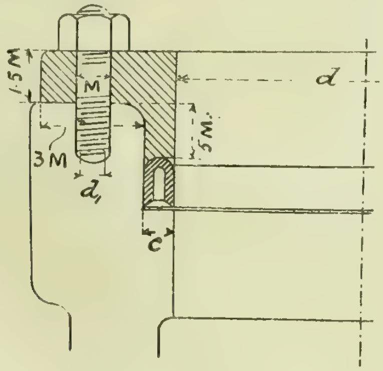

Fig. 34.

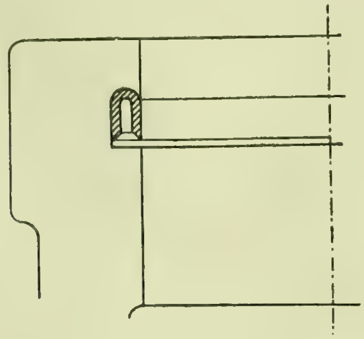

Fig. 35.

A very simple method of ascertaining the approximate friction of a ram packing is available when the ram can be loaded and fixed so as to rise and fall vertically. Let the ram be loaded, perfectly central, with any weight, the amount of which need not be exactly ascertained, and let the pressure per square inch required to raise the ram at the slowest speed be ascertained by means of an accurate pressure gauge communicating directly with the cylinder, and let the pressure be P_1. Next let the pressure in the cylinder be similarly ascertained when the ram is descending as slowly as possible, and let the pressure be P_2. It is very important that the motion of the ram should be exceedingly slow during the experiment. Then the friction of the packing will be approximately $\frac{P_1 - P_2}{2}$ × area of ram in square inches.

It is most necessary in carrying out such an experiment as this, however, to test the accuracy of the pressure gauge employed, since the ordinary commercial pressure gauge is frequently grossly inaccurate, and in the case of high hydraulic pressures as a general rule absolutely unreliable. This point we shall recur to subsequently, it being one with regard to which the writer has had very special experience.

The following table gives suitable dimensions of the packing space for stuffing boxes of various diameters:—

Diameter of Ram.	Diameter of Stuffing Box. Inside.	Depth of Stuffing Box.	Diameter of Ram.	Diameter of Stuffing Box.	Depth of Stuffing Box.
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1	1⅝	2	12	14¼	6½
2	2⅞	3	14	16¾	7
3	4⅛	3½	16	18½	7½
4	5¼	4	18	20¾	7¾
5	6⅜	4½	20	22⅞	8¼
6	7⅝	4¾	22	25	8½
7	8¾	5¼	24	27¼	9
8	9⅞	5½	26	29¼	9¼
9	11	5¾	28	31½	9½
10	12⅛	6	30	33½	10

The dimensions of the gland studs for stuffing boxes should be proportioned in a similar manner to those for the glands for U leathers, but with a larger margin of strength.

Let, as before, n be the number of studs on bolts

In inches $\begin{cases} d_1 \text{ the diameter of a stud at the bottom of the thread} \\ D \text{ the diameter of the ram or rod} \\ D_1 \text{ the internal diameter of the stuffing box} \end{cases}$

P the maximum pressure in pounds per square inch

Then $d_1{}^2$ should not be less than

$$\frac{(D_1 - D)\,(D_1 + D)\,P}{5000 \times n}$$

The thickness of the flange of the gland should not be less than one and three-quarter times the external diameter of the stud, and its width may be three times the diameter of a stud for cast iron.

P in the above formula is to be taken as the maximum working pressure or one-half the test pressure, the larger of the two values being selected: that is, if the maximum working pressure be greater than half the test pressure, P must be taken equal to the working pressure; but if half the test pressure be greater than the maximum working pressure, then P should be taken equal to half the test pressure.

MATERIALS OF ENGINEERING.—XV.

Chains, Ropes, Lubricants.

In this concluding article I will summarise the more important particulars relating to chains, ropes, and lubricants.

Chains are made of BB quality of Shropshire iron. Those used by engineers are almost invariably the close link or short link kinds. These are oval in form, as distinguished from the circular link and the stud link types. Common oval link chains have their links longer than the close link, in the proportion of about 6 to 5. The proportions of close link chain are given in terms of the diameter of the iron of which it is made. The length of link in these is from about 4⅔ to 5 times the diameter. The weight of close link chain is about two-thirds that of the bar from which it is made, estimating in equal lengths.

The oval form given to the links of these chains is conducive to elasticity, as they yield and stretch when subject to stress. The length of the link is a practical matter. The shorter the links the more flexible they are, and the less the bending stress to which they are subjected when passing over a pulley. Because of this bending stress, a good rule is, that the diameter of a sheave pulley should not be less than thirty times the diameter of the iron of which the chain is composed. It is not practicable to weld links shorter than those in the close link chain. During the process of manufacture they are welded up in succession;

but when a shutting link is inserted, as is often necessary in the shops, then it is made longer than the contiguous links, and also about $\frac{1}{16}$in. thicker, because of the difficulty of welding.

Stayed link chains are not used to any considerable extent in engineering. They are heavy, and ride roughly over the pulleys, but they are stronger than the open link made of the same size of iron, in the proportion of about 9 to 6.

The strength of the iron of which chains are made is about 26 or 27 tons per square inch; but the ultimate strength of a chain is not double this, but often something like 25 per cent less. This reduction of strength is due to imperfect welds and to burning of the iron during welding.

The strength of chains is commonly estimated in terms of the square of the diameter of the iron, and that of ropes by the square of their circumference. But this mode of estimation is strictly applicable only to those of moderate dimensions, because in large dimensions the strength is no longer proportionate to size.

To estimate the strength of chains approximately, the safe-working load of a 1in. chain is about six tons. Then the comparative strength of other chains is to the 1in. chain as the square of the diameter of the iron from which they are made. This is not strictly correct in very small or in very large chains. Another approximate rule for the safe-working load of chains is: Square the number of eighths of an inch in the iron, and strike off the last figure as a decimal; the result is the greatest safe-working load in tons; if there is a single figure only, it represents the decimal fraction of a ton. Chains are usually tested to about one-half their estimated breaking strength; the proof strain is about double the safe-working load. Chains of great length are apt to twist, and this is a source of danger, as tending to stress the links. The twist should always be promptly removed. In chains used for hauling, the common smooth pulley, with a semi-circular groove, is generally discarded in favour of the grooved pulley, with or without side-flanking flanges. The latter are mostly superfluous. For the same reason a crank hook is attached to the chain through the medium of a swivel, so that the hook may turn without twisting the chain. When the pulley has to draw the chain it is recessed to receive the successive links. The term cup-drum is often applied to such a pulley. Chains require constant care if they are to be maintained in efficiency and safety. They should have frequent lubrication with oil, properly applied with a brush. After a chain has been in constant use for several months it ought to be annealed by being warmed over a wood fire, by which process the brittle condition of the iron is partially or wholly removed, the crystalline character being changed again to fibrous.

The fibres of hempen ropes are from three to three and a half feet in length, and when twisted to form a yarn their mutual friction prevents the rope from being drawn asunder. The amount of twist given to a rope determines the amount of the shortening of the fibres which results. If shortened a quarter of their length, the twist is said to be one quarter, &c.

White or Manilla ropes are stronger and more pliable than the tarred hemp ropes. Tarred ropes retain their strength longer, particularly when subject to the action of wet. Tarred ropes which are made by the warm register—that is, spun hot—are stronger than those made with the yarn cold, because the heated tar, being more fluid, penetrates the fibres, and air and moisture are driven out, so bringing the fibres close together, rendering the whole mass impervious to water. But if stronger, it is less pliable, and for this reason the cold registered rope is generally preferred for crane work.

Dr. Anderson's experiments at Woolwich showed a very great variation in strength in pieces cut from the same coil of rope. In a 6in. rope the strength varied from $14\frac{1}{4}$ tons to 17 tons, in a 9in. from 25 tons to $29\frac{11}{16}$ tons. Moreover, a few months working vastly diminished the strength of a rope. Thus, a 6in. Russian hemp rope, whose strength when new was $11\frac{1}{4}$ tons, broke afterwards with $5\frac{1}{2}$ tons.

The old rule for the strength of ropes is, that the square of the girth in inches was equal to the breaking strength in hundredweights. The square of half the girth equals the weight in pounds per fathom. A double rope suspended from a crane hook will break at less than double the strength of a single rope. But a double rope suspended from a pulley or thimble will bear twice the load of a single rope.

To obtain the breaking strength of wire ropes of iron, square the circumference in inches, and multiply by 1·5. For ropes of steel, square the circumference in inches, and multiply by 2·5. The breaking strength of round wire ropes is also estimated as 2 tons per pound weight per fathom for iron, and 3 to $3\frac{1}{2}$ tons per pound weight per fathom for steel. The working load is taken as about one-sixth of the breaking strength.

Many points have to be regarded in the selection of lubricants. Some lubricants have much body—*i.e.*, are thick; others have little body—that is, are thin. Castor oil, tallow, neatsfoot, and rape are thick and heavy; lard, olive, sperm, and mineral oils are light or thin. Thick oils last longer, but thin oils diminish friction in a greater degree, and so prevent heating; but as thin oils become rapidly squeezed out from bearing surfaces, their use is unsuitable in cases where the bearings are subject to great pressure.

But this is only one aspect of the matter. There is, for example, a vast difference between the lubrication of a line of shafting or the bearings of a machine running at slow or moderate speed, and that of engine cylinders and their parts where the temperatures are high. Then there is the tendency of some oils to generate heat by chemical action, or to act chemically upon certain metals. The animal and vegetable oils do not generate heat in dangerous quantity; hence their flashing and firing points are high. But mineral oils have a low flashing point; hence the latter are unsuitable for cylinder lubrication, for which properly the animal oils are adapted. Many oils flash below 212 deg. Fah., a standard too low for safety. No oil ought properly to be used even for machinery whose flashing point is below 300 deg. or 350 deg. Fah. For cylinder lubrication a much higher standard should be employed, say 500 deg. Fah.

The tendency to spontaneous ignition is produced by the oxidation or drying of the oil, a source of frequent fires when the oil droppings have been allowed to accumulate in a warm place, as on a roof beam in contact with waste, wipers, or other inflammable material. The "gumming" or clogging of bearings is also due to the oxidation of oils; hence drying oils are unsuitable in themselves—that is, if used alone for lubrication. Most of the vegetable oils and fish oils are drying oils; animal and mineral oils are not.

Engine cylinders that have been long in use, and lubricated with tallow frequently, show large pittings and corrosions, the work of acids generated by the decomposition of the tallow. These acids are found to be developed only in animal and vegetable oil; they are not in mineral oils, properly refined. An oil that evaporates rapidly at a moderate temperature should be avoided as being wasteful. Although the fixed vegetable oils, by their absorption of oxygen and by their development of acidity, are in these respects unsuitable for lubrication, and although the animal oils are liable to develop acid, and the volatile mineral oils have a low flashing point and are very thin, yet by a judicious mixture of various kinds the evils incidental to each are neutralised, and the various compound oils so formed are rendered suitable for any required condition of work. The tendency of the vegetable oils to dry is quite neutralised by the addition of a small quantity of a mineral oil, and the tendency to acidity is neutralised by the admixture of mineral oils. Even though an oil or fat may be procured free from acid, yet it does not follow that it will always remain neutral. Acids are liable to be developed at any time by the decomposition of animal and vegetable oils.

The mineral oils are hydro-carbons obtained from various sources, among which are those obtained in small quantities from coal and shale in this country, while the bulk are hydro-carbons, obtained from American petroleum. These are quite free from the tendency to develop acid or to oxidise. Various processes are necessary to prepare the crude oils and render them suitable for different classes of machinery. They are filtered, heated with superheated steam, passed through beds of charcoal, distilled, and otherwise purified, the processes varying according to the nature of the lubrication required. But the result is that compound oil of almost any required grade suitable for any class of machine can be obtained from the refiners, who make their preparation a study, and the tendency, therefore, now is in the direction of the more general employment of compound oils, and to the corresponding partial abandonment of the simple oils and fats.

J. H.

HOLLOW IRON PIG PATTERNS.*

For the past year we have had in use at the Durham furnace a set of hollow pig patterns made of iron, which have given such satisfactory results that I have thought a description of them would be of interest to the members of the institute.

Before the introduction of these iron patterns, we used the ordinary wooden patterns, made in the usual way, with straps of iron along the sides to protect the corners from wearing off. The size and shape of these wooden patterns are shown in fig. 1.

When the patterns were new, the pigs weighed about 130lb. each.

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* By B. F. Fackenthal, jun. Trans. of Am. Inst. of Mining Engineers.

They were uniform in size, and the moulding was clean; but constant use soon wore the patterns away, and at the end of a few months the pigs had become, in consequence, so much lighter that the moulding daily of several additional beds was necessary to accommodate the same quantity of iron. As the patterns wear away, the moulding becomes ragged, and the pigs rough. Moreover, wooden patterns are often destroyed by fire. I have known an entire set to be destroyed by a break-out of iron.

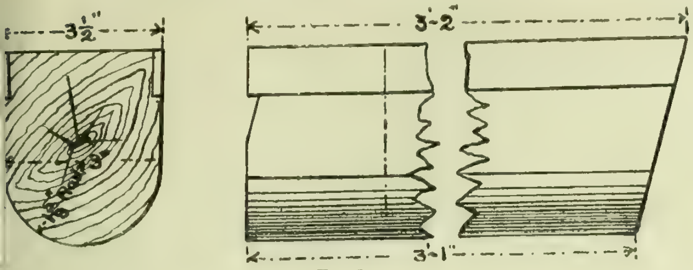

Fig. 1.

The iron pattern which I have designed is free from all the objections to the wooden pattern, being not only more durable, but, in the long run, far cheaper.

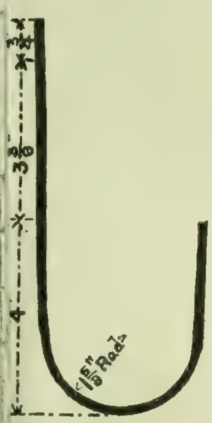

Fig. 2.

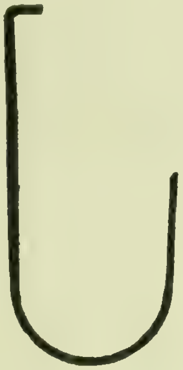

Fig. 3.

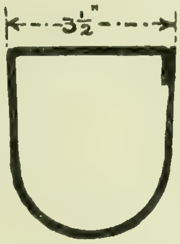

Fig. 4.

The iron pattern, having the same shape and size as the wooden one, is made of the best flange iron, of No. 13 gauge. After the sheets have been cut to the proper size, three heats are required for the flanging. At the first heat each piece is stamped in a cast-iron form, which gives the proper shape to the bottom part of the pattern, as shown in fig. 2. At the second heat it is flanged as shown in fig. 3. At the third heat it is again flanged, giving the pattern its final shape, as shown in fig. 4.

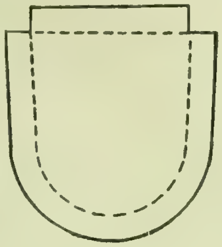

Fig. 5.

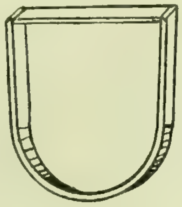

Fig. 6.

The flanging is done on a square mandrel.

Care should be taken to have the corners left full and perfectly square.

It now remains only to rivet the pattern together, and put the heads or ends in. The ends are also made of No. 13 flange iron, and are stamped in a cast-iron form or die by means of an old screw-punch, the iron being cut to the proper shape before stamping, as shown in fig. 5.

These ends can be made very quickly, only a few seconds being required for the stamping. The finished end is shown in figs. 6 and 7.

The end farthest from the sow, and shown in fig. 7, is, of course, put in first, the flange going inside the body of the pattern, as shown. The end next to the sow is then put in, with the flanged part to the outside, as also shown in fig. 7. This forms the handhold for drawing the pattern out of the sand. The rivets are placed about 1½in. apart, and are all countersunk on the outside, the holes being drilled after the pattern is flanged.

A finished pattern of this kind weighs no more than a new wooden pattern after it has become water-soaked. Thinner iron could be used; but I have thought it best to use No. 13, and thus make a strong pattern, capable of withstanding the rough usage to which pig-bed patterns are subject. The patterns which we have had in use during the past year show but little wear. They are smooth, though the slight oxidation to which they are subject prevents them from getting very bright. While we have had no trouble with water leaking through the seams, the joints remaining tight, I have thought that it would be an improvement to bronze the joints. A very neat pattern could also be made by casting it of bronze; but this would be more costly, and I do not see that it would be any better. The set of patterns in use at Durham cost about 1·75 dollars each, of which 75 cents is the cost of the iron. They can, doubtless, be made more cheaply when the men become more skilful in the work.

INSTITUTION OF NAVAL ARCHITECTS.

On Wednesday, the 10th inst., the annual session of the Institution of Naval Architects was opened in the rooms of the Society of Arts. The proceedings extended over three days. The annual dinner of the institution took place on the same day, at the close of the morning meeting. The morning was occupied by the formal business of the association and the reading of an important paper by Mr. W. H. White, Director of Naval Construction and Assistant Controller of the Navy, and a discussion upon it. The proceedings commenced by the reading of the annual report by the secretary, and the election of officers of the council, Lord Ravensworth, president of the institution, occupying the chair.

Lord Ravensworth's Presidential Address.

The Chairman then delivered his annual address. After alluding in appropriate terms to the losses by death sustained during the year by the association, he congratulated the members on the position of the association. Their financial position was sound, the number of members was increasing, and there was every prospect of a bright future for the association. He also congratulated them on the very substantial return to commercial prosperity throughout the country. He thought the whole of our industries were in a condition of prosperity not known for many years past. Perhaps there was no branch of industry in which the activity was more marked than in the great industry of shipbuilding. He was not exaggerating when he said that all the great shipbuilding establishments were at this moment actively employed, and the prospects for at least a year were very favourable. And when they looked further forward, and saw the prospect of a large amount of Government work, which he rejoiced to think would largely be shared by private establishments, he thought the prospects for more than a year were highly favourable. Lloyd's List showed that at the commencement of the year 445 merchant steamers were under construction, with an aggregate tonnage of 811,000 tons. One satisfactory feature was the progress that was

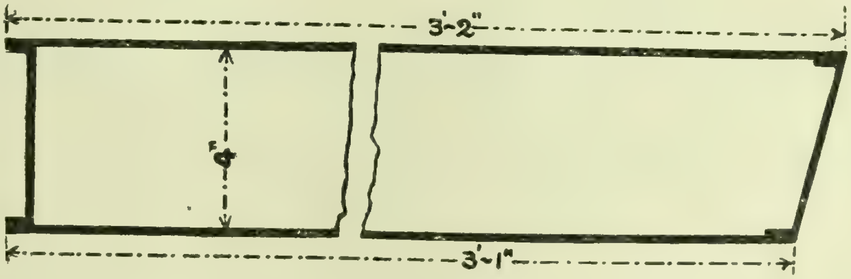

Fig. .

being made in the structural strength of cargo steamers and the general improvement of our cargo ships, and what was specially worthy of remark was that these improvements were not the result of accident or guesswork or conjecture, but were being effected by careful calculation by the shipbuilders of the strains produced on the different sections of the ship at sea, and by provision being carefully made to withstand those strains. While congratulating themselves on this progress, however, they should not forget that some foreign nations were at the present time showing great activity in the construction of what were called "commerce destroyers." This fact was of deep significance for us, and he was quite sure the taxpayers would not grudge the patriotic effort that was now being made by the Admiralty to protect our commerce. The Admiralty programme, which had already been practically endorsed by Parliament, was an extensive and continuous programme, and would include the formation of what would really be a new and powerful fleet. A paper would be read on the designs of these ships, which had been met with stringent criticism from certain naval constructors. The designs that had been adopted came before the country with very high credentials. The designer possessed the entire confidence of the Admiralty, and had had before him in coming to a decision not only the plans of all previous British vessels, but also those of the leading vessels of foreign fleets. He hoped that the subject would meet with thorough searching and discussion, and would only remind them that criticism, to be effective, must be fair.

THE DESIGNS FOR THE NEW FIRST-CLASS BATTLE-SHIPS.

Mr. W. H. White then read his paper. Its object was to describe the main features of the designs for the new battle-ships, and to contrast their protection, armament, speed, and coal endurance with the corresponding features in other battle-ships designed during the last twenty years. The choice eventually made by the Admiralty was made from a considerable number of alternative designs, and in full view of the most recent types for the Royal navy, and for foreign navies. Two designs had been prepared and approved by the board. In both designs were embodied identical qualities so far as related to the disposition of the armament, the number and calibre of the heavy guns, nature, disposition, and protection of the auxiliary armament, the distribution and thickness of the hull armour, the propelling machinery, speed and coal supply, the complement, equipment, magazines, &c., and the principal dimensions. The essential differences were that, while one design was for a turret ship with moderate freeboard at the extremities and with guns about 17ft. above water, the other was for a barbette ship with the guns carried about 6ft. higher and with high freeboard at the bow and stern. Mr. White then, by the aid of large diagrams, described the disposition of the armament in the existing vessels of various types in our own and foreign navies. After considering all these, the following principles for the new designs were laid down: 1. That there should be four heavy guns placed in two protected stations, situated at a considerable distance apart, each pair of guns having an arc of training of about 260 deg., equally divided on each side of the line of keel, all four of these guns to be available on each broadside; 2. That the greater portion of the auxiliary armament should be placed in a long central battery, situated between the two heavy gun stations, and so disposed that there should be practically no interference with the fire of any one gun by that of any other; 3. That, in view of the development of high explosives, it was desirable to secure the widest possible distribution of the guns in the auxiliary armament, and that it was preferable to mount the auxiliary armament on two decks, rather than to carry the guns chiefly between decks. The advantages claimed for these designs were the avoidance of the risk of the principal armaments being placed *hors de combat* by the explosion of a single heavy shell by the distribution of this principal armament into two positions wide apart, and the great increase in the strength of the auxiliary armament. The objections which had been taken to the designs were that they necessitated the weakening of the armour on the central auxiliary armament battery, and that this disadvantage was not counter-balanced by the small increase in the strength of the auxiliary armament. Sir E. Reed, in fact, had described this increase in the auxiliary armament as "too small to dwell upon." But, as a matter of fact, the total weight of the auxiliary armament was nearly three times the weight of the corresponding armament in the Trafalgar, and to provide for this increase was one of the principal problems in the design. It necessitated, no doubt, the lightening of the armour, but this had been accomplished with the least possible risk, the protection of the heavy guns having, in fact, been increased. No point had received more careful consideration than this, and it had been decided that it was preferable to have two separate strongly protected stations for the four heavy guns rather than to have a single citadel the whole length of the vessel. This it was that expressed the most important distinction between the two systems; and Mr. White contended that the selection was fully justified by all considerations of respective risks and dangers. Sir E. Reed challenged this decision, and used very strong language in its condemnation, but he could have no experimental data to go upon, and his objections seemed to rest on purely hypothetical assumptions of what kind and extent of damage was likely to happen to a ship lightly armoured above the belt, when she came under the fire of an enemy's gun. Sir E. Reed's objection was that the thick armour on the side rose only 3ft. above water, instead of 10ft. in the Trafalgar, his contention being that damage to the sides of the belt in action would speedily cause the ships to become unstable and liable to capsizing. Here lay the pith of the whole question. Were such extensive damages likely to be done in action to such ships? As a matter of fact, in the recent battle ships of all foreign navies belts of thick armour as narrow as, or narrower than, those condemned by Sir E. Reed were being adopted, while in these foreign ships these narrow belts were not associated with as effective cellular construction of the sides, nor with the same coal protection as is possessed by the belted ships of the Royal Navy. Much less had there been in foreign ships lightly armoured citadels above the belt, as was proposed for the new ships. Mr. White next dealt with Sir E. Reed's objections to the speed, the coal endurance, and the size of the new vessels. He showed that the speed and the coal endurance would be greater than in the case of any existing battle-ships. As to the great size of the vessels, he said that was necessary by the great loads of armament, equipment, and board margin they carried on a moderate draught at high speed, and maintained that the new ships, though of a displacement surpassing all previous battle-ships, were certain to be much more manageable than many of their predecessers with equal or greater length and not possessing twin screws. Lastly, though he might not make any statement as to the Admiralty estimate of the cost of these ships, he might say that the cost of the armour would be largely reduced.

Sir E. Reed criticised the various statements and arguments in Mr. White's paper. He maintained that it was most dangerous to reduce the thickness of the armour on the centre of the ship, and to reduce the depth to which it went below the water line. He also maintained his previous criticisms as to the speed and the coal endurance of the new ships. If they were to have a sufficient coal supply, it would only be at the sacrifice of the 4 per cent margin which the Admiralty had solemnly promised to the House of Commons should be provided in all vessels in the future.

Lord C. Beresford said that the contest was one between armament and armour. If they built a ship in the way that Sir E. Reed demanded, they would have nothing offensive with which to hit the enemy. A ship was always a compromise. He should like to take the argument out of the line of the constructors, and treat it from the point of view of a seaman who had to fight the ship; and from this point of view he thought Sir E. Reed was wrong. If he had been satisfied with condemning the vessels of the Admiral class he would have agreed with him, because that vessel could be easily put out of action without the armour being pierced at all, and could be capsized by comparative light armament. This was not the case with the new vessels. By all means let them have heavier armour if they could, but to have it they must either sacrifice coal or have larger ships, or must do away with what he as a fighting man considered the most important thing of all—the auxiliary armament. They must not sacrifice in any degree that they could prevent the offensive power of knocking the enemy into a cocked hat.

The discussion was continued by Sir N. Barnaby and Captain FitzGerald.

ANOTHER SHIP CANAL.—Canal projects seem to be booming just now. The latest is, according to the *American Engineer*, the contemplated building of a ship canal across the Upper Peninsula of Michigan to connect the two great lakes of Michigan and Lake Superior. The project is to cut a canal directly across the peninsula from Gladstone, a town near the head of Little Bay de Noquet, an arm of Green Bay, and run it due north to Au Train Bay, on Lake Superior, a length of about 35 miles. Au Train Bay is about 20 miles east of Marquette. This canal would shorten the distance between Chicago and Duluth some 270 miles, and report says that it would be a comparatively simple undertaking. The canal would be about 35 miles long, and would require two locks. It is receiving strong endorsements from prominent men of the lake marine, and on the face of it would seem to be a very promising project and worthy of immediate attention.

THE CAPACITY OF AIR PUMPS.*

A PERSON not informed of the facts might think that the air pump, dating, as it does, from the days of Watt, should now have settled down to fixed proportions which such a mass of accumulated experience would indicate as the best. If he were told that with jet condensation the capacity of the air pump may vary from $\frac{1}{4}$ to less than $\frac{1}{10}$th of the cylinder capacity, he would probably suggest that the special conditions under which air pumps work must vary in a similar way; but if further informed that two engineers designing air pumps to work under exactly the same conditions will often assign to them very different proportions, there is no escape from the difficulty unless he comes to the conclusion that either or both of the engineers does not know his business, or that within the limits of variation it does not matter much what size the air pump be made. If he adopts the former conclusion, he belongs to a class which is but too numerous, and probably will not give any further attention to the subject. In any case, we have nothing more to do with him. If, on the contrary, he possesses a scientific mind, he will not be content to get out of the difficulty in this way, and on investigation we find that each of the engineers can justify his practice by reference to the results obtained with pumps made in accordance with it. One will proudly show a vacuum of 27½in.; and the other may be able to record 28in., and it is possible that the latter may be the man who supplies the smaller pump; but, again, other results taken from their practice will reverse the first records. Here, then, is a confirmation of what he previously suspected, viz., that such a variation in shape of the pumps as is found in these cases does not affect the vacuum. This fact will require explanation, and our inquiring friend will seek one of the text books, manuals, and treatises on the steam engine. In all, he will meet with the statement that the usual practice is to make the capacity of the air pumps between such and such fractions of the cylinder capacity "only that and nothing more" in the majority, but in one or two he may find a calculation for determining what the capacity of the pump ought to be, and as the result will not agree with practice, it will be necessary to assume that air pumps are very inefficient, and to multiply the result by a factor, perhaps 2 or 3.

In none will he find a detailed account of scientific facts upon which to build a rational theory of the action of the air pump, nor any attempt to show how the vacuum depends on the capacity of the pump and the conditions under which it works. If he have the inclination and leisure, he will inform himself of these facts, and it is the writer's object in what follows to state such of them as are essential to a correct understanding of the problem, and to endeavour to exhibit their application to its solution.

The function of the air pump is to remove from the condenser water resulting from the condensation of steam, and when jet condensation is used the condensing water in addition, together with such permanent gases as may be liberated therein. The permanent gases are introduced mainly by the water carrying them in solution, and generally consist of oxygen, nitrogen, and carbonic acid gases—that is, of the chief constituents of the atmosphere; but since carbonic acid is more soluble than oxygen and the latter than nitrogen, the proportions of the dissolved gases, even if they are absorbed from the atmosphere, as in the case of rain water, are different from those which obtain in the atmosphere. However, as all these gases behave like perfect gases within the temperature and pressure limits to which the following calculations apply, it is not necessary to know in what proportions they are at present, if only the total volume dissolved in the water is given. Though differing in proportional composition from ordinary air, it will be convenient for shortness to refer to the mixture of gases as air. Besides the water and air, there is aqueous vapour mixed intimately with the air. It is not necessary for the air pump to remove the vapour, for it cannot accumulate in the condenser like the water and air, but nevertheless its presence affects the working of the pump, as will be seen further on. The pressure in the condenser and the height of the barometer determine what vacuum is possible, for the vacuum is the difference between these quantities, and as the height of the barometer and the vacuum are generally given in inches of mercury, it will be convenient to express all pressures in terms of that unit. It was shown by Dalton that for mixed gases and vapours (such as air and aqueous vapour) which had not any chemical effect on one another the total pressure of the mixture contained in a closed vessel was the sum of the pressures which each constituent would exert if all the others could be removed from the vessel. This law of partial pressures has been amply proved, and it shows us that the total pressure in the condenser is the sum of the pressure of the aqueous vapour and that of the air. Of these, the pressure of the aqueous vapour depends solely and entirely on its temperature, and is independent of the air pressure, which in its turn only depends on the weight of the air in the condenser and on its temperature.

Thus the vapour pressure is entirely independent of the action of the air pump, while the air pressure, depending as it does on the weight of the air in the condenser, is directly affected by it. To take a numerical example, suppose the height of the barometer to be 30in. and the atmospheric temperature 59 deg. Fah., the condenser temperature 102 deg. Fah., then the vapour pressure will be 2in., and if the air pressure be ½in. the total condenser pressure will be 2½in., and the vacuum 27½in. The volume of a given weight of air under these conditions will be $\frac{30}{\frac{1}{2}} \times \frac{461 + 102}{461 + 59} = 65$ times as great as it would be under atmospheric pressure and temperature, and the air pump must be capable of removing whatever air may be introduced per stroke when expanded to this volume. The quantity of air introduced into the condenser per revolution of the engine depends on the volume of water which passes in during the same time, and on the amount of air dissolved in that water, and also, of course, on air leakage, but as this is very slight indeed when the engine is in good order, the air so introduced will be neglected for the purposes of the calculations which follow. The volume of water introduced into the surface condenser is very slight, but considerable amount makes its appearance in the jet condenser. As the latter was the earliest form, and is still more largely used for land engines, and since it is the practice of many marine engine builders to make the air pump so that it will work with jet condensation, this paper will be mainly devoted to the consideration of air pumps for this type of condenser.

One of the variable quantities for which provision must be made is the volume of gases disolved in different kinds of water. The following information on this point is obtained from Watt's *Dictionary of Chemistry*, in which the detailed analyses of a large variety of waters are given. Spring water may contain from 2 per cent to 10 per cent of its volume of dissolved gases, but the higher figure is due chiefly to carbonic acid, which is found in such quantities in mineral springs. Three samples of spring water gave dissolved gases 2·46, 1·81, and 7·14 per cent, the mean being 3 803 per cent by volume. Fine samples of Welsh and Cumberland river and lake water gave total dissolved gases varying from 2·04 to 2·94 per cent, the mean of the nine being 2·32 per cent of the volume of the water. The remarkably small variation in the percentage of dissolved gases in the above nine samples would indicate that in clear river or lake water uncontaminated with sewage, &c., 2 32 per cent by volume represents very nearly the quantity of gases dissolved.

The case is different when we take the analysis of samples from such rivers as the Thames at and below London. The dissolved oxygen diminishes, but the carbonic acid increases in a much larger proportion as the water gets more impure. Thus when a large proportion of the London sewage was discharged into the Thames, the volume of the dissolved gas increased from 5·2 per cent at Kingston to 7·43 per cent at Erith. For such water as that a mean value of 6·3 per cent by volume of dissolved gases would be probably not far wrong. Ten samples of water, mostly from Continental rivers and lakes, gave total percentages of dissolved gases varying from 2·2 to 5·8 per cent, the mean value being 3 69 per cent. The volume of dissolved gases varies least in rain water, as might be expected, and it amounts to 2·5 per cent. For most kinds of clear fresh water, then, 4 per cent by volume of dissolved gases would be an ample allowance; but since some waters contain up to 10 per cent, the value 5 per cent would be a fair mean, and this figure will be used in the following calculations. The percentage contained in sea water is said to vary from 1 to 4 per cent; but accurate analyses of samples from different localities do not seem to have been made. It is probable, however, that 5 per cent is the greatest quantity in ordinary sea water. The above figures all refer to the volumes dissolved under ordinary atmospheric conditions of pressure and temperature. For such gases, however, as oxygen, nitrogen, and carbonic acid, the weight of gas dissolved is proportional to the pressure, and decreases as the temperature rises; thus when the injection water enters, the condenser being broken up into spray and having every facility for giving up its dissolved gases, it will only retain the proportion which it could take into solution under the temperature and air pressure conditions existing in the condenser.

(To be continued.)

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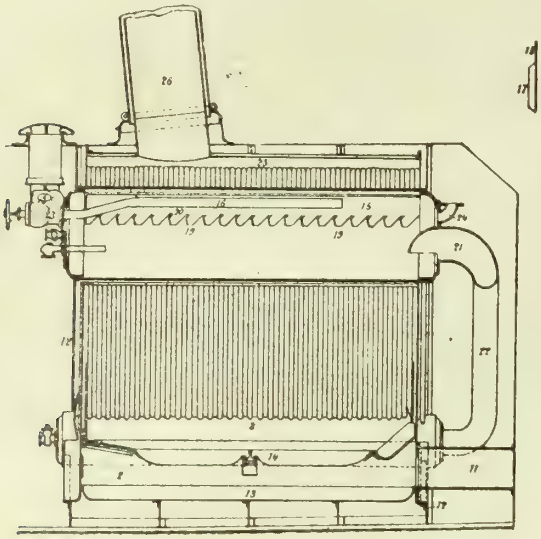
* Paper by Mr. J. H. Hamilton, B.Sc., read before North-East Coast Institution of Engineers and Shipbuilders, 8th April, 1888.

NEW STEAM BOILERS.

(*Continued from page* 180.)

Fig. 11.



Figs. 13 and 14.

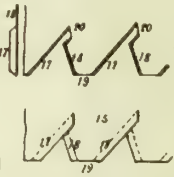


Fig. 12.

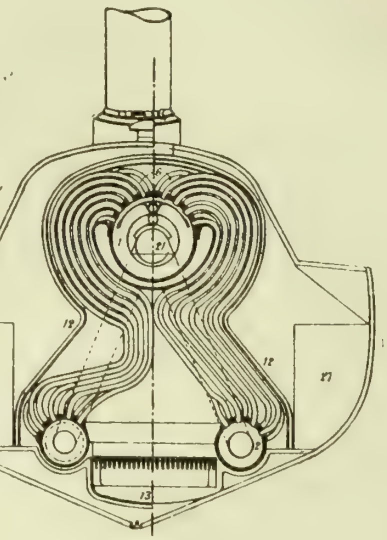


Fig. 15.

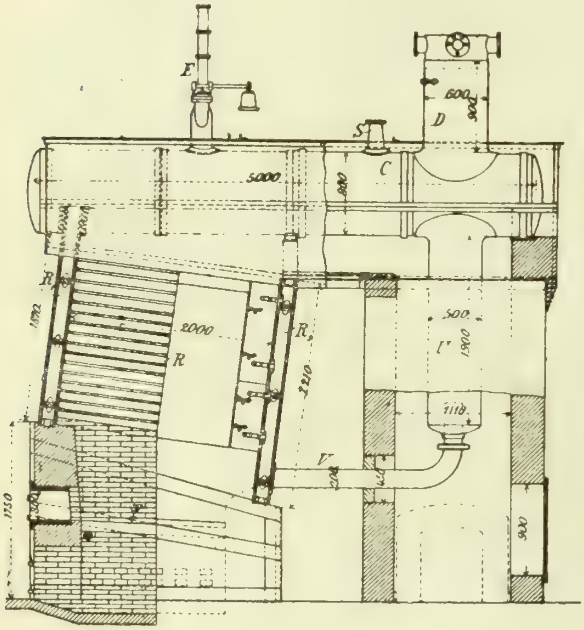


Fig. 16.

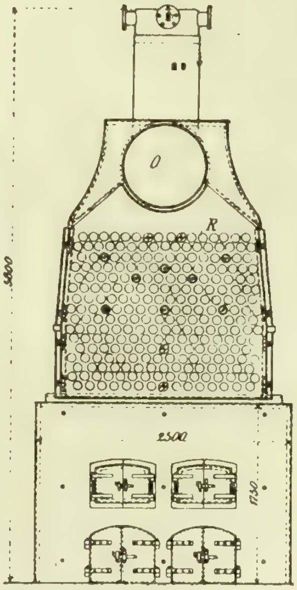


Fig. 17.

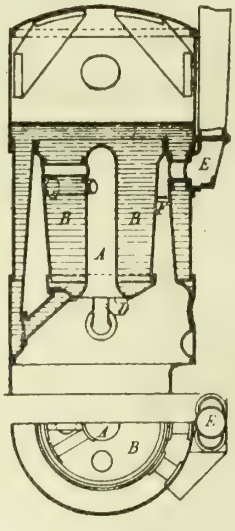
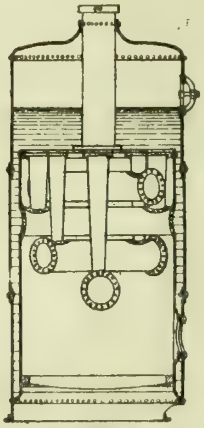


Fig. 18.



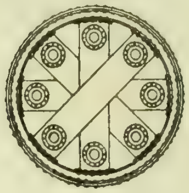


Fig. 19.

The Thorneycroft boiler is shown at figs. 11, 12, 13, and 14, and is of very peculiar construction and arrangement. It consists of a steam chamber or reservoir 1 (figs. 11 and 12), and two boiler tubes 2, lying alongside the firegrate, and connected to the steam chamber by numbers of small iron tubes of somewhat irregular appearance, as seen in fig. 12. These tubes generate steam and discharge it into the steam space at its upper part; they are arranged to form the walls of the furnace, and are enclosed within a casing; on one side, left-hand of fig. 12, they are arranged to form a return passage for the gases of combustion. The lower part of the steam chamber is protected against the direct action of the fire by an asbestos lining, suitably supported. The steam supply pipe 16 extends throughout almost the whole length of the steam chamber, and is covered by a kind of umbrella-like shield, the edges of which are seen in detail at figs. 13 and 14, intended to separate water and steam, and collect and return the excess water without allowing it to be dragged into the steam supply pipe.

The pipes 21 and 22 are intended to cause rapid circulation. The passage 11 is intended for carrying off steam in the event of a tube bursting or cracking; 23 and 24 are attachments for safety valve arrangements, 13 is the ashpit, 12 the shell plating covering the tubes, 14 the firegrate, and 27 the hull of the ship.

We cannot say that we appreciate the points of this boiler. It seems to us most complex and objectionable from many points of view, and most likely to give serious trouble. Still it would be wrong to condemn it entirely, as engineers of Messrs. Thorneycroft's experience must have some good reason for designing so unusual a combination. We fear the grand simplicity of the Lancashire boiler somewhat unfits us for the consideration of such a complex construction.

The Oriolle boiler, figs. 15 and 16, presents no especially new features, but is a well-arranged one of the water-tube type, consisting of two flat walled steam and water chambers R_1 and R_2, fig. 15, stiffened by screwed stay bolts, and connected to the steam upper chamber O. The enclosed tubes R, connecting the two sides, are the water tubes, and the water is intended to be kept at such a level that the upper tubes R, together with O, are dry, and serve as superheaters. As usual in such boilers, the water circulates in the direction of inclination upwards. The lower back portion of R_2 connects by the pipe V to a projecting cylindrical portion U, and is intended to act as a feed heater and to help to abstract heat from the furnace gases after leaving the furnace and passing over the bridge.

The design is an attempt to compromise between the water-tube system and the ordinary tubular boiler.

The Buckland vertical boiler is illustrated at fig. 17, and the novel feature consists in filling up the space usual in the interior of such boilers by an interior shell, connected as shown to the general circulation of water within the boiler. The illustration shows the construction clearly. Additional heating surface is no doubt gained, but at a serious additional complexity.

Wood and Son's vertical boiler is shown at figs. 18 and 19, and is of much simpler construction, while it also gives a considerable increase of heating surface.

MARKING OFF MANHOLES AND HANDHOLES.

In most boiler-making establishments it is usual when a manhole or handhole is required to be cut, for the "marker off" to describe an appropriate ellipse to some given dimensions for the length of the transverse, and conjugate diameters or axes, and as in many cases such sizes are given irrespective of any particular method of construction, and without any regard being paid to the relation that one dimension should bear to the other, it becomes a matter for experiment before he can determine the proper centres and radii necessary to draw a fairly approximate ellipse.

To put the matter in a practical form, we give below three simple methods of describing, by means of circular arcs, an approximately true ellipse, and we trust that they may be found useful to those of our readers who may have occasion to mark off manholes or handholes in boilers. The appended table will be found to give the relation of the width to the length of approximate ellipses produced by either of the three methods of construction given below.

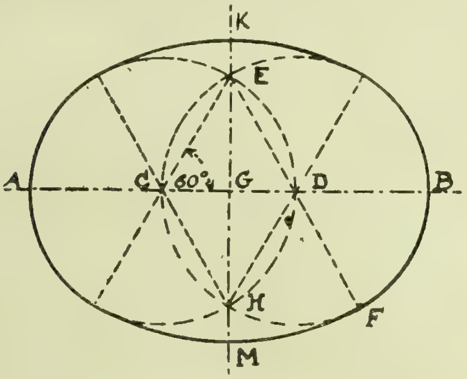


Fig. 1.

From an inspection of the sketches, or the table, it will be seen that the methods differ from one another, inasmuch as for equal lengths fig. 1 gives a broader ellipse than fig. 2, and still broader than fig. 3.

First Method.—*Giving a comparatively broad ellipse in proportion to the length.*

The length of the transverse or longer axis AB (fig. 1) having been predetermined, divide it into three equal parts, AC, CD, and DB, then with points C and D as centres, with a radius equal to CD (or one-third AB), describe the circles DEA and BHC, intersecting at H and E. Join E D, and produce the line to cut the circle BHC at F. Then, from points E and H, with radius equal to EF, complete the ellipse by describing circular arcs touching the circles DEA and BHC at points diametrically opposite to E and H. If we now analyse the figure, we can determine the relation between the major and minor axes.

Let R represent the length of the larger radius EF, and r the smaller radius CD, and let L and W represent the length and width of the ellipse, and h the perpendicular height EG.

Then, as the width KM (= W) is equal to twice the difference between the radius R and the perpendicular height h (or EG), we may write

$$W = 2\,(R - h),$$

and as the angle ECG is 60 deg. (by construction), h may be readily shown to equal ·866 times the radius r,

$$\text{or } \cdot 866 \times \frac{L}{3};$$

therefore, as $R = \frac{2}{3}L$, it follows that

$$W = 2\left(\frac{2L - \cdot 866L}{3}\right)$$

that is to say, the width—

$$W = \cdot 756 \text{ times the length};$$

and therefore, the length—

$$L = 1\cdot 323 \text{ times the width}.$$

In column 2 of the table annexed is given the widths due to this construction for the different lengths given in column 1.

Second Method.—*Giving a width slightly less (in proportion to the length) than Method No. 1. (See Figure 2.)*

Divide the major axis AE into four equal parts, AB, BC, CD, and DE, and with points B and D as centres, with a radius equal to BA (*i.e.*, one of the parts), describe the three circles ATC, BFD, and CGE.

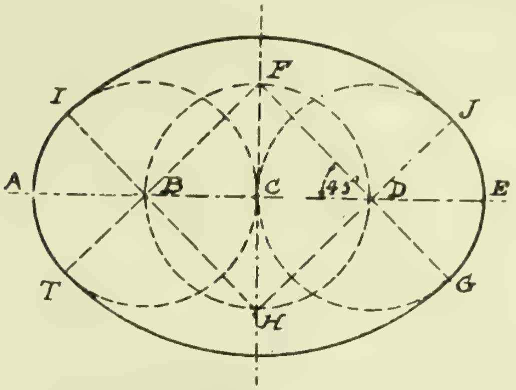


Fig. 2.

From the point F, where the centre circle cuts the vertical line, or minor axis, draw FB, and produce the same to T; then with centres F and H, with a radius equal to FT, complete the ellipse by describing the circular arcs TG and IJ.

Then, as the angle FDC is 45 degrees, and the radius FT therefore equal to 2·414 times the radius of the smaller circles, it follows that the width W = ·707 times the length L, and that the length

$$L = 1\cdot 414 \text{ times the width W}.$$

In column 3 of the table will be found the widths due to this method of construction for the length given in column 1.

Table of Proportions of Manholes for Boilers and Tanks.

	Width of Minor Axis.		
Column No. 1.	Column No. 2.	Column No. 3.	Column No. 4.
Length or Major Axis.	Method No. 1. Formula W = ·756L.	Method No. 2. Formula W = ·707L.	Method No. 3. Formula W = ·634L.
Inches.	Inches.	Inches.	Inches.
4	3	$2\frac{13}{16}$	$2\frac{9}{16}$
$4\frac{1}{2}$	$3\frac{3}{8}$	$3\frac{3}{16}$	$2\frac{7}{8}$
5	$3\frac{3}{4}$	$3\frac{9}{16}$	$3\frac{3}{16}$
$5\frac{1}{2}$	$4\frac{1}{8}$	$3\frac{7}{8}$	$3\frac{1}{2}$
6	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{13}{16}$
$6\frac{1}{2}$	$4\frac{15}{16}$	$4\frac{5}{8}$	$4\frac{1}{8}$
7	$5\frac{1}{4}$	$4\frac{15}{16}$	$4\frac{7}{16}$
$7\frac{1}{2}$	$5\frac{11}{16}$	$5\frac{5}{16}$	$4\frac{3}{4}$
8	$6\frac{1}{16}$	$5\frac{11}{16}$	$5\frac{1}{16}$
$8\frac{1}{2}$	$6\frac{7}{16}$	6	$5\frac{3}{8}$
9	$6\frac{13}{16}$	$6\frac{3}{8}$	$5\frac{11}{16}$
10	$7\frac{3}{16}$	$7\frac{1}{16}$	$6\frac{3}{8}$
11	$7\frac{9}{16}$	$7\frac{3}{4}$	7
12	$8\frac{7}{16}$	$8\frac{1}{2}$	$7\frac{5}{8}$
13	$9\frac{3}{16}$	$9\frac{3}{16}$	$8\frac{1}{4}$
14	$10\frac{5}{8}$	$9\frac{7}{8}$	$8\frac{7}{8}$
15	$11\frac{5}{16}$	$10\frac{5}{8}$	$9\frac{1}{2}$
16	$12\frac{1}{8}$	$11\frac{5}{16}$	$10\frac{1}{8}$
17	$12\frac{13}{16}$	12	$10\frac{3}{4}$
18	$13\frac{5}{8}$	$12\frac{3}{4}$	$11\frac{7}{16}$

No. 3 Method.—*Giving a width slightly less than either of those obtained by the preceding methods. (See Figure 3.)*

Divide the longer axis AE into *four* equal parts, AB, BC, CD, and DE, as in the second method, and with centres B and D, with a radius equal to one of the parts, describe the two circles AFC and CGE, and from the same centres, with BD (equal to two of the parts) as radius,

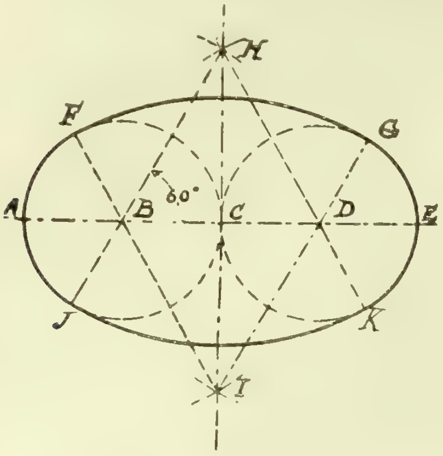
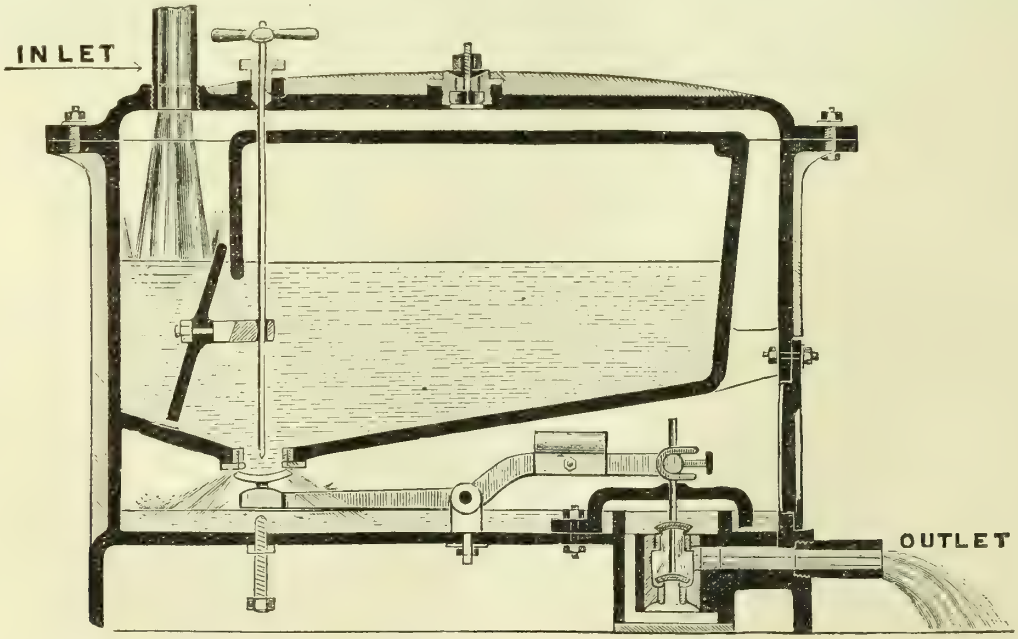


Fig. 3.

describe small arcs intersecting at H and I, join I D, and produce the line thus obtained to G; then complete the ellipse by describing the circular arcs FG and JK, with a radius equal to IG from the two centres I and H. Then, as the angle HBD is 60 deg., it may be easily proved that the width W = ·634 times the length L, and also that the length L = 1·577 times the width W. In column 4 of the table will be seen the widths calculated from this formula.

THE WUFF PATENT STEAM TRAP.

Steam traps are a somewhat favourite subject for the exercise of the inventive powers of engineers, and many ingenious contrivances have been designed and constructed to overcome difficulties due to the imperfect reliability of hollow floats. Such traps have probably been most used, and they act well so long as the float continues intact. In this trap the water is admitted and separated from the steam in an internal chamber, which is sealed at its lowest point by a valve having a very narrow seat, and kept up to its face by the pressure of a weighted lever, which acts at its other end upon a double-beat valve opening to the discharge pipe. Our illustration on this page shows these points very clearly. The water, entering at the inlet along with the steam, fills up the chamber in time, and the pressure upon the valve below increases. As the steam entirely surrounds this valve, it is subject only to downward change of pressure by the increasing column of water. When the pressure exceeds that of the balance weight and the friction of the mechanism, the valve falls and the other end of the lever rises, opens the balanced double-beat valve, and the water passes from the cistern to the lower part of the trap and is discharged. So soon as the water valve returns to its seat again, the lever closes the discharge valves, and the trap remains closed until the water has accumulated to a sufficient extent again. The handle shown is intended to test the valve and lever by thrusting downwards, and so make certain that there is no under friction or obstruction of the action. We understand that large numbers of these traps are at work. They are manufactured by the Wuff Patent Steam Trap Company, Leeds. The arrangements are ingenious and very simple.



THE INSTITUTION OF CIVIL ENGINEERS.

At the twenty-first ordinary meeting of the session, on Tuesday, the 9th of April, Sir George B. Bruce, the President, being in the chair, the paper read was on "Armour for Ships," by Sir Nathaniel Barnaby, K.C.B.

The author described and illustrated by drawings the applications of armour to ships in the French navy between 1858 and 1888. He directed attention to the increasing thickness of armour to meet the growth in the gun, to the corresponding reduction in the area of surface covered, and to the eventual disuse of side-armour for protecting the batteries. Thereupon the development of quick-firing shell-guns was rapidly extended, and high explosives, such as gun-cotton, melinite, bellite, lyddite, &c., were introduced, and were being perfected as bursting charges for shells. On the assumption that thin armour was, and would remain, effective against such projectiles, armour of four and five inches in thickness was again being demanded by sailors for the defence of the sides of the ship in front of the batteries. Believing that such armour would be costly, ineffective, and even dangerous, and that it would tend more than ever to reduce the number of ships which could be brought into action, the author drew attention at the outset to what he conceived to be a wrong policy for this country. He observed it was certain that, apart altogether from these quick-firing guns, it would only be necessary to put up targets of thin armour, and expose them to the fire of heavy projectiles in order to show the frightful wreck, behind the target, which occurred years ago, and which led to thicker, and ever thicker, armour. But there would be this difference in favour of the gun, that the projectiles were heavier and stronger, the velocities higher, and the explosives more powerful. He showed that, without going beyond the ships now building, an expenditure of £1,000,000 per ship had been reached. On examining all such large ships, whether British or foreign, it would be discovered that they were most seriously exposed to the attack of the powerful weapons now in rapid course of development. The naval authorities had to decide whether they would concur in still further enlargement in individual ships; or would endeavour rather to meet these weapons by combining the forces of smaller ships.

The author considered there was no difficulty in taking the latter course, and that it had many advantages. The principle of subdivision was consistent with perfect seaworthiness, with speed as high as that of the largest ships, with the control of weapons which could be used with fatal effect upon the most powerful ships of the enemy, and with such powers of endurance as would enable the smaller vessels to receive injuries from the largest ships without necessarily fatal results. If it should be said that this dispersion of force entailed a risk of destruction in detail, by encounters with units of greater force in the hands of an enemy, that argument simply went to show that organising skill would be required to ensure the presence of the united forces where they were needed. Referring to the concentration of material value in a few ships, thus preventing the construction of many ships, he remarked that in the line-of-battle ship of fifty years ago the value of the material for a single command was about £100,000, and the value per man in the crews of such ships not more than £150. In the ironclad of 12,000 tons of to-day, the value of ten of the former line-of-battle ships was entrusted to each captain, and not less than £2,000 to each man in the crew. In order to put forward, in a concrete form, his view as to the type of fighting ship most suitable for the present needs of the British navy, he had brought forward a design. It was for a ship of 3,200 tons displacement, costing one-fourth of the so-called first-class battle-ship of to-day. A sufficient number of ships of this type could probably be built and armed in two years. It might be said nothing that could be done upon such dimensions, and at such cost, to entitle the ship to be called a battle-ship. But the seventy-four gun line-of-battle ship of fifty years ago had only a total displacement of 3,000 tons; and the eighty-gun ship of the same period 3,500 tons. This design came between the two, and would only cost as much as three seventy-four gun ships. If the British Government determined to spend money upon invulnerable ships, the difficulty in getting enough ships would be perpetually growing. There was no obstacle, except in finding the money, to making an invulnerable ship. Ships could be built and navigated which no torpedo, or ram, or gun that could be worked from any ship now in existence, could fatally wound. In such a ship every man might be absolutely protected, high explosives notwithstanding. But there would be so few of them that commerce and the Colonies might be lost for want of ships, and there would only be the satisfaction that the sailors had been protected in such ships as existed. The question was, Ought England at the present moment to move still further onward in increasing the size and cost of heavily-armoured ships, requiring four or five years to complete? Or, ought this country rather to endeavour to increase rapidly the number of protected ships, capable, by reason of their speed and armament, of taking part in any engagement with an enemy, however powerful? In this exposition of the uses of armour, it was apparent that fighting ships must continue to use it. When armour was employed in the form of comparatively thin horizontal plating, experiment seemed to have shown that steel, low in carbon, was the best material. When it was employed in the form of a wall, either upright or inclined, and comparatively thick, the value of a hard face became very marked. The various modes of manufacturing thick armour for upright, or nearly upright, defences were described, and illustrations were given of the comparative resisting power of compound and of forged-steel plates; also of two armour plates of great excellence, manufactured at Sheffield, one of them compound, having a steel face and an iron back, and the other of forged steel throughout. The superiority of the compound plate was very marked. The author also drew attention to the improvement effected by the use of the hydraulic press in the manufacture of thick armour plates. To many minds it seemed that the hope of the future, for peaceful sea-traders, lay rather in abasing than in increasing the individual superiority of the special ship of war. No efforts should be spared to raise the character and strength of the fast mercantile ships. But it must be admitted that there was no prospect of a diminution in the use of armour in regular fighting ships. The evident tendency was towards its introduction into every fighting ship. Referring to the aspect of the question from the side of the attack, the author remarked that when the large unarmoured structures in the French ships were considered the seriousness of the new attack became evident. And it was the artillerist who must be first impressed. It was of more consequence to be able to inflict damage in action than to be able to avoid it. The best defence was to be found in a vigorous attack. It must be understood that the powerful ships in modern navies were not protected, so far as their batteries were concerned, by the armour which the French thought necessary. They were unarmoured from their lower decks upwards. The author asked: Was full advantage to be taken in the British navy of these high explosives in any war which might break out within the next two or three years? Writing before the Goverment proposals had become known to him, he would agree cheerfully to any suggestions by the Government as to the size of the new ships and as to the use of armour for them, if they were laid for approval before some competent technical committee for a month. If the author were responsible for the steps which must be taken by the Administration, he would insist upon having the soundest independent judgment which could be obtained. He felt satisfied that if such a body as the council of the institution had been consulted in 1868, 1871, and 1875, when naval ordnance was in a crisis and under serious debate, it would not have happened that the question of breechloading would have been kept closed from 1866 until 1879. He believed that if such a body had been consulted in 1859, it would have appreciated better the significance of the four ironclad ships then building in France, and the Government proposals would have been wisely modified. The attitude of the engineer towards questions of war material differed from that of a member of a political administration, and from that of naval and military officers. The engineer was mainly interested in the question of the development of the powers of the weapons of war, and he was constantly thinking how they might be extended, and how the maximum of power might be got out of a given expenditure. The tendency with the Administration was to estimate the comparative value of available resources of rival governments, and not to look beyond the immediate future. It might be seen from the speech of Sir John Pakington, when introducing the Navy Estimates, on the 25th of February, 1859, and when the French ironclad sea-going ships were being built, how easy it was to undervalue new forces. This Administration undertook the building and conversion at that time of sixty-seven wooden line-of-battle ships and frigates; and they were all in the hands of the dockyard authorities, in various stages of production, a few months afterwards. But not one of them was suitable for the circumstances of the time. Many of them were never finished.

SHIPBUILDING.

There was launched recently from the yard of the Tyne Iron Shipbuilding Company a steel screw-steamer, built to the order of Messrs. William Milburn and Company, of Newcastle and London. She is of the well-deck type, and of the following dimensions: Length, 312ft.; breadth, 40ft. 6in.; depth, 24ft. 6in. She will carry upwards of 4,000 tons dead weight, and will be engined by the Wallsend Slipway and Engineering Company with powerful triple-expansion engines. She is fitted with all modern improvements for the rapid loading and discharging of cargo. The vessel was named the Cape Colonna.

Messrs. Thomas and William Smith have launched from their shipbuilding yard at North Shields an iron screw-steamer of the following dimensions, viz.: Length, 225ft.; breadth, 33ft.; depth, 16ft. Her engines will be of the triple-expansion type, with cylinders 16½in., 27in., and 44in., by 33in. stroke, by the North-Eastern Marine Engineering Company Limited, from their Wallsend works. The vessel has a dead-weight capacity of about 1,650 tons, is built in the highest class at Lloyd's and is adapted for the general carrying trade, being fitted with every facility for quick loading and discharging of cargoes.

On Saturday, March 30th, there was launched from the shipbuilding yard of Messrs. John Readhead and Sons, West Docks, South Shields, a steel screw-steamer of the following dimensions, viz.: 290ft. by 39ft. by 20ft., classed 100 A1 Lloyd's special survey. The vessel is of the improved well-deck type, schooner rigged, and is fitted with all the appliances for grain cargoes and general trades. She will be fitted with triple-expansion engines (also being constructed by Messrs. Readhead), having cylinders 23in., 37½in., 61½in., and 39in. stroke, and supplied with steam from two large steel boilers at a working pressure of 160lb. per square inch. The vessel has been built to the order of Messrs. Edward Hain and Son, St. Ives, Cornwall, and was named the Trevorian. The Trevorian is a sister ship to the steamship Trewellard, whose trial trip was run on Thursday last. This is the seventeenth vessel built by Messrs. John Readhead and Sons for Messrs. Hain.

A valuable addition was made to Messrs. Dent and Co.'s (Newcastle and Blyth) fleet of steamers on March 29th, when the Blyth Shipbuilding Company Limited, Blyth, launched from their works a fine cargo steamer, built to Lloyd's highest class, and of the following dimensions: Length, 260ft.; breadth, 36ft. 6in.; depth, 19ft. 4in. The vessel has been constructed of steel, with cellular bottom for water ballast, web frames, &c.; and her deck arrangements consist of a long raised quarter deck, with short poop aft, where accommodation is provided for captain, officers, &c., a long bridge extending from after end of engine-room to the foreside of foremast. The crew are comfortably berthed in the forepart and the engineers in the afterpart of the bridge. There is also the usual forecastle. The vessel has been built to comply with the Board of Trade requirements for carrying grain in bulk. There are four large cargo hatches, each having a powerful steam winch fitted by Messrs. J. Smith and Son, Newcastle-on-Tyne, for the working of cargo. An Emerson Walker's patent windlass for working the stockless anchors, a Donkin and Nichol's steam steering gear is placed amidships, and a powerful screw gear aft. The engines are triple expansion, and will be supplied by the North-Eastern Engineering Company, Wallsend, with cylinders 20in., 33in., and 53in. by 36in. stroke, and 160lb. pressure. The vessel was named The Crown, and is the third vessel of similar dimensions launched by the Blyth Shipbuilding Company this year, and they have several vessels on hand in various stages of construction.

The new steel screw-steamer Trewellard, built by Messrs. John Readhead and Sons, West Docks, South Shields, was taken to sea on her trial trip on March 28th. The dimensions of this steamer are: Length, 290ft.; breadth, 39ft.; 20ft. depth. She is classed 100 A1 at Lloyd's, under special survey, and is of the improved well-deck type. The vessel is fitted with shifting boards, &c., as required by the Grain Cargoes Act. The engines are of the triple-expansion type, having cylinders 23in., 37½in., and 61½in., with 39in. stroke, steam being supplied at a pressure of 160lb. to the square inch by two large steel boilers; the engines and boilers are also being made by Messrs. John Readhead and Sons. On the trial the engines worked very smoothly and satisfactorily. Several runs were made on the measured mile and along the coast, and the mean speed attained was 11½ knots per hour. The Trewellard has been built to the order of Messrs. Edward Hain and Son, St. Ives, Cornwall, and is the sixteenth vessel built by Messrs. Readhead for this firm.

On Wednesday, the 3rd inst., Messrs. Richardson, Duck, and Co. launched from their building yard, at South Stockton, an iron screw-steamer of the following dimensions, viz: Length over all, 287ft.; breadth extreme, 37ft. 5in.; depth of hole, 20ft.; and tonnage gross about 2,058. The vessel, which has been built to the order of Messrs. Christie and Co., Cardiff, is the seventh built for them by Richardson, Duck, and Co. She has short poop, a raised quarter-deck, and a long bridge extending to stem; is classed 100 A1 at Lloyd's, has double bottom on cellular principle in after and main holds, and under engines and boilers. She will be fitted with four steam winches, steam steering gear, patent stockless anchors, and all modern improvements for facilitating the loading, discharging, and manœuvring of the vessel. The engines are by Messrs. Thos. Richardson and Sons, Hartlepool. Cylinders 21in., 35in., and 58in., by 36in. stroke. The vessel was named the Moonstone.

On Thursday, the 4th inst., there was launched from the shipbuilding yard of Messrs. John Priestman and Co., Southwick, a handsomely-modelled steel screw-steamer of the following dimensions: Length, 290ft.; breadth, 39ft.; depth of hold, 9ft.; with a poop and raised quarter-deck aft, long bridge to foremast, and topgallant forecastle. She has been built to the order of Messrs. Henry Samman, Hull, and is to have the highest class at Lloyd's, and is designed to carry 3,100 tons of cargo. Water ballast tanks are fitted in the fore and aft holds capable of containing about 500 tons. The main and quarter decks are of iron. She is schooner-rigged, with lower masts of steel, and is fitted with four large steam winches made by Messrs. Welford Bros., Pallion, and the windlass by Messrs. Emerson, Walker, and Thompson Bros. Ltd. The engines, which are supplied by Mr. George Clarke, of Southwick, are of 1,000 indicated horse power, the working pressure of the boilers being 160lb. The ship was named Deddington.

Messrs. W. Gray and Co. Limited, of West Hartlepool, have launched from their shipbuilding yard a fine steel screw-steamer of the following dimensions, viz.: Length over all, 270ft.; 36ft. 6in. beam; 19ft. 5in. depth; and capable of carrying 2,550 tons dead weight, to the order of Messrs. Hardy, Wilson, and Co., of that port. She will take Lloyd's highest class, and is a well-decker, her poop having saloons and cabins. Her triple-expansion engines, and two steel boilers, up to 150lb. pressure, will be supplied from Messrs. W. Gray and Co.'s Central Marine Engine-works. She was named Norlands.

Her Majesty's ship Basilisk was successfully launched at Sheerness, on Saturday, the 6th inst. The Basilisk has a displacement of 1,170 tons, and will be armed with eight 5in. breech-loading guns and eight machine guns. Her machinery will be of the triple-expansion type, developing 2,000 horse power.

Her Majesty's ship Marathon, built by the Fairfield Company, Govan, and engined by Messrs. R. and W. Hawthorn, Leslie, and Co. Limited, St. Peter's, Newcastle, on Friday the 15th ult., underwent on the Clyde a preliminary trial of her machinery prior to her departure for the south. The machinery was tried under forced draught for over 2½ hours, and the engines worked with great smoothness and regularity at a speed of 120 revolutions per minute. The trial was considered as eminently satisfactory in every sense. The vessel afterwards left for Portsmouth. It may be mentioned that H.M.S. Magicienne, sister ship to the Marathon, completed on Tuesday, the 19th inst., her official trial of 12hours' duration at Portsmouth in a satisfactory manner, developing over the contract power of 5,500 h.p.

Messrs. W. Gray and Co. Limited, West Hartlepool, have received an order from Mr. C. Furness, of that port, to build a new steel screw-steamer to carry 6,300 tons d.w., which will measure 400ft. in length. She will carry nearly 2,000 tons above any vessel ever yet built at West Hartlepool.

Messrs. William Dobson and Co. have launched from their shipbuilding yard at Low Walker, a steel screw steamer, built to the order of Messrs. Adam and Co. of Aberdeen. The vessel is about 2,200 tons burden, built to the highest class at Lloyd's, and will be fitted with triple-expansion engines by Messrs. Black, Hawthorn, and Co., of Gateshead. The vessel was named the Arndilly, and was taken direct to Newcastle Quay to receive her machinery.

Recently there was launched from the Walker yard of Messrs. Sir W. G. Armstrong, Mitchell, and Co., a steel screw-steamer, specially built from the patent designs of Mr. A. F. Swan, for the carriage of petroleum in bulk. The vessel has been built to the order of Messrs. H. E. Moss and Co., of Liverpool and London, for the Lumen Steamship Company, Limited. Her dimensions are: Length, 304ft.; breadth, 37ft. 9in.; depth, 27ft. 9in. She has a total carrying capacity of 3,500 tons of oil and coal. She is built to the highest class of Bureau Veritas, under the superintendence of Mr. A. G. Schaeffer, of Newcastle. The vessel will be fitted throughout with the electric light, and will have a double set of Worthington pumps, &c. The steamer was named the Lumen, and the machinery is being manufactured by the Wallsend Slipway and Engineering Company, of the triple-expansion type, embracing all the latest improvements.

The official trip of the steamship Antoinette took place on Tuesday, April 9th. The vessel, which is 234ft. B.P. long, breadth 34ft., depth 9ft. 1in., has been built to the order of Mr. C. A. Jones, of Monte Video, by Messrs. T. and W. Smith, of North Shields and Newcastle, and is intended for general trade in the River Plate. The engines, which are twin screw, of the triple-expansion type, have been built by Messrs. Ernest Scott and Co., Close Works, Newcastle, and are fitted with cylinders 11in., 17in., 28in., by 21in. stroke, and a large steel boiler, made by Mr. J. T. Eltringham, South Shields, 13ft. diameter by 10ft. long, fitted with three corrugated furnaces 38in. diameter, for a working pressure of 160lb. per square inch. The crankshaft and all principal working parts are of steel, and the bearings, which are of very ample surface, are lined with white metal throughout. The engines ran most satisfactorily, and, upon arrival in the Tees, the vessel was tried on the measured mile, and attained a speed of over 10 knots, the horse power developed being 455, revolutions 155, vacuum 27¼in. After the trial, the vessel was moored in Middlesbrough Dock, to load with general cargo for Monte Video.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

LEAKAGE IN BOILER.

To the Editor of "The Practical Engineer."

Sir,—If not too late to enter the discussion on this matter, I should like to make a few remarks and to offer a suggestion to "Engine-man." The great peculiarity about the case certainly is that all the seams on one side of the shell are leaking, but I cannot think that the leakage is due in any way to over-heating from deposit. It could scarcely result from local over-heating at the leaky parts, as the heat in the side flue would not be sufficiently intense, and the bottom of the boiler, which receives the first heat after the tubes, and where the deposit would be more likely to lie, would suffer sooner than the parts in the side flue, and, probably, the only way in which the leakage could result from over-heating would be by expansive straining through over-heating at some other part of the boiler.

The amount of solid matter in the water, 23 grains per gallon, is certainly above the average, but is not exceptionally heavy, and is stated to consist principally of carbonate of lime. Now, carbonate of lime is not usually a scale-forming substance, but forms a flour-like deposit, and "Engine-man" informs us that in the present instance the plates are as clean as if scoured. Such deposit does, however, frequently cause over-heating of the furnace tubes, and more especially if mixed with grease from the hot well, or from the feed being heated by the engine exhaust steam. But in such case the defects would most assuredly be in the form of leakage or other defects in the furnaces. Nor do I suppose that the leakages are caused by inequality of temperature due to the mode of setting, or to the fact of the left side flue being the most direct route to the chimney, as, if this were so, I should expect the leakages to be at the colder side, which would be in the right side flue, the feed being discharged at this side of the boiler, and which would be strained in resisting the elongation of the hotter parts.

The argument that the leakages may be caused by displacement of the hot gases in the bottom flue when the fire doors are open carries little practical weight, as the bottom flue is not exceptionally shallow, and the air has to pass over the fires, and would certainly not be cold on reaching the bridges. Any injury from this source would also be localised, and would affect the tubes only.

The only conclusion I can arrive at is that the fault lies in the workmanship, notwithstanding "Engine-man's" assurance to the contrary. The scarfing down and fitting of the butt strips under the lap at the ring seams, and the bulging and bedding of the plates over the strips, form one of the most critical points in the making of a boiler, and, with the thick steel plates now so frequently used, it is considered best to jump joint the butt strips, and to make an "engine work fit," as explained by "Chalkline," in preference to scarfing or thinning. This course is, I know, usually specified by one boiler insurance company, and, I believe, by the Steam Users' Association. What I would suggest to "Engine-man" is that he have a few of the rivets removed at the junction of the ring and longitudinal seams, so as to see if the holes for the four thicknesses of plate are fair, and if the rivets have properly filled the holes. If not, the holes should be rimered out, and larger well-fitting rivets should be inserted. The removal of the rivets would probably enable him also to see if the plates are well bedded together.

It would interest me, and I have no doubt many other of your readers, if "Engine-man" would inform us as to the result of whatever course he may take.—Yours, &c., C. T.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

Sir,—I have never had anything to do with this type, but I read the remarks in "Chalkline's" letter with very great interest. Can he, however, support the statements he makes in your issue of the 5th inst.? They are most damaging. The fact—if fact it is—as to the wetness of the steam is alone sufficient to condemn it, without counting burnt or cracked tubes. I always had the idea that the advantages of these boilers lay in their having a high evaporative efficiency, accessibility for repairs (but needing few), and compactness for a given power. To give one example: There are boilers to the amount of 656 H.P. of this type at the Grosvenor Gallery Electric Light Station, London, where, as the whole of the machinery, &c., had to be placed in a vault excavated for them, space was certainly limited, and electric lighting at present does not pay so well that we could afford to burn extra coal and spend money on repairs without necessity. They have had nearly five years' trial there under heavy and varying loads, yet the company are putting down the same type at their Deptford station, where they will ultimately produce some 150,000 H.P., running some 2,000,000 glow lights of 10 candle power each, or their equivalent; so it seems as though they had succeeded with this company. Then, again, a very large power is being produced by the Babcock-Wilcox boilers at Vienna (also for electric lighting), besides dozens of steam users in various parts of the country, who surely would not adopt them without due consideration. As to the "forcing" on the market, surely this is an exaggeration. A steam user is not tied to one particular make; and if he finds he can get more economical results by a new type than by an older one he will certainly put in the new one, although of course we must expect the makers of the old type to say they are of no use.

Then as to the "safety." Now, in an ordinary Lancashire boiler of a certain size there may be, perhaps, 10 tons of water heated up to considerably over atmospheric boiling point. Now, should a rupture take place, all this water will very quickly be converted into steam, and sufficiently easily to lift the boiler bodily from its seat, as has often happened before now. On the other hand, in the water-tube pattern we have a much smaller quantity to blow out, and owing to the large heating surface it is much more near the nature of an explosion than a sky-rocket effect. Of course a man could easily be scalded to death by such an explosion, as it does not take much to do that, and we cannot make any boiler "safe," from that point of view. A man must chance it in any case, taking due care. Next as to the "priming." Surely this may be remedied by a fairly large "steam drum" and steam dome; also by putting a large trap on the main steam supply, and, if necessary, slightly superheating the steam. Lastly, as to the circulation and sludge difficulty. I believe that this is considered *the* bugbear; but could it not be overcome by forcing the water to circulate by means of a pump? This was suggested by *The Engineer* not long ago. I hope some of the makers of this type will enter the lists.—Yours, &c.,

G. T. P.

QUERIES AND REPLIES.

26. Cavities in Siemens Cast Steel.—Can any reader explain the cause of the hollow cavities occasionally met with in Siemens cast-steel ingots? I mean hollowness so bad as to completely destroy the ingot.—W. P.

Answer.—The cavities in steel ingots were at one time attributed to the presence of carbonic oxide; on further investigation they were shown to contain hydrogen and nitrogen, while another explanation is, that when the metal is being poured into the ingot mould air is carried down with it, as may be seen when pouring water into a glass, but steel being more viscid, the air is unable to escape as in the case of water, and as the temperature of the steel is very high, the air is expanded considerably, as well as the gases formed from the moisture which may be present with the same, and in this manner the steel becomes porous.—Orion.

29. Cementing Rubber to Metal.—Can any reader give me information as to the best cement for fastening a rubber stamp to metal. The cement must stand frequent pressure upon the rubber without being loosened.—J. A. L.

Answer.—I beg to refer "J. A. L." to a reply on this subject which appeared in this journal for 20th July last, page 347.—Orion.

32. Could any of your practical readers inform me how to calculate the thickness of liners to be put under a bearing next to a paddle wheel? Suppose a crank shaft of a paddle boat and the bearings next to the wheels in paddle box had dropped, I require the thickness to put under them so as to only have to lift them once or so. Centre of crank pin to centre of shaft, 2ft. Distance from face of crank cheek, 5ft. Difference the crank shows top and bottom centres, $\frac{7}{16}$in. Hints will much oblige.—Dummy.

Answer.—I regret having to apologise to the Editor and "Dummy" for an error in my calculation of the answer to this query given last week. It will be seen that half the difference was given as $\frac{17}{32}$in. instead of $\frac{7}{32}$in., which would make the corrected answer $\frac{35}{64}$in.—Compound.

34. Weight on Chock on Colliery Incline.—What is the weight resting on a chock placed across the rails of an incline which has a vertical rise of 1 in 12? Set of 30 tubs, each of which weighs 12 cwt. The chock prevents the downward movement of those tubs.—Student.

Answer.—The weight on the chock depends upon its position relative to the centre of gravity; if the point of contact of the chock was at the same level above the rails as the centre of gravity, it would be as stated on page 261, but as it is probably below the centre of gravity, it will be increased, and may be found as follows: Let

x = height of centre of gravity above the rail;
w = force due to gravity acting through the centre of gravity parallel to the plane;
f = amount absorbed by friction (coefficient varies from ·0027 to ·004);
W = weight on the chock;
y = distance from points of contact of the wheels with rails and chock;

then W is found from the equation $Wy = x(w - f)$;

$$\therefore W = \frac{x(w-f)}{y}.$$

Orion.

16. Setting Corliss Valves.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—Engineer.

23. Light Mixing Mill.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—Eastern.

35. Locomotive Driving Wheels.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

36. Nut Cast on Iron Screw.—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and $\frac{3}{8}$in. pitch.—Subscriber.

37. Steam Joints.—Which is best for steam joints, such as valve box covers and steam pipes, indiarubber, asbestos, or thin wire gauze? Is there any reason for preferring any one of them in special cases?—Subscriber.

38. Duplex Mining Pump.—Which is the best duplex action mining pump for use with compressed air, taking into account compactness and first cost as well as economy?—S.

39. Separate Condenser.—Which is the best separate condenser for use with high-pressure engines, and state advantages?—H.

40. Barffing Cast Iron.—Can any of your readers inform me whether cast iron which has been subjected to the process known as "Barffing" will withstand the action of a boiling solution of weak sulphuric acid? Also, can you give me the name and address of any firm where this process is carried out?—Works Manager.

TO CORRESPONDENTS.

E. T., Bradford.—We are much obliged for your letter and information regarding metallic packing in practical use, and we shall be pleased to hear from you, in say another three months, to learn if it still works satisfactorily, without cording the rod or other trouble. Many metallic packings have been tried for piston rods, but for several reasons they have been but little used; consequently we shall be pleased to learn that the old difficulties have been overcome.

R. W., Craiglockhart.—By attaching the suction pipe of a manual fire engine to the street mains, instead of drawing the water from a well or river, the work required from the main would be reduced by supplying water freely to the pumps and avoiding the work of lifting the water from the level of the well or river to the engine. If the level of the river, for instance, was ten feet below the fire engine, then the men have to perform the work necessary for lifting all the water ten feet in addition to that required to force it to a height. This expenditure of power would be saved, and therefore with the same exertion they would be able to force the stream discharged to a greater height. If the pressure from the street main was sufficiently great, the suction valve would not be closed at all on the discharge stroke, but would be kept open all the time, and the water would run continually through the cylinders, notwithstanding the downward stroke; but the pressure would not assist, as the opposing force would equal the acting one.

J. B., Stoke-on-Trent.—Spongy iron is used with great success in purifying water by decomposing and oxidising the organic matter contained in it; its main action is in oxidising previous to filtration, and its durability depends on the amount of oxidising to be done. Messrs. Easton and Anderson, engineers, of Erith, near London, have carried out important waterworks, using spongy iron as an oxidising agent; they will, no doubt, be willing to give you information as to price and other matters.

B. T., Netherton.—Your question is not sufficiently complete; write more fully and explain in detail what you require. To what use is the fountain to be applied?

Vertical.—Thanks for further details respecting engine. The diagrams you send are very fair ones for the type of engine, and the only fault is rather too little lead. Your indicator spring has been a light one, and has run up the compression line rather quickly, and so given a slight fall just before steam admission; but that is not due to any defect in the engine, but to error of the indicator itself.

J. McM., Ardrossan.—We do not know of any work specially upon the manufacture of Siemens-Martin steel; but you will find information upon the subject in Percy's "Metallurgy," and "The Manufacture of Steel," by Grüner, published by Messrs. E. and F. N. Spon, London; or you can get it through any bookseller. An interesting paper was read by the late Mr. Hadfield before the Institution of Civil Engineers on steel castings in 1888, to which you could refer in any free library.

MISCELLANEA.

A large piece of coal, weighing 5 tons 10 cwt., has been cut at Abercarne Colliery, to be sent to the Paris Exhibition as a specimen of the Welsh mining industry. The block measures 7ft. 6in. high, 5ft. 6in. wide, and 3ft. 6in. deep. Five other blocks, each 2½ tons, will accompany it.

An artesian tube well for the waterworks of Wimborne Minster, 130ft. deep, has just been completed by the engineers, Messrs. Le Grand and Sutcliff, in the short space of eighteen days. A strong artesian spring has been tapped in the chalk, which rises and overflows 2ft. above the surface at the rate of 80,000 gallons per day, the actual computed yield by pumping being over 250,000 gollons.

A Great Ore Crusher.—One of the largest rock and ore breakers ever built has been received at the Edgar Thomson Steelworks from the Gates Ironworks, Chicago. This machine weighs 45 tons, and will break any kind of rock at the rate of from two to three tons per minute. The Gates Ironworks have recently sent several of their rock and ore breakers to the Argentine Republic for use in the mines.

Bakers' Blowers.—The Saville Street Foundry and Engineering Co., Sheffield, have disposed of their Bakers' blower business, with the plant, including drawings, patterns, and templates necessary for manufacture, to the Bakers' Blower Engineering Co., Stanley Street, Sheffield, by whom these well-known blowers will continue to be manufactured.

Hall's Patent Stone Breakers and Ore Crushers.—We are informed that Mr. Charles E. Hall has taken over from the Saville Street Foundry and Engineering Co., Sheffield, their business in his patent ore crushers, stone breakers, and differential bone mills and disintegrators. Mr. Hall now manufactures these machines at his establishment, the Standard Ironworks, Washford Road, Sheffield, where the inventions have the advantage of his personal supervision.

Dr. John Hopkinson, F.R.S., has given the Royal Society some interesting facts relating to the magnetisation of iron at high temperatures. At 737 deg. C. all traces of magnetism disappear, but before this point is reached, viz., 727 deg., its permeability increases with great rapidity to a very high figure, when it suddenly drops to unity. In a subsequent paper he showed that the resistance also makes an abrupt change at the same temperature, which is that of recalescence, as discovered by Barrett.

New Tramways in Egypt.—Chances for Contractors.—The Egyptian Government has decided on authorising the construction of several tramways, namely, one from Old Cairo to the Abassieh, with a branch from the About-Ela Bridge to Boulak; two lines from the El Lemoun Bridge, one of which will follow the Choubra Avenue, and the other the Sablieh Road; and finally a tramway from the Kasr-el-Nil Bridge to the Pyramids, with a branch line to the Boulak Dacrour Railway Station. Specifications can be obtained at the office of the Minister of Public Works in Cairo.

The Great Cable for the Eiffel Tower.—A hoist has been completed by the firm of Stein and Co., of Danjoutin, and will be forwarded to Paris in a few days. This remarkable cable is composed of hemp interwoven with iron wire. In the north of France the foundries and rolling mills are fairly occupied, and the ironmasters maintain their prices at 130f. to 140f. per 1,000 kilos., though they find some difficulty in imposing them on the Paris merchants. It appears that the contract for the Clermont-Royat tramways, which were to be worked by electricity, is, after all, likely to fall through, since the board refuses to allow the rails to be utilised for the return current.

Liverpool Overhead Railway Company. — Capital £375,000 in 37,500 ordinary shares of £10 each at par. The company has been incorporated for the purpose of constructing and working the overhead railways authorised by the Mersey Docks and Harbour Board (Overhead Railways) Acts, 1882 and 1887, and it is proposed to construct a double passenger line nearly six miles in length, extending along the line of the Liverpool docks, from the extreme limit of the dock estate in Forth Road, Bootle, at the north end, to the Harrinton Dock at the south end. The directors lay stress upon the fact that as the railway will run almost entirely upon land belonging to the Dock Board or upon public streets, the expenditure in purchasing land, which ordinarily forms so large an outlay in the cost of a railway, will be avoided.

Manchester Ship Canal.—Mr. Walker, the contractor for the Manchester Ship Canal, has given an *Echo* correspondent some very remarkable figures. The "plant" employed on the works is worth more than three-fifths of a million sterling. By the end of June, or thereabouts, there will be 20,000 men at work—beyond which strength, in muscular power, it is not, we believe, intended to go. Nearly one-third of the total excavation (reckoned at forty-seven millions of cubic yards) has been finished. And yet it is only about two years since the first spadeful was turned up at Eastham. Twenty-thousand men between the Eastham and Manchester termini means a thirty-four-mile-long row of men, each standing at a distance of three yards from his next neighbour.

Petroleum Works in the Punjab. — The Kattan Petroleum Works have, it appears, now passed beyond the experimental stage. An agreement has been definitely entered into to supply the works at the Khojak tunnel with about 3½ million gallons of the oil. The wells, which are 42 miles from the railway, have been connected with Babar Kuch on the Sind-Pishin line. The saving to the State from the use of the petroleum on the Khojak works alone will, it is estimated, be enough to cover all the cost of the Kattan experiments, and leave a balance of over five lakhs of rupees. And there is no reason to anticipate that the benefits of the apparently inexhaustible supply should end here. On the contrary, in a country like Beluchistan, where every stick of wood is worth its weight in silver, the demand for the new fuel must be great; and in addition to other advantages, its use may be expected to put a stop to the destruction of the forests, which, until recently, was going on at an alarming rate. It is now intended to replace the expensive and wasteful system of camel-carriage by laying a pipe-line from the wells along the Babar Kuch Road; and should Government decide on sanctioning this, it may be confidently expected that the capabilities of Kattan will emerge once for all from the cold shade of neglect and scepticism in which an exaggerated idea of its remoteness has left it so long.

Institute of Iron and Steel Works Managers.—On Saturday night, the 13th inst., an ordinary general meeting of the above institute was held in the Mechanics' Institution, Dudley; Mr. H. Parry presiding. There was a good attendance. Mr. G. H. Walkenden read a paper entitled "Notes on the Lancashire Boiler." He condemned the ordinary or random firing as extravagant and producing much smoke, and advocated the method known as side-firing, in which the fuel is thrown on each side alternately, thus leaving one side with a bright fire, which tends to consume the gases evolved from the green fuel on the opposite side. There was also the careful or coking firing. After the fires have been lighted some time, and got up to the required thickness, the fresh charge of green coal is placed on the front of the grate, and after remaining there seven or ten minutes, according to the weight of the charge, it is pushed forward in a body, and a fresh charge takes its place. The plan was not often adopted, but it was economical, and conducive to the prevention of smoke. A discussion followed, in which Messrs. Pilkington, Farnworth, sen., Tucker, Roberts, Millard, Danks, Haynes, and others took part. A vote of thanks was passed to Mr. Walkenden.

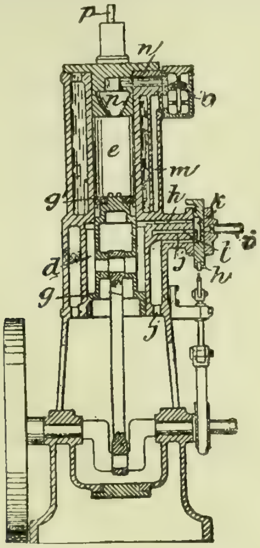
The Extension of the Birmingham Cable Tramway.—The work of completing the New Inns portion of the cable tramway is being rapidly pushed forward, in order to get it ready for traffic on Easter Monday. The new stretch of line from Hockley to the New Inns terminus is about a mile and three-quarters in length, and thus when the whole is complete the entire route will be about three miles long. There is very little difference between the new stretch and that within the city boundary, the principle of construction being practically the same, with the exception that the pulleys over which the cable runs are not so close together. The time of service and rate of fares are at present under consideration, but it is probable that penny fares will be taken, and that a five-minutes' service of cars will run from Monmouth Street to the New Inns. The only obstacle at present in the way of opening the Handsworth route by Easter Monday is the wet weather. Gangs of men are engaged in clearing out the tube, preparatory to the pulleys being fixed, which will be followed by the threading of the cable. The rails have been supplied by the Hematite Steel Company, Barrow-in-Furness, the general ironwork by Messrs. Tangye; while the general construction has been contracted for by Mr. John Fell, of Leamington, under the supervision of the resident engineer (Mr. W. A. Pritchard). Messrs. E. Pritchard and Kincaid are the engineers.

Engineering Society, King's College, London.—At a general meeting of this society held on Tuesday, March 26th, the president in the chair, Mr. Hawkins read a paper on Electric Lighting Machinery. He first gave a description of the separate parts of a dynamo, the methods of exciting field magnets, shunt, and series winding, and the automatic regulation, (*a*) by controlling the exciting current at constant speed, (*b*) by controlling the speed. He also discussed series and shunt winding with comparative curves, characteristic curves, Deprez's theory of self-regulation, and compounding. The author then dealt with close coil armatures, and curve of potentials in a close ring, armature re-actions and theory of angle of lead, continuous current dynamos, with closed coil armature. Amongst the various improvements, the author mentioned improvements in Gramme dynamos, in the magnetic circuit in Crompton, and other dynamos, the use of Swedish wrought iron in magnets and armature cores, and the latest Crompton dynamos for slow speed, &c. A description of Patterson and Cooper's dynamo, Victoria dynamo, with comparison with Shuckert's dynamo, and the cross connecting armature coils for multipolar fields, was then given. The author then referred to the improved forms of Edison's dynamos with drum armature, short solid field magnets, and the shunt wound machine introduced last year in America, incandescent lighting, and also of Edison-Hopkinson's dynamo. The principles and construction of open coil armature, interference of arc light wires with telephone lines, and steadying effects of electro magnets in the circuit, brush dynamo, brush method of regulation, Thompson and Houston dynamo, and apparatus for regulating by shifting the brushes. He then gave the principles of altering current machines, armatur windings, and arrangement of coils in series for arc lighting, and in parallel for incandescent lamps in parallel, Gramme's alternators, with rotating field magnets, Siemen's alternate current dynamo, Mordey alternator, steadying effect of the heavy revolving field magnets on the speed, Ferranti dynamo. The author then gave the regulation of alternating current dynamos, compounding Kennedy's method for constant current and Tipernaevasti's for constant potential, for machine with stationary armature and revolving magnets, by passing a current from one coil through a commulator to feed the magnets, including in the same circuit the secondary coil of a transform, having the primary in the main circuit for constant potential, and as a shunt to the main for constant current. He then described the method of application to machines with revolving armature, by drawing a current from one coil through a suitable commutator, and passing the current from the transformer through an independent commutator on an extension of the shaft to rectify it. He then described the general method of automatic regulation of dynamos by the electric engine governors, to regulate the supply of steam to cylinders, Williams's governor, Richardson's governor, and other detail matters.

ILLUSTRATED PATENTS.

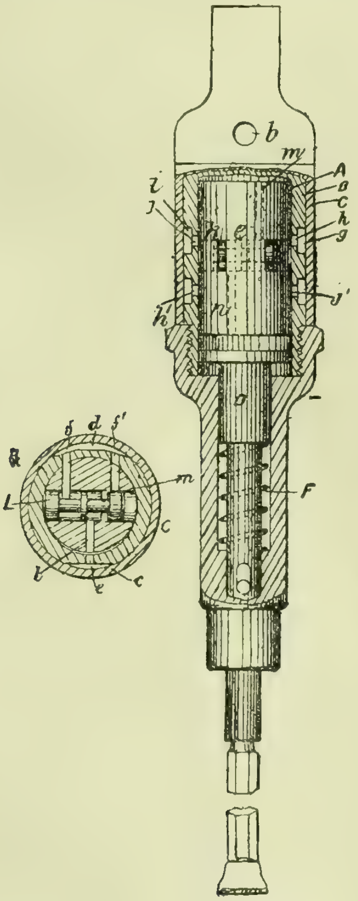
16,029. Gas Engines, H. Williams, Stockport.

The enlarged front d of the cylinder e forms the charging pump, the two pistons g, g^1 being in one piece. During the outstroke while the ignited gases are expanding in e a charge of gas and air is drawn into d through the air and gas passages j and i, the valve k, and port h. At the end of the outstroke, the piston g^1 uncovers the exhaust ports, and a charge from the reservoir m enters the cylinder through the clack valve o and passage n. On the instroke this charge is compressed in the cylinder, and the charge that was drawn into the pump on the outstroke is compressed through the ports h and l into the reservoir m. The charge is ignited at the point of greatest compression by the hot tube p.—November 22, 1887. [8½d.]



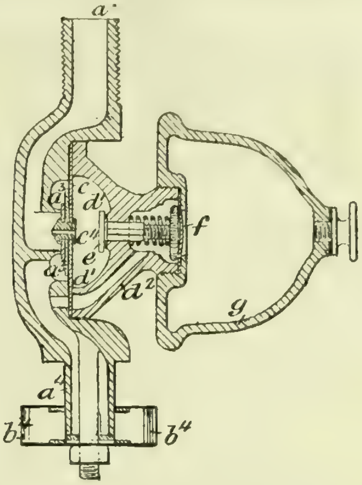
16,077. Dressing Stone, Planishing Metals, &c., J. S. McCoy, Brooklyn, New York, U.S.A.

Relates to a method for dressing stone, planishing metals, &c., by means of a percussion tool in which the striker is reciprocated with great rapidity. The enlarged head D of the tool holder, is struck by the piston or striker A, which is actuated by compressed air or steam. The cylinder is built up of an inner and an outer casing B and C, between which are the various air passages, of which h, h^1 and e are inlets, and j, j^1, f, and f^1 exhaust ports. The piston fits loosely in the cylinder, and contains a transverse piston valve L. When the piston A is at the top of the cylinder one end of the piston valve communicates with the steam inlet e, by the passages h and g, while the other end is open to the exhaust b by the passages j, i, and d. This throws the valve over and opens the lower part of the cylinder to exhaust by the passages n, k, f, d, while steam is admitted to the top through m, l, e, c. At the end of the down stroke the valve is opposite the ports h^1 and j^1, and the communications are reversed. The ports are so arranged that cushioning takes place at both ends of the cylinder. A spring F is used to return the tool after it has been struck.—November 22, 1887. [8½d.]



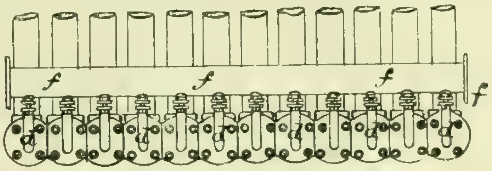
16,109. Fire-extinguishing Sprinklers, G. W. Crawshaw and J. Tonge, both of Rochdale.

The starting and stopping of the discharge from the sprinkler is controlled by a thermostatical apparatus, consisting generally of a liquid enclosed in a vessel with a flexible diaphragm which acts on the valve. In the form illustrated the liquid is enclosed in a vessel g, having at one side a flexible diaphragm f, which presses on the end of the spindle of the valve e. The valve e is thus opened when the temperature in the room rises above a certain limit, water passes from the chamber d^1, through the passage d^2, to the revolving spreader b^4, and, at the same time, the diaphragm valve c is opened by the excess of pressure on the side next the supply passage a^1. The spreader is then supplied directly from a^1, through a^3 and a^4. When the temperature falls the valve e is closed, and the pressure on opposite sides of the diaphragm c is equalised through the small passage c^4.—November 23, 1887. [8½d.]



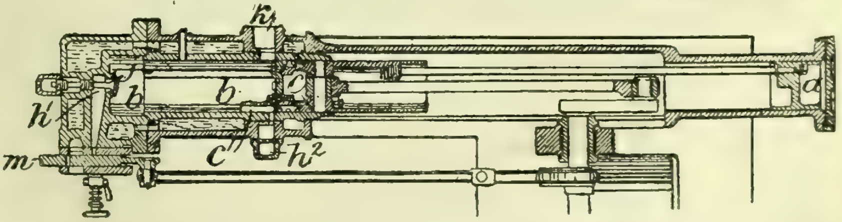
16,114. Fuel Economisers, A. Lowcock, Shrewsbury, and T. Sykes, Manchester.

In order to secure uniformity in the flow of water through the various pipe sections, each bottom box is connected to the water supply pipe by a branch, the total section of these branches being made equal to that of the said supply pipe. A front elevation of part of one is shown, in which the bottom boxes are connected to the supply pipe f by small branches d, d. This construction also enables any single box to be examined by removing its branch, while the others are left undisturbed.—November 23, 1887. [8½d.]



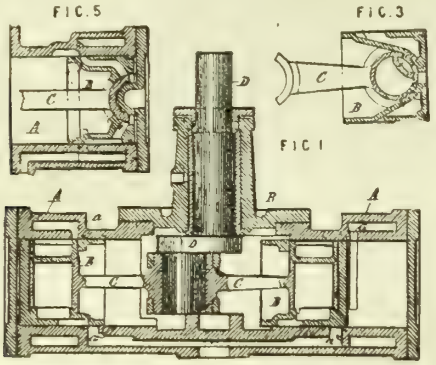
16,144. Gas Engines, H. Williams, Stockport.

In the "Stockport" and other engines one portion of the charge is admitted at the back of the combustion chamber simultaneously with the other part which enters through a port uncovered by the piston on the end of the outstroke; the exhaust port is also uncovered by the piston at the same time. The drawing is a sectional plan of an engine. The charge is compressed by the pump a into a reservoir, and admitted to the cylinder b, at the end of the outstroke of the piston c, through the ports h^1 and h^2; the part which enters through h^1 is directed towards the sides of the cylinder by a deflector j; that entering through h^1 is prevented from escaping through the exhaust port k by the shield c^1. The charge is compressed in the cylinder b during the instroke, and ignited when the latter is completed by a slide m. The flame may be admitted to the cylinder eithe behind the deflector or close against the piston.—November 24, 1887. [8½d.]



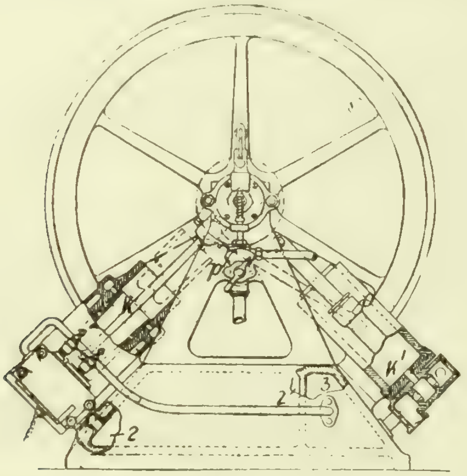
16,182. Steam and other Engines, F. W. Dodd, Forest Gate, Essex.

Consists in forms of enclosed single-acting trunk engines, wherein the distribution of steam is effected by the rocking of the connecting rod end in the piston. The cylinders A, A are situated on opposite sides of the crank chamber, on one side of which the crank shaft D is supported in a single bearing E. The connecting rods C, C at the crank end have segmental sockets bearing against the crank pin, and kept in engagement therewith by means of a pair of rings embracing the two. At the piston end they expand into the form of oscillating valves, of which three suitable varieties are illustrated—the hollow cylindrical sleeve shown in fig. 1; a similar valve, fig. 3, in which the steam is not admitted to the interior but only to a cavity cast in the side; and a segmental shell, fig. 5, working loosely against a socket, and kept in contact with the valve by steam pressure, which in this case is admitted to the crank chamber. The steam is conducted towards and away from the valve by passages in the pistons B, B, the openings of which come at certain periods during the movement of the piston opposite to the steam and exhaust ports a^2, a in the interior face of the cylinder. In place of packing the piston as usual, the cylinder itself may be packed by a resilient packing inserted in grooves.—November 24, 1887. [8½d.]



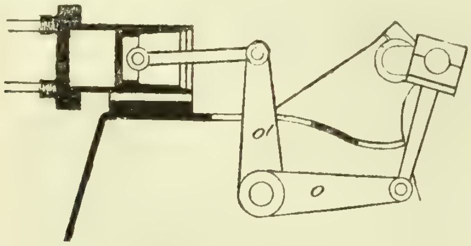
16,257. Gas Engine, P. J. Ravel and E. Breittmayer, both in Paris.

The engine is of the one-revolution cycle type, and the invention consists in compressing air and gas into separate reservoirs and admitting them to the cylinder through a tangential port near the cover at the time the piston uncovers the exhaust port, the air valve being opened a little before the gas valve. A horizontal engine is described, and also the one shown in which the motor cylinder K and the air and gas pumps K^1 and O are inclined and connected to the same crank. 2 is the air, and 3 the gas reservoir; the governor p controls the gas valve. A magneto-electric igniting apparatus is described.—November 26, 1887. [1s. 4d.]



16,309. Gas Engine, T. Sturgeon, Ilkley, Yorkshire.

In one-revolution cycle engines in which the pump plunger performs the quickest part of its instroke, and compresses a charge into the motor cylinder at the same time that the motor piston is uncovering the exhaust ports at the end of its outstroke, the plunger and piston are both connected to the same crank. Arrangements are shown, 1st, in which the pump is horizontal and the cylinder vertical and inverted, an oscillating beam being employed between the piston and connecting rod; 2nd, in which the cylinder is horizontal and the pump vertical; and 3rd, in which the cylinder and pump are side by side, and the pump plunger is connected to the crank through the bell crank lever O, O^1. A slide valve is shown which admits the charge to the pump and to the cylinder from the pump, and also ignites.—November 28, 1887. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

April 1st.

5516 Heating Water, G. E. Sherwin, Birmingham.
5522 Motor Engines, J. Brown, London.
5524 Furnaces, F. Hoyer, Liverpool.
5534 Driving Gear, J. Farquharson, London.
5535 Propeller, W. Blair, Paisley.
5540 Fasteners, E. Tweedale, Halifax.
5551 Motive-power Machines, E. Edwards, Middlesex. (Messrs. J. Colin and Co., France.)
5557 Lock Nut, F. Girein, London.
5558 Cutting Metals, A. Downie and J. A. Snowdon, London.
5559 Separating Machines, H. Bergner, London.*

April 2nd.

5571 Forging Machine, H. Hammond, London.*
5575 Moulding, J. N. Matlock, London.
5579 Starting Engines, A. Melvin, Glasgow.
5585 Belt Fasteners, J. B. Parrie and J. H. Connor, Canada.*
5593 Blast Apparatus, W. S. Hide, London.
5600 Sprinklers, H. W. Knight, London.
5602 Roller Bearings, J. Gibbons and C. D. Meneely, London.*
5605 Gas, P. Farrelly and J. Sudall, Blackburn.
5615 Electricity, I. A. Timmis, Westminster.
5616 Motor Shaft, C. Denton, London. (The Motoren Fabrik Deutz, Germany.)
5618 Railway Ties, E. N. Higley, London.*
5619 Steam Engine, A. A. Garside, Barnsley.
5624 Tube-corrugating Machine, J. S. Taylor and S. W. Challen, Birmingham.
5627 Steam Boilers, H. Tomkins and T. Sudron and Co., Limited, Stockton-on-Tees.
5631 Wheels and Pulleys, W. H. Luther and J. Cockburn, Glasgow.
5633 Petroleum Engines, C. Wells, Middlesex.
5643 Corrosion of Vessels, A. J Boult, Middlesex. (Messrs. Jung and Lindig Germany.)*
5662 Chucks, J. Barlow, London.
5663 Cutting Machines, J. F. Berndes, London.
5667 Ingot Iron or Steel, J. H. Darby, London.*
5669 Aluminium, C. M. Hall, London.*

April 3rd.

5681 Propelling Ships, S. R. Lane, London.
5694 Metallic Packing, J. Allan, South Shields.
5697 Fuel Blocks, B. F. Kelly, J. H. Spencer, and H. Spencer, Birmingham.
5703 Nitre Cake, H. J. Kirkman, London.
5704 Starting Machinery, Pickerings, Limited, J. T. Pickering, E. W. Sant, and A. R. Davies, London.
5707 Wagons, F. Fleiss, London.
5709 Propulsion, G. Wicks, Berwickshire.
5710 Joints for Pipes, W. W. Fyfe, London.
5719 Locomotives, W. R. Rowan, London.
5720 Projectiles, W. Kennish, London.*
5721 Fire-extinguishing Buckets, J. S. Braidwood, London.
5731 Valve, G. C. Webb, London.
5733 Weighing Machines, R. W. Page, London.
5736 Securing Collets, E. Partridge, London.

April 4th.

5745 Pump Buckets, O. Phalp, Cardiff.
5751 Wrenches, J. Case and H. Allcard, Sheffield.
5752 Heating Apparatus, R. W. Holden, Sheffield.
5754 Gas Meters, S. Glover and T. Glover, Manchester.
5755 Flywheel, D. Halpin and I. A. Timmis, Westminster.
5757 Looms, W. E. Heys, Manchester. (Messrs. Pinon et Guérin, France.)
5774 Electric Lamps, R. P. Sellon and A. J. Spiller, Lambeth.
5780 Type-writing Machines, F. Myers, Liverpool.
5791 Cleaning Vessels, Martin van Look, London.

April 5th.

5799 Packings, D. Walton, London.*
5809 Ratchet Clutches, H. J. H. King, Gloucestershire.
5822 Brake, J. Darling and A. Darling, Glasgow.
5826 Joint for Pipes, R. Robinson, London.
5828 Cut-off Valve, J. Hewitt, Newton, Hyde.
5829 Looms, W. Harwood and G. Higson, Halifax.
5831 Generators, J. Barker and L. Delaney, Bradford.
5832 Electricity Meters, G. Hookham, Birmingham.
5834 Valves, D. Carmichael and A. Mackie, Glasgow.
5835 Flushing Apparatus, J. Shanks, Glasgow.
5839 Dynamo-electric Machines, T. H. Allum, G. C. Fricker, and J. R. Bainton, Putney.
5844 Protecting Installations, O. J. Lodge, Liverpool.
5848 Pulley-blocks, H. A. Rooke, Liverpool.
5852 Registering Pistons, R. Hack and R. E. Plaistowe, Tottenham.
5859 High-speed Engines, A. Sneath, London.
5860 Type-writing Machines, M. G. Merritt, London.*
5861 Compressing Powdered Substances, J. A. McFerran, London.
5864 Couplings, A. E. Schurr, London.
5868 Generators, L. Steinmüller and C. Steinmüller, London.*
5875 Leak Detectors, A. M. Clark, London. (A. F. Peterson, United States.)
5877 Tool-holders, W. Bashall, Middlesex.*

April 6th.

5879 Fire Grates, L. Hopcraft, London.*
5888 Measuring Electric Resistance, A. P. Trotter, Westminster.
5889 Gases, W. G. Hicks, Ramsgate.
5891 Boilers, J. Fagan and J. B. Moorhouse, Keighley.
5895 Air Engines, William de Westbury, W. H. Baraclough, and W. H. Ingall, Birmingham.
5902 Sewing Machines, W. E. Burnell, W. Burnell, and W. Evans, Middlesex.
5905 Lubricators, C. Stiles, Westminster.
5915 Locomotives, F. Koernig, London.
5916 Sluice Valves, J. Barr, Glasgow.
5918 Water Gauges, T. Sandiford, A. Diggle, and M. Mitchell, Rochdale.
5924 Spring Motors, C. Wells, London.
5928 Steam Boilers, C. Schaefer, London.
5931 Carding Engines, J. Walmsley, Huddersfield.
5933 Wheel, W. W. Horn, Middlesex. (T. J Rice and A. E. Wheeler, United States.)

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE
PRACTICAL ENGINEER,

APRIL 26TH, 1889.

ROTARY ENGINES.

An attentive examination of the patent list at once reveals the astonishing amount of effort among inventors devoted to the production of rotary steam engines, an effort in the main expended upon false grounds, and in consequence of illusive hopes. A very common fallacy among inventors of this class is the idea that power is lost in the ordinary reciprocating engine in the frequent changes of motion of the piston at the termination of its stroke, and one leading idea among many is to save this power by causing the piston to revolve. Fabulous estimates are continually made of the saving to be effected in this way, and although competent engineers have proved over and over again that there is no loss from change of motion in reciprocating engines, and consequently no gain to be obtained on the score of economy in rotary piston engines, yet the old fallacies are continually repeated by sanguine but misinformed inventors, who tell the world through the medium of the daily press that their new rotary engines will use only one-fifth of the fuel of any ordinary steam engine, and when made in larger sizes the new motor may be confidently expected to use one-tenth of the best ordinary consumption for equal power.

Rotary engines have a well defined and exceedingly important position for practical purposes, which we would not for a moment attempt to minimise, but their true position will be rendered all the more evident and secure by an attentive examination of the common fallacies respecting them. We are well aware that such fallacies are clearly understood by many of our practical engineers and by all of our leading engineers, but nevertheless it may save some ingenious but mistaken inventor much thought and useless labour if we point out clearly the errors respecting rotary engines, as well as their true position in engineering work.

At first sight it seems very likely that power should be lost by reciprocating in the common form of piston engine, but a little consideration will prove that this is not the fact. Take, for instance, the case of an engine where the piston, piston rod, crosshead, and connecting rod—in fact, all the reciprocating parts—weigh together five cwt., and suppose that the highest piston speed—not the average—is 600ft. per minute; then the total energy contained in the whole moving mass at the instant of maximum velocity is about 870 foot pounds. If the stroke be of such length that 250 revolutions per minute are made, then, as the direction of motion is changed 500 times per minute, if power be lost by change of direction, then the total possible loss is $870 \times 500 = 435{,}000$ foot pounds per minute, or about thirteen horse power. That is, if the whole power expended in giving the piston motion from the beginning to the middle of the stroke is lost in reversing the motion when the piston reaches the end of its stroke, that is the amount of power which would be lost in such an engine. But inventors seem to forget that if work requires to be done to give the piston velocity, it, on the other hand, must do work in order to lose velocity and come to rest. The work done in the early part of the stroke in giving the piston velocity is returned to the crank pin at or before the end of the stroke. This is more easily understood if we suppose, for a moment, that our engine is driven round by a belt at its full speed with the cylinder covers off, so that there may be no pressures or resistances generated save those due to movement. Here the piston is entirely driven from the crank pin, and whatever pressures come upon the pin are due to the reciprocating parts alone.

In the first half of any stroke, under those circumstances, the piston and moving parts are dragging upon the connecting rod if it is taking the out-stroke, and causing pressure upon it if it is taking the in-stroke; it is either in tension or compression. During the first half of the stroke the velocity is constantly increasing, and the crank pin is experiencing resistance to its motion. In the latter half, on the other hand, the velocity of the moving parts is diminishing, and therefore pressure is being applied to the crank pin, assisting it in its motion instead of retarding it. Neglecting frictional losses and losses due to vibration, or shock from slack bearings or brasses, the power so given up by the moving parts to the crank pin is precisely equal to that absorbed by them from the crank pin. In the engine in question the crank pin would do 870 foot pounds on the piston and other parts during the first half of the stroke, and they would return the same work in slowing down during the last half of the stroke, so that the crank pin would be driven by the reciprocating parts just as much and no more than it drives them.

In high-speed engines the pressures upon the crank pin from the moving masses form no inconsiderable part of that due to steam, and engines are sometimes designed in which this diminution of pressure at the beginning and increase at the end of the stroke is utilised to equalise the effort of the steam upon the crank pin, and cause fairly uniform pressure throughout the whole stroke, even with great expansion.

There is no saving in this respect by using rotary engines, because the loss is an entirely imaginary one, and has no real existence, except to a very minute extent in improperly designed engines, when a hammering action is set up and heat generated. Even then the loss of power is but slight.

The real function of the best type of rotary engine is not to save fuel, but to save space. Provided that the pistons of rotary engines are as steam-tight, and are arranged to use steam as expansively as in ordinary engines, there is no reason why they should not be as economical; but, as a matter of fact, few such engines are economical. Their advantages lie in high speeds, small bulk, and, consequently, great power—not in economy. Very few can be considered as truly rotary—that is, nearly all of them contain some part which reciprocates, and in many so-called rotaries the pistons themselves have a relative reciprocating motion. The commonest type, in patent specifications at least, contains a revolving piston within a cylinder and a reciprocating shutter, which serves as an abutment or cylinder bottom, and moves to and fro relatively to the cylinder. Another type has a spherical cylinder and flat piston, with spherical periphery, which has a combined revolving and reciprocating motion. The well-known Tower spherical engine is a good example of this kind, in which the mechanical difficulties are most ingeniously overcome, and a steam-tight piston secured without useless friction under most trying conditions.

Perhaps the most truly rotary engine is Parson's steam turbine, from which enormous velocities and good power can be obtained in very small bulk, and a fair measure of economy as well. Mr. Rigg's beautifully conceived revolving steam engine is not really a rotary but a reciprocating engine, where the reciprocations are relative, not actual, and on which any actual reciprocation appears not in the cylinders and pistons, but in the connecting rods. Consequently enormous velocities may be obtained without vibration.

These and many other rotary, or partly rotary, engines are very admirable examples of what can be done by ingenious design and first-class workmanship to solve the difficult problem of attaining high velocity of rotation and great power in a very small space, but in not one of them is the economy of steam nearly so good as is attained easily in the best types of reciprocating engine. At best the complexity and nature of the working parts in such engines render them more expensive in first cost, and less easily kept in order, than the ordinary reciprocating piston type. This is readily understood when we consider the difficulty of getting steam-tight pistons working easily against the various surfaces required in such engines.

Inventors may entirely dismiss from their minds the idea that great economy is to be obtained from such engines, and turn their attention to more promising fields for improvement in engine construction. The steam engine is still capable of considerable improvement, but not in this direction.

THE ARGENTINE REPUBLIC.

On Tuesday, April 2nd, Mr. F. R. Smythes read an interesting paper upon the Argentine Republic before the Society of Arts, and a valuable discussion followed. It appears that since the election of General Roca as president, in 1880, his Government has been powerful and stable, and has entirely put an end to Indian raids and internal revolution, so that the country has progressed rapidly, and offers a great field for industrial and engineering enterprise.

The total exports and imports in 1887 amounted to £42,349,840, or £9 13s. per inhabitant, against £8 8s. in France, £6 7s. in Germany, £6 in the United States, and £2 4s. in Russia.

Of the exports those resulting from pastoral pursuits have up to now given the largest returns, especially wool and hides, but in a few years the products of agriculture will far exceed those of stock at present. At present grazing lands are being rapidly ploughed up and devoted to crop raising, which is the reverse of the change going on in England. The amount of food sent to this country from there is already considerable, and as more land comes under cultivation it will largely increase. In the Argentine Republic there are more sheep than in any other country in the world, the total being about 90,000,000, and of horned cattle there are 18,000,000.

An enormous quantity of wheat is now grown by farmers, who are principally Italians, and the most improved machinery is used for reaping and threshing. The threshers used are of the largest and most modern type, the furnaces being arranged to burn straw. We are pleased to note that the favourites are of English manufacture, mostly those of Messrs. Ransome, Sims, and Jeffries, as well as Messrs. Clayton and Shuttleworth's. River Plate wheat and maize get the highest prices in the European markets, and it is stated that the country possesses many advantages over the United States for raising corn and other produce, as the prairie land is situated on the seaboard, and along the Parana, which is navigated by large ocean steamers as far as Santa Fé, or about 700 miles from the mouth of the river.

There are now about 5,000 miles of railways at work in the country, and concessions have been granted for about as much more. There are many minerals in the country, and some very rich silver mines, such as those at Famatina.

In the discussion which followed many interesting facts were elicited. Mr. J. W. Batten stated that railways could still be largely developed without fear of harmful competition, as there were no roads, and it would not pay to carry wheat beyond 40 miles; the farmers settled down as near the rail as possible, and carried their crops to the nearest railway station, but never beyond that distance.

Nothing was manufactured in the country, but immense quantities of raw produce were sent out in the form of hides, tallow, wheat, maize, and wool. All over this large area—from twenty to thirty times the area of England—people were crying out for English manufactures, but were unable to get them. Some English firms recognised the splendid opening offered, among them Messrs. Negretti and Zambra, the London opticians, who were actually engaged in exporting coals because the Italians had asked them to do so. This year he (Mr. Batten) had sent out thirty young men to the Argentine Republic, who were earning small wages in this country on the railway, all of whom were now doing extremely well. He had just had a letter from one who had been a porter upon the South-Western Railway, who wrote saying, that he was able from the sixty dollars a month which he received to bank twenty-five dollars. There were not many porters in England able to do that.

Major Craigie said that nearly one million sheep had been landed on our shores from the Argentine Republic last year, and considerable imports of mutton were now taking place from Argentine into France.

Mr. R. Herbert Lepâge, speaking as an engineer, stated that there was nothing to fear as yet from undue railway competition, as there were no roads in the country, and no stones in the greater part of it with which to make roads; therefore it was cheaper to make iron roads, which were effectually ballasted with the black soil of the plains. The soil was of an excellent kind, and if properly irrigated would give immense returns. The trade in frozen meat should rapidly improve, as animals could be purchased at a very low figure and transported cheaply. Large additional freezing stations are to be established shortly to meet the increasing demand.

The Chairman (Col. Hyde Clarke) said that commercially the question of the Argentine Confederation was of great importance, and that its development industrially was largely due to English capital and engineering enterprise. The cheap transit by sea would have been impossible but for the inventions of men like Bessemer and Siemens. He warned Englishmen from too rash a belief in the stability of the Government there, and said that English labourers for many reasons preferred Canada.

It seems undoubted, however, that the Argentine Republic offers a good field for English engineers and manufacturers. A population of nearly five millions, and a fertile country producing abundance of food and having large mineral resources, without manufactures, must require large supplies of goods which we can furnish, and it seems to us that it would be well worth the expense for our leading engineering firms to send out reliable representatives to inquire more closely into the needs of the people.

STATE OF THE SKILLED LABOUR MARKET.

THE following memorandum has been prepared for the *Journal* by the Labour Correspondent to the Board of Trade: The returns sent in this month by the chief societies representing skilled labour again show an increasingly prosperous condition of their labour market. Not only is the demand for labour fully sustained in the shipbuilding, engineering, coal, and manufactured iron trades, but the improved state of the weather has given freer play to outside industries, while the textile and clothing trades are now beginning to feel the stimulus of the general prosperity. Seventeen societies have reported. These show an aggregate membership of 179,857, and in every case a decrease of unemployed members is reported. For these same labour organisations last month the total of men out of work was 4,831. For this month the figures are down to 3,904, which, stated in percentage, is 2·8 for last month and 2·17 for this month. For the corresponding month of last year the percentage of unemployed was 5·7, and for the preceding year 7·7. Four trade societies generally describe trade as "very good," eight as "good," three as "moderate," one as "well employed," and one as "improving." The most notable change is observable in respect to the building trades, where the proportion of those not in work has gone down from the 6·4 per cent of last month to 4·7 per cent now, as against 8·5 per cent for April of last year. The shipbuilding, engineering, ironfounding, and cognate industries are still improving, and are now very nearly up to the level of the best of times. Miners are everywhere well employed, and in the manufactured iron and steel trade great activity is being displayed. Additional furnaces are in some cases being put into blast, and in the Midland iron-manufacturing districts difficulty is experienced in finding puddlers. Cabinet-making and brushmaking are also greatly improving, while in the tailoring and boot and shoe trades the workers are better employed than for some months back. Scottish and provincial printers complain of dulness, but in London this department of industry is quite up to the average for the season. Indeed, the improvements indicated by the figures for the month may be truly said to be an all-round improvement, and prospects for the summer are remarkably good.

ELECTRO-MOTORS AND THEIR APPLICATIONS.*

THE electro-motor is a machine for converting the energy of electric currents into the energy of mechanical motion.

In the older forms of motors—that is, in all those before 1872, when Gramme discovered the reversibility of the dynamo—the principle of action consisted in the attractive forces exhibited between masses of magnetic metal; but in the commercial motor of to-day the action is quite different, and depends upon the principle that when a current passes through a wire the latter becomes surrounded by a field of force similar in nature to that pertaining to permanent magnets. Every conducting wire is surrounded by a sort of magnetic whirl, because of which, if the current is going in a certain direction, the lines of force appear to circulate from left to right, and with a current in the contrary direction from right to left, as in fig. 1, where the current is supposed to pass through a wire not shown in the direction of the arrow. Fig. 2 shows the supposed variation in disposition of those lines of force. The wire in this condition, when brought into proximity to a magnet, is attracted or repelled in the same way as if it were a magnet, and the attraction or repulsion is determined by the direction in which the lines of force circulate, or, in other words, by the direction of the current.

In the dynamo, the motion of a conductor, if moved in a field of magnetic force so as to cut the lines of force, produces a current of electricity in the conductor, but a certain mechanical power is required to force the conductor through the magnetic field. The currents so generated have a direction such that their reaction tends to resist the motion which produces them. In the motor the conductor produces motion.

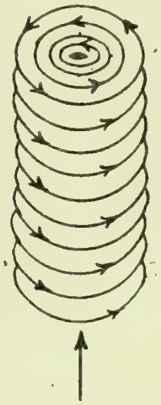

FIG. 1.

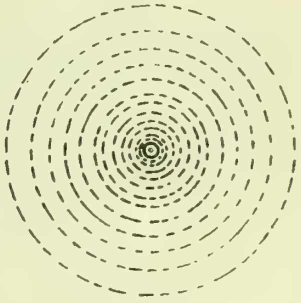

FIG. 2.

There are three methods of winding the field magnets of the continuous current motor, known as series, shunt, and compound. The advantages or defects of each will be briefly described.

The shunt wound motor has no starting power, since its armature when at rest forms a circuit of very low resistance. Therefore to start a shunt motor it is necessary to temporarily put a resistance in the armature circuit, so that the field may become excited before the current is allowed to flow into it. When it has attained a good speed, the resistance is cut out. The chief advantage of this form of winding is, that its speed when running without any load is only slightly greater than when fully loaded, whereas the speed of the series motor when running empty is excessive. A shunt wound motor runs in the same direction as it ran as a generator.

Motors may be arranged with a combination of both shunt and series winding for their field magnets, so that, when supplied with a constant current, or a constant electro-motive force, they will always run at a constant speed, whatever the load. The only difficulty in working with this form is that, when the current is suddenly turned on to start it, the greater part runs through the armature and series coils, and very little through the shunt; the result is that the shunt coil gets less than the demagnetising series coil, and so the motor is liable to start in the wrong direction.

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* Paper read by Mr. L. Gregson, Stud.Inst.C.E., before the Students' Section of the Inst.C.E., Birmingham.

The winding of a series motor is shown in the diagram, fig. 3. The coils of the field magnets and amature are in one circuit. As this type is most generally used, the remarks in this paper will refer to it more particularly.

It is principally applied to the propulsion of vehicles, which require at starting a power greatly in excess of that needed when running. The torque or rotary effort of the motor depends on the current and strength of field, but not on the speed.

Between the poles marked S and N the armature, such as that shown in fig. 3, a gramme ring, revolves. It consists of a circular iron ring, which is wound with a continuous helix of copper wire, and certain parts of the helix are joined by connecting wires to the commutator plates.

The current generated from all dynamos, both continuous and alternating, is in reality alternating, and the current appears as continuous only in the external circuit when directed by the commutator.

Electro-motors capable of working with their alternating current would do away with the double transformation, and therefore be of great use, as it is now common to use the alternating current on electric lighting circuits, on which the ordinary continuous current motor will not work with any degree of efficiency.

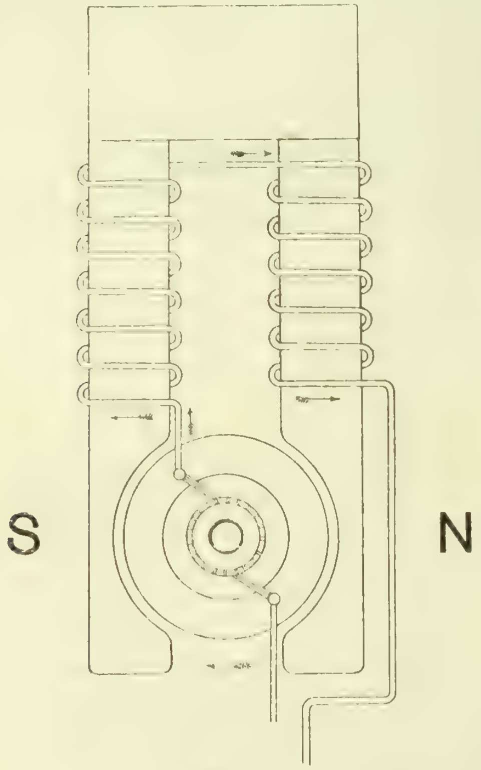


Fig. 3

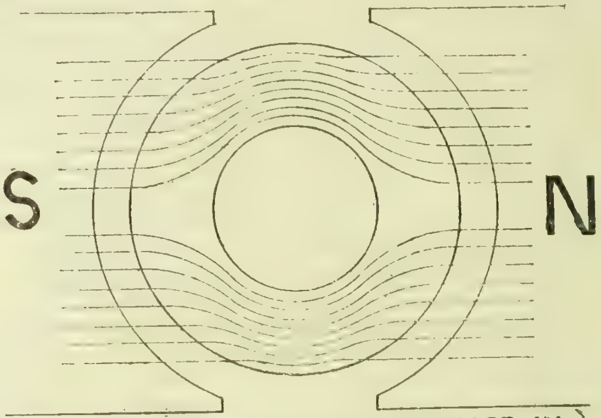
Between the poles, south and north (fig. 4), the lines of force are shown, as formed when no current is passing through the armature.

Fig. 5 shows the magnetic reactions between magnets and armature in a motor. A current supplied from an external source magnetises the armature and makes it powerfully magnetic, and the poles would be at right angles to the line adjoining the pole pieces were it not for the fact that lead must be given to the brushes.

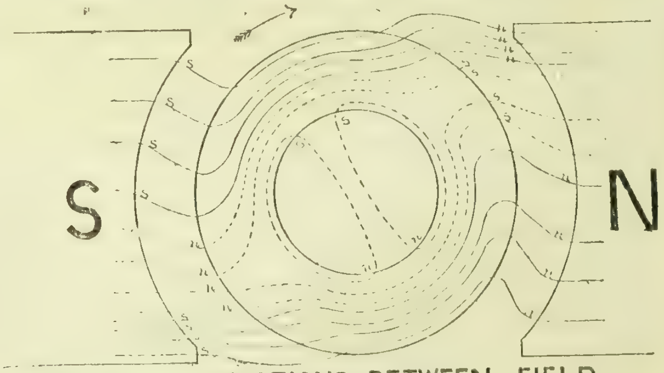
Suppose the current so traversed the armature that it caused the highest point to be a south pole and the lowest point a north pole, and that the south pole of the field magnets is on the left and the north pole on the right, clearly the armature will revolve right-handedly, because the south pole on the top will be repelled from the south pole on the left, and attracted towards the north pole on the right. A still more important effect will be that these two polarities will attract each other. The north pole on the right tends to induce a south pole on the part of the armature nearest to it, and there will be a strong resultant south pole at an oblique position on the right of the highest point. The diagram (fig. 5) shows the course of the lines of force in the mutual field, and shows also how the armature's magnetism reacts on the field magnets, adding to its lines of force (those which are dotted are supposed to be due to the armature) and perturbing its field. The brushes must have a forward lead if the proper advantage is to be taken of the mutual strengthening of the two magnetic forces. But if forward lead is given to the brushes in order to obtain the most powerful torque, then it will be obvious that at the instant that each coil passes the brush it will be actively cutting across the magnetic lines of the mutual field, and there will be much sparking in consequence. If the motor is not to spark, it is essential that it should not have a forward lead, and, indeed, if the armature's reaction is powerful enough to perturb the magnetism of the field magnets (as in the diagram), then there must be backward lead if the sparking is to be avoided.

It has been found possible to do away with lead in either direction by winding the armature in a special manner, so that the coils are so connected to the commutator plates that they lie along the diameter joining. The brushes are cut out of circuit by being closed on themselves, as these coils, if active, would tend to induce poles in the armature at right angles to the axis of magnetism. This would weaken both the armature and field, because in the motor the field and the armature tend to mutually strengthen each other.

Fig. 4.



MAGNETIC LINES OF FORCE INDUCED IN IRON RING BY FIELD MAGNETS



MAGNETIC REACTIONS BETWEEN FIELD MAGNETS AND ARMATURE IN MOTOR

Fig. 5.

It is generally stated in text books that both dynamos and motors should have enormously powerful fields, or, in other words, the magnetic moments of the field and armature should be as widely different as possible. This principle is certainly carried out fairly well by all the best dynamo makers, but in practice it is found that the motor should have an armature and field with relatively equal magnetic moments. This result can only be obtained by making the armature much larger in proportion to the total weight of the machine than is considered advisable in a dynamo. The efficiency of motors made on this principle of construction is greater than those made on the dynamo type.

If gross weight be neglected, and a minimum expenditure of copper be desired, the single horseshoe is chosen, as in fig. 8; but if a light weight be desired, the double horseshoe magnets are used, as in fig. 6 and 7. This type involves double the number of converse turns to give the same strength of poles as the single magnet does, but the result and yield are more uniform, and less trouble is given by the brushes; hence it is more generally used.

The late Sir C. W. Siemens has shown that it is possible for a motor to give from 80 to 95 per cent efficiency, if it be not expected to do its work very quickly; in fact, if the motor be so arranged to do its work at less than its maximum rate, by being geared so as to do much less per revolution, but yet so as to run at a higher speed, it will be more efficient; that is to say, though it does less work, there will be still less electric energy expended, and the ratio of the useful work done to the energy expended will be nearer unity than before. Figs. 6 and 7 show the form of motor generally used for tramcar work. Fig. 6 is an end elevation, and fig. 7 a side elevation. This form of motor is very efficient, and is also very light and compact. Fig. 8 shows a form of machine which can be used equally well either as a generator or as a motor. This is more often used for stationary motors.

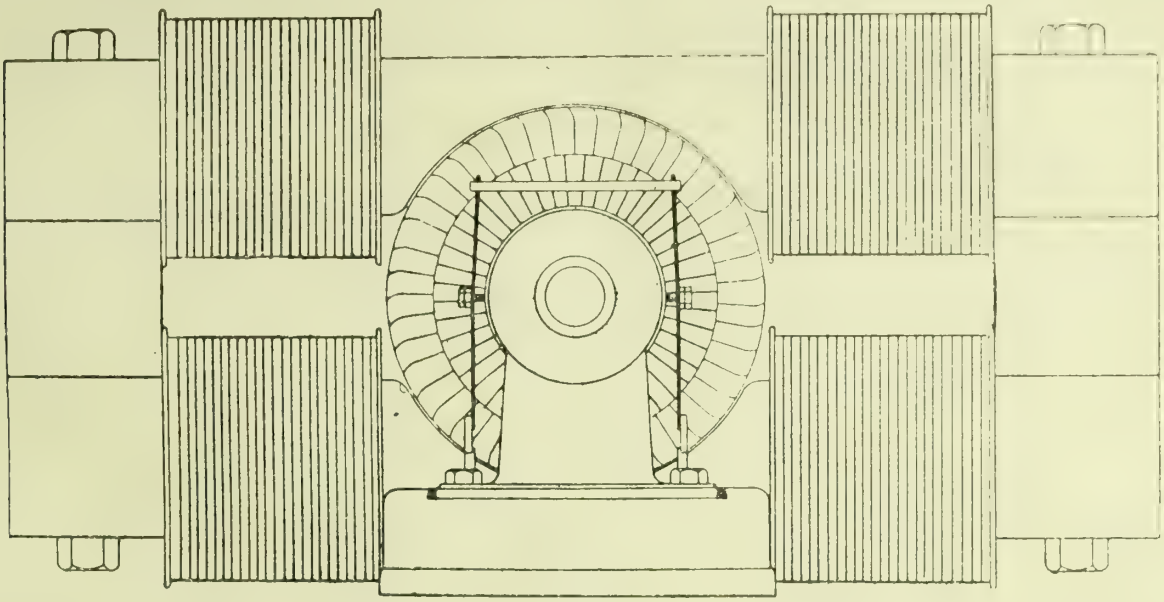


Fig. 6.

The transmission of energy by means of electricity is found to be exceedingly economical, and as regards portability it has the advantage over hydraulic and air power. For transmitting short distances, say up to one mile, it is found that the cable is the cheapest; but when the distance is increased, say to five miles or more, electricity takes the lead, and retains it before all other methods, including even gas. The longer the distance, and the greater amount of power to be transmitted, the more favourably does electrical transmission compare with other systems.

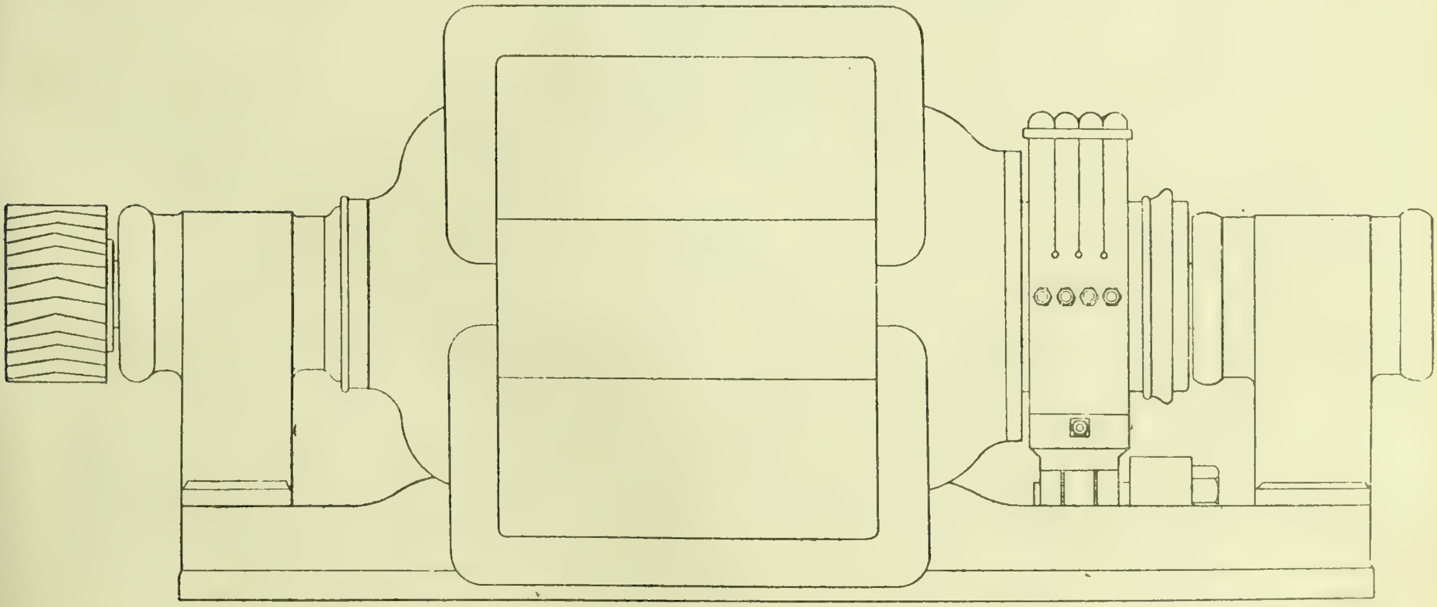


Fig. 7.

The average price in America for supplying one-horse power per year is 110 dollars, but of course, in cases where the power is got from waterfalls, the price would be much less.

Monsieur Chretien, a French engineer, gives the total water-power in France as 17,000,000 horse power, and has suggested that if by electric transmission only a part of this vast amount of energy were made available for useful purposes, an enormous economy in the consumption of fuel would be effected. This suggestion has borne fruit. Near Bienne, in Switzerland, there is a waterfall representing an energy of several thousand horse power. A small portion of this is utilised by a turbine which works a generating dynamo. The current is conveyed by an overhead line consisting of two copper wires 270 millimetres diameter, to Bienne, a distance of about a mile, where it works two electro-motors, one in a mill where silver is rolled, where the power required is very variable; the other in a watch factory where the work is very delicate and an absolutely constant speed is required. The installation has been at work with perfect success for over two years.

A company has recently been formed in America for transmitting the power obtained from the Niagara Falls, by means of electricity, to Buffalo, a distance of 25 miles. Marcel Deprez was the first to transmit power by this means over long distances.

Professor Ayrton gave an instance before the British Association last year of a motor which actually gave out $87\frac{1}{2}$ per cent of the power put into an Edison-Hopkinson machine when 50 H.P. was being transmitted. How does this compare with the combined efficiencies of an air pump and an air motor, or a water pump and a water motor? In either of these cases is not 60 per cent considered satisfactory? As far, then, as the terminal losses are concerned, electric transmission of power is certainly superior to air or water transmission.

Fifty H.P. was transmitted from Kriegstteten to Solothun, in Switzerland, a distance of five miles, with an entire loss in the dynamo motor and wire of only 25 per cent, so that three-quarters of the total power supplied by the waterfall was actually delivered five miles away.

During the last few years the electro-motor has been used as a motive power for a great variety of purposes, the one which has perhaps attracted most attention being its utility for propelling vehicles, one of the first applications of this kind being that of the electric railway constructed by Messrs. Siemens at the Berlin Exhibition of 1879. A middle rail was employed to carry the current, and a brush fastened beneath the car was used to collect it. This railway was a great success. Since that time tramways worked by electricity have increased rapidly. In America there are now twenty-two lines, carrying 4,000,000 passengers annually. In Great Britain there are only six working solely on this system, namely: Blackpool, Portrush, Bessbrook, Newry, North Metropolitan in London, Ryde, and Brighton.

The electric current for the Blackpool tramway is generated from dynamos at a station, and is conveyed to the car by means of a conductor, placed under ground, consisting of two semi-circular channels of copper, supported by, but insulated from, cast-iron chairs. The current is collected by means of contacts on the car sliding along the underground conductor. This line is two miles in length, and has been working for some two years. The return current flows along the rails.

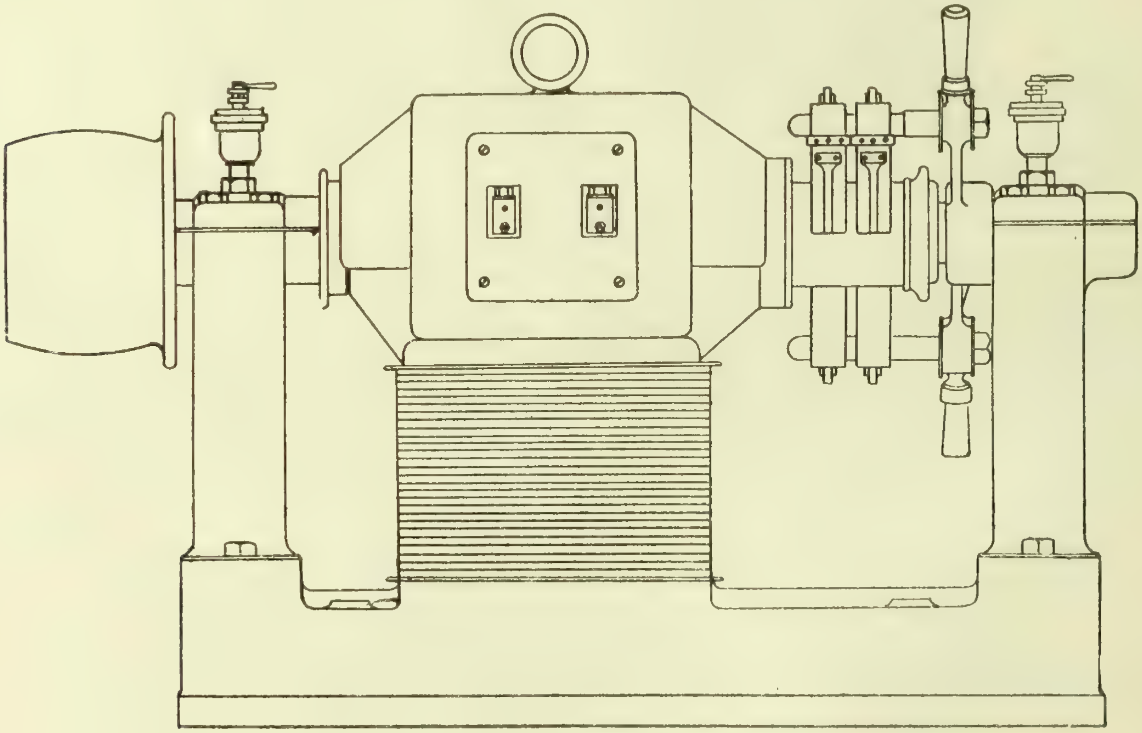


Fig. 8.

At Portrush, in the north of Ireland, the current is conveyed to the car by means of a T-shaped iron, placed on short standards and insulated from the ground, and is collected by means of a sliding collector on the car. This line is six miles in length, and has been working since 1882.

The line at Bessbrook and Newry is about three miles in length. The power is generated by a waterfall and turbine; the conductors are on the same principle as the Portrush line. The North Metropolitan line, in London, is worked by secondary batteries, which are placed under the seats of the car.

The Ryde Pier electric railway has been very successfully managed, as for the half-year ending December, 1886, the receipts per train mile were 19·9d., and the expenses per train mile only 6·48d. This line is only 716 yards long, and the positive conductor consists of an insulated channel iron, the tram rails serving as a return. The generating dynamo is driven by a gas engine, the gas costing 3s. 11d. per 1,000 cubic feet, less 5 per cent.

The electrical method of transmitting power has been found to be very suitable for mining operations, as the wire conveying the current can be brought to the bottom of the mine to where the motor is without any difficulty, and its advantages in this direction are rapidly becoming recognised. It has been successfully introduced into Trafalgar collieries and several Welsh collieries, and abroad it is largely used as a motive power for pumping, winding, haulage, and ventilation.

The purposes to which electro-motors are being applied are increasing every day, and possibly, when every large town has its central station for supplying electricity, motors will be used for working knife cleaning and other domestic machinery.

INSTITUTE OF MARINE ENGINEERS.

A meeting of the Institute of Marine Engineers was held in the Langthorne Rooms, Broadway, Stratford, on Friday, the 12th inst. Mr. J. H. Thompson—one of the vice-presidents—occupied the chair. About sixty members and visitors were present. Letters were received from Messrs. A. Beldam (president), J. Mc F. Gray (vice president), H. M. Rait (vice-president), and a telegram from Mr. A. J. Maginnis (member and author of the paper to be read), expressing regret that pressing engagements and detentions elsewhere prevented them from being present to take part in the proceedings, especially as the meeting was the inaugural one of the institute in respect to the reading of papers.

In the absence of Mr. Maginnis, Mr. J. R. Ruthven (member) read the paper on a steering apparatus (which has been patented by the author), illustrated by diagrams and drawings. The chief merits and advantages possessed by the apparatus, as claimed by the patentee, are that it dispenses entirely with wheel chains and their usual connections, has fewer working parts, holds the rudder steady, works without noise itself, and prevents the noisy effects due to vibration at the rudder head. The arrangement of the gear from the rudder head consists of a segment with teeth which work into a worm fitted on a shaft with two feathers, so that it is free to move and accommodate itself to the pitch of the teeth as nearly as possible as it travels. The thrust on the worm is transmitted by means of the worm rod or shaft to a piston, called the worm piston, which revolves in a cylinder, called the cushion cylinder, which is full of oil, and kept supplied by means of an arrangement of portway in the cylinder, regulated by the worm piston. The strain is then carried through the volute springs, and received by the crosshead, holding the top spring in position. Indicator diagrams have been taken frequently to illustrate the strains on the rudder when struck by heavy seas. In some cases these strains have been registered to as high as 30 to 40 tons.

Several questions were put, and a discussion ensued as to the various points of advantage set forth in the paper in favour of the Maginnis patent as compared with many other gears in the market. Messrs. A. W. Robertson, W. J. Craig, H. Barringer, A. Gibb, J. Hawthorn, J. W. Dimmock, and others took part in the discussion.

The remarks made by the various speakers were interesting, and elicited much more information regarding the detailed working of the apparatus than could be obtained by merely hearing the paper read. It was questioned—in view of considering an ideal steering apparatus as compact, noiseless, and occupying small space—whether the cushioning cylinders and connections could not be placed in another position than where shown in the drawing, as in the case of a steamer with an open poop, and no house for the gear, the cylinders would be somewhat in the way of the hawsers and warps. It was remarked that in place of the cylinders being placed as shown, the cushioning cylinders and gear might be transferred to a modified arrangement in the piston of the horizontal cylinder. To this arrangement there are objections, and the patentee has, after considerable thought and experience, come to the conclusion that the cylinders, with the volute springs to act as buffers, are the preferable plan.

It was pointed out that the bolts in the connecting shaft seemed weak, considering the strain upon them, and it was questioned if, in the event of the whole of the bolts giving way, could the hand gear be shipped readily? The shocks, too, which would at times be very severe, as instanced by the diagrams showing the enormous strain thrown on the rudder-head by the force of the seas striking the rudder, were transmitted from the rudder-head to the toothed quadrant, thence to the worm, and finally received by the volute springs. It was questioned if the shocks could not be taken up, so to speak, at the rudder-head, in place of being passed through the gear to the cushioning cylinder; also, would it not be better to machine the teeth, so as to have a more exact fit and less vibration?

It was replied by Mr. Gibb, representing the patentee, that the volute springs were found to be the best for the purpose; that the force expended by the sea on the rudder at times was so great that only the strongest and the most reliable form of spring was found to withstand the strain. It is only by experience that matters of detail of this character can be dealt with. What may appear theoretically to be the best frequently proves very inferior when put to a practical test, and while the cushioning arrangement may appear cumbrous, it has not been objected to in practice. There are several modifications of the arrangement, designed to meet any special cases which arise. The engine itself may be placed in the engine-room, and the gear connected to the rudder-head by means of counter-shafting. The shocks on the rudder are transmitted to the cushioning gear through the quadrant and worm arranged on the rudder-head, and the play due to clearance is trifling. The teeth are carefully moulded, and it will probably be admitted that when the casting is clean and the teeth accurately moulded, there will be considerably less wear without than with machined surfaces in contact. One large steamer has now been running with this gear across the Western Ocean for two years, and the wear on the teeth is very slight, and, indeed, scarcely perceptible. The bolts in the shaft are carefully worked out as to the strain upon them, and due allowance made for severe shocks. They have not been found in practice to be inefficient for their purpose. Mr. Gibb dwelt further upon the ease and facility with which this gear could be disconnected at once when it became necessary to ship the hand gear, and explained several other matters of detail, which were not apparently clearly understood from the drawings without explanation. In closing, Mr. Gibb expressed regret that Mr. Maginnis was unable to be present himself, as he fully intended and expected to be.

The hon. secretary, Mr. Adamson, announced that other papers were in preparation, one of these being by Mr. Gibb. The announcement regarding the date of the next meeting would be issued shortly.

AN addition has been made to the Royal Navy by the completion for sea at Sheerness Dockyard of the new composite sloop Daphne, which is 195ft. in length and 30ft. in breadth, and has a displacement of 1,140 tons. The Daphne is unarmoured, but her vital parts are protected by a steel deck, extending over the boiler and engine rooms, and she is equipped with eight 5in. steel breech-loading guns. She also carries six Nordenfelt machine guns, and two Gardner machine guns. The Daphne will be commissioned on May 2 by Commander C. R. Wood for service on the Pacific station.

LESSONS IN MECHANICAL DRAWING.—XXVII.

By Prof. A. MacLay, B.Sc., C.E.

Point Paths in Mechanism.—*Continued.*

The Double Slider Crank.

The double, like the single slider crank, is a four-link chain, but as the name implies, there is now a *double* sliding pair. Instead of three turning pairs and one sliding pair, we have now two of each kind, viz., two parallel cylinder pairs ($C_2{}''$), and two pairs of prisms, either ($P_2\perp$) or ($P_2\angle$), according as they are set at right angles or at some oblique angle to one another. There are thus two varieties of this chain, (1) represented by the formula ($C_2{}''P_2\perp$), in which the slides are set at right angles to one another, hence called the *normal* double slider crank; and (2) represented by ($C_2{}''P_2\angle$), in which the slides cross obliquely, the *skew* double slider.

Figs. 161-64 illustrate the four mechanisms derived from the normal arrangement of the chain, by placing it on each of the links in turn. The same figures may represent the skew arrangement if we suppose the slides set at any angle other than a right angle.

Of the four mechanisms shown, two, viz., those obtained by placing the chain on links *d* and *b*, give the same motion with straight line point paths, thus $(C_2{}''P_2\perp)^d = (C_2{}''P_2\perp)^b$, or, more concisely $(C_2{}''P_2\perp)^{d=b}$. The other two, viz. $(C_2{}''P_2\perp)^a$ and $(C_2{}''P_2\perp)^c$ give different motions and point paths, of which fig. 165 illustrates some of those for the former, and the latter had an illustration in figs. 103 and 103A, in Lesson XIX.

$(C_2{}''P_2\perp)^d$ (fig. 161) is distinguished as the *turning* double slider and $(C_2{}''P_2\perp)^b$ the swinging cross block. They are of frequent application in machinery where a circular motion has to be transformed into a straight line motion, or *vice versa*, and the space too limited for the use of a connecting rod.

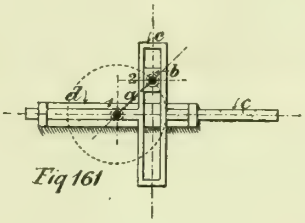


Fig 161

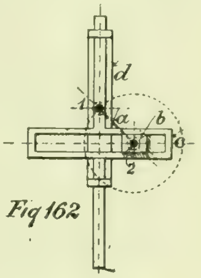


Fig 162

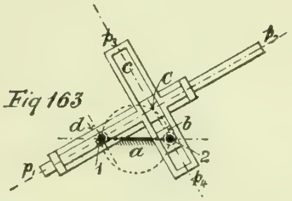


Fig 163

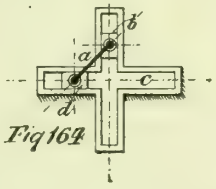


Fig 164

$(C_2{}''P_2\perp)^a$, fig. 163, the swinging cross-block double slider, has two well-known applications in Oldham's coupling for parallel shafts, and the elliptic chuck for turning ovals. In the former, link *a* represents the fixed supports, *b* and *d* the two shafts, and *c* the sliding crosspiece between them. In the latter, link *a* represents the headstock of the lathe, *b* the mandrel, *c* the chuck, and *d* the eccentric ring behind it.

$(C_2{}''P_2\perp)^c$ the *swinging* double slider has a well-known application in the elliptic trammel, fig. 103A. Fig. 166 shows an application of the corresponding mechanism $(C_2{}''P_2\angle)^c$ of the *skew* double-slider crank chain.

Exercises.

Ex. 182, Fig. 161.—Link *a* represents a crank turning about a fixed centre at 1, on a frame *d*. It works a block *b* in a slide *c*, which has itself cross arms sliding in the frame *d*. Draw in dotted outline the range of motion of the cross-piece *c*. Radius of crank, 18in. Scale, $\frac{1}{12}$.

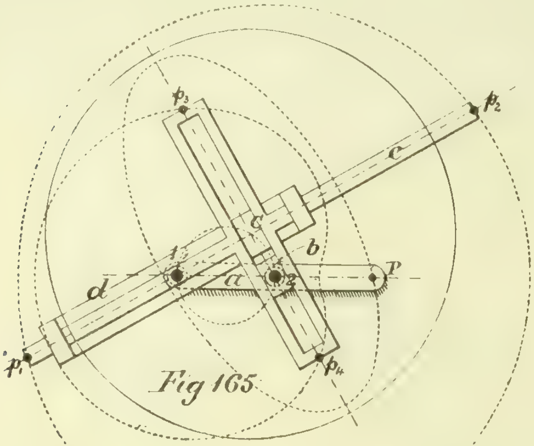
Ex. 183, Fig. 162.—Repeat the last exercise for the pieces *c* and *d*, when the block *b* is the fixed link, and the crank *a* turns about centre 2.

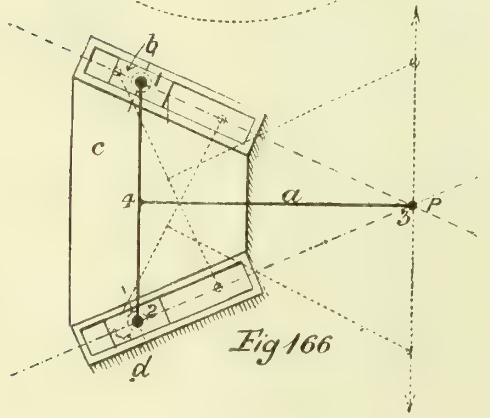
Ex. 184, Figs. 163, 165.—Link *a* is now fixed, links *d* and *b* turn on centres 1 and 2 respectively, and *c* slides on *b* and *d*, as before. Draw the paths of the following points: (1) the centre C of the cross-arms *c*, (2) the extremities P_1 P_2 of the long arms of the cross, (3) the extremities P_3 P_4 of the short arms. Distance, 1 – 2 = 1″, $P_1 P_2 = 5\frac{1}{2}''$, $P_3 P_4 = 3''$.

The path of C is a circle of diameter 1 – 2. Compare Exs. 100, 101 and fig. 118, Lesson XXI. The paths of the other four points are cardioids, drawn from circle on 1 – 2, as a base, those of p_1 p_2 having point 1, and those of p_3 p_4 point 2 as poles respectively. Compare Exs. 159 and 162, fig. 142, Lesson XXV.

Ex. 185, Fig. 165.—Suppose a circular disc to be attached to the cross-arms *c*, and that the link *a* is extended to P, through a hole at which a pencil or other describing point is held against the face of the disc, show the curve which would be traced on it. Distance, $1 - 2 = 4\frac{1}{8}'' = 2 - P$; disc, 18″ diameter; scale, ¼.

The curve would be the same whether we suppose *a* or *c* to be the fixed link, so long as the relative motion of these two pieces remains the same. In the case supposed, *c* is the actual moving link and *a* the fixed one; but for simplicity in drawing the curve, let *a* move and *c* be at rest, as in fig. 164. The curve traced by P will then be seen at once to be an ellipse, as in figs. 103, 103*a*, to which refer for the method of drawing it in. If *c* represents the lathe chuck on which any object to be turned is placed, and P the turning tool held by the tool rest, which, when stationary, may be regarded kinematically as part of the lathe bed represented by the fixed link *a*, then the ellipse, obtained as above, would represent the shape to which the body would be turned.





Ex. 186, Fig. 166.—A T-shaped bar is connected at the extremities of its cross arms, with two blocks sliding in guides placed at an oblique angle, say 45 deg. Find the point path of the third extremity P. Let the length 1 – 2 be 2½″. That of 4 – 3 is to be found by joining 4, the middle of the bar 1 – 2, when in mid position, as shown, with point 3, the intersection of the centre lines of the guides.

This is an example of the skew double slider. When the length of 4 – 3 is taken as described above the path of P, its extremity is a straight line.

THE QUADRIC CRANK.

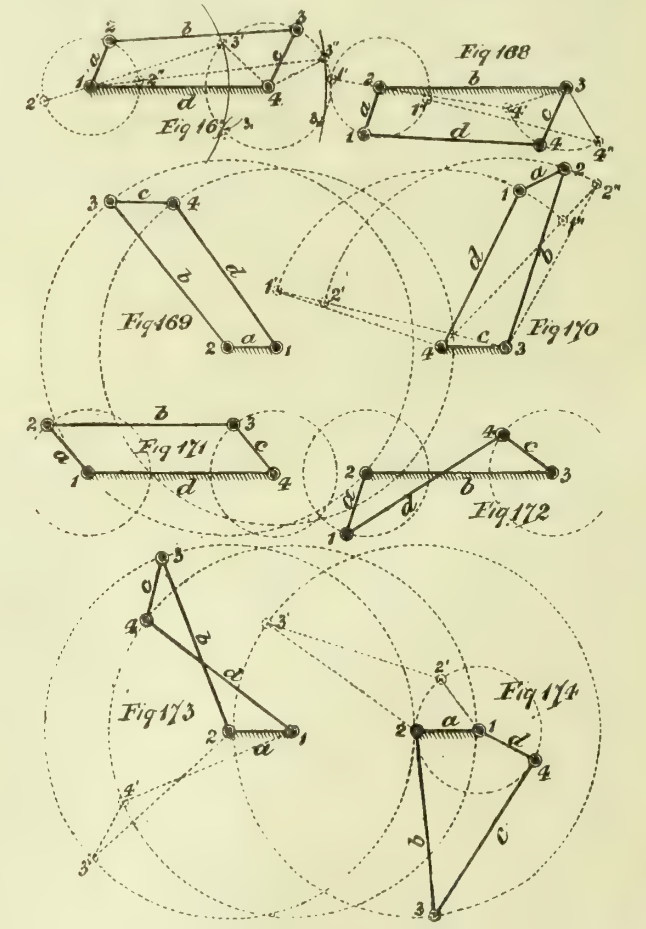
Another very important chain among mechanisms is that which consists of four links connected by four parallel cylindric pairs—hence called the *Quadric Cylindric Crank Chain* (C_4''). There are many varieties of it, depending upon the relative lengths of the links. To enable the student to trace the connection in the exercises which follow, let us first note, as the representative form of the chain, that in which all four links are of different lengths, then some modifications of it. In the general form, represented in fig. 167, *a* is the shortest link, *c* the next, and *b* is > *d*. The four mechanisms obtained by placing the chain on each link in turn are:—

(A) *The Lever Crank* (Figs. 167, 168).—By fixing link *b* or link *d*, represented by $(C_4'')^{b=d}$. These two mechanisms give the same kind of motion. In each *a* is a turning link—a crank, *c* a swinging link—a lever. In the one *d* is the coupler and *b* the frame, and in the other that relation is reversed.

(B) *The Double Lever* (Fig. 170).—By fixing link *c*, represented by $(C_4'')^{c}$. Links *b* and *d* are now both levers with a limited range of movement, and *a* is the coupler.

(C) *The Double Crank* (Fig. 169).—By fixing link *a*, represented by $(C_4'')^{a}$. Links *b* and *d* are now both cranks, and *c* is the coupler.

There are a great number of modifications of the general form, a few of which are illustrated in figs. 171—74. When, for example, opposite pairs of links are equal, the mechanism is a double crank, and if the cranks are set as *a* and *c* in fig. 171, we have *parallel* cranks; as in fig. 172, *reverse anti-parallel* cranks; and as in fig. 173, *converse anti-parallel* cranks in allusion to the characteristic motion. In fig. 172 the cranks are always moving in the opposite directions, and in fig. 173, though not parallel, they always move in the same direction. Fig. 174 represents those cases in which adjacent pairs of links are equal, and in the exercises there are several examples with one opposite pair equal, *e.g.* fig. 175.



EXERCISES.

Ex. 187, Fig. 167.—In a certain beam engine the radii of the beam and the crank are 12ft. 3in. and 5ft. respectively. The length of the connecting rod is 23ft. 6in., and the distance between the turning centres of the beam and the crank is 26ft. 9in. Show the paths of three points on the connecting rod, situated at ¼, ½, and ¾ of its length from either end of it. Scale, $\frac{1}{48}$ (¼in. to 1ft).

An example of the lever crank. In fig. 167 *a* represents the crank, *b* the connecting rod, and *c* the half length of the beam. To find the range of movement of *c*, notice that in two positions of *a* and *b* they get into one straight line. In the one case they lie extended, 1, 2^{11}, 3^{11}, in the other they overlap, 2^1, 3^1. With 1 as centre, first, with radius $a + b$, cut path of 3 at 3^{11} and 3_{11}; then, with radius $b - a$, cut the path of 3 at 3^1 and 3_1. Then, while *a* turns once round 1, *c* can either move from 4, 3^1 to 4, 3^{11}, and back again; or from 4, 3_1 to 4, 3_{11}.

Assume then a number of positions of point 3. Find the corresponding positions of point 2, draw in *b*, and measure off the required distances for the points whose paths are required.

Ex. 188, Fig. 175.—The figure represents Watt's parallel motion. Links *a* and *c* are each $3\frac{3}{4}$in. long, $b = 2$in., and $d = 8{\cdot}4$in. Trace the paths (1) of a point P in the middle of the coupling link *b*, and (2) of any other point situated between 2 and 3.

An example of that particular case of the double lever, where $a = c$ and $> b$. To determine the range of the movements of *a* and *c*, it can easily be seen by inspection that in two positions *a* and *b* come into one straight line, as at 1, 2^1, 3^1, and 1, 2_1, 3_1. In these cases *c* must then occupy its extreme positions; and *vice versâ* by the symmetry of the arrangement, when *b* and *c* are in line, as at 4, 3^{11}, 2^{11}, and 4, 3_{11}, 2_{11}, *a* is in its extreme positions.

Having drawn the circular arcs, which are the paths of the extremities 2 and 3, of the link *b*, then, with centres 1 and 4, radius $a + b$ or $c + b$, describe arcs intersecting the paths of 2 and 3, at 2^{11} 2_{11}, and 3^1 3_1 respectively; 1, 2^{11} and 1, 2_{11} show the range of movement of *a*, and 4, 3^1; 4, 3_1, that of *c*. Next assume a number of positions of joint 2 in the arc 2^{11}, 2_{11}, and find the corresponding positions of 3 in the arc 3^1 3_1, through which to draw as many positions of the link *b*. On these mark off the series of positions occupied by the points P and Q, and through them draw the required curves.

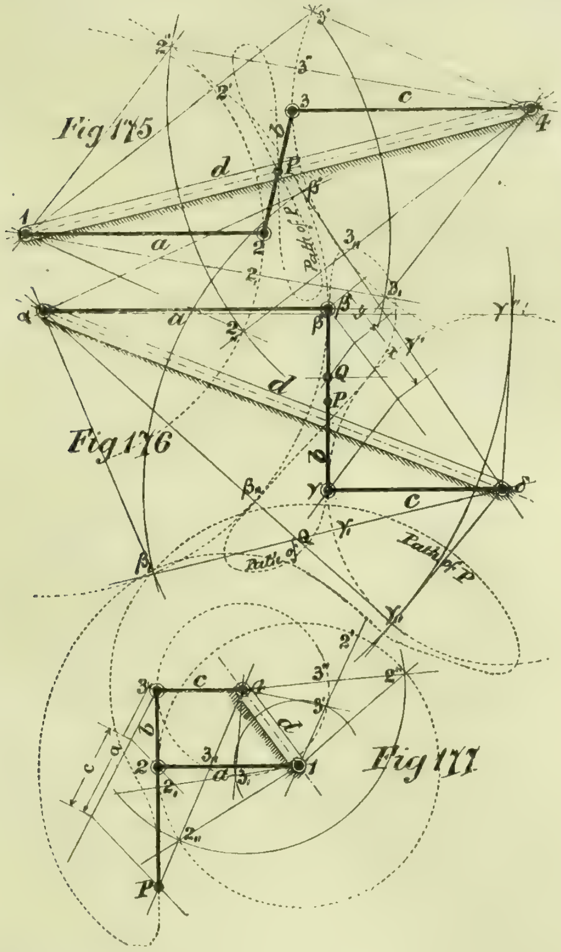


Fig 175

Fig 176

Fig 177

Ex. 189, Fig. 176.—The figure shows a slightly different form of Watt's parallel motion from the last. Link *a* represents the beam, *c* the radius bar, and *b* the fore link or coupler. The lengths are $a = 4\frac{1}{2}$in., $b = 3$in., and $c = 2\frac{13}{16}$in. Show the path of (1) P, the middle point of the link *b*, and (2) Q, a point which divides *b* into two parts *x* and *y*, such that $x : y :: a : c$.

An example of the double lever, in which, as drawn in the figure, the adjacent links *b* and *c* are very nearly equal.

For the range of movement of the levers *a* and *c* proceed as in fig. 175, Ex. 188. With centre α radius $a + b$, cut the circular path of γ at γ^{11} and γ_{11}, and with centre δ, radius $c + b$, cut the path of β at β^1 and β_1. Then $\alpha\beta^1$, $\alpha\beta_1$ show the extreme positions of link *a*, and $\delta\gamma^{11}$, $\delta\gamma_{11}$ those of link *c*. Assume a number of intermediate positions of *b*, and mark off P and Q, as in the last problem. The path of Q will be found to be approximately a straight line through a considerable range.

To find distance of Q from β or γ, divide the length of the link *b* into two parts in the proportion of *a* to *c* as explained in Lesson VI.

Ex. 190, Fig. 177.—The figure represents the modification of Watt's parallel motion used when the radius bar is placed above the beam. Link *b* is prolonged beyond joint 2 to a point P, such that $3,P : 2,P :: a : c$. Draw the path of P.

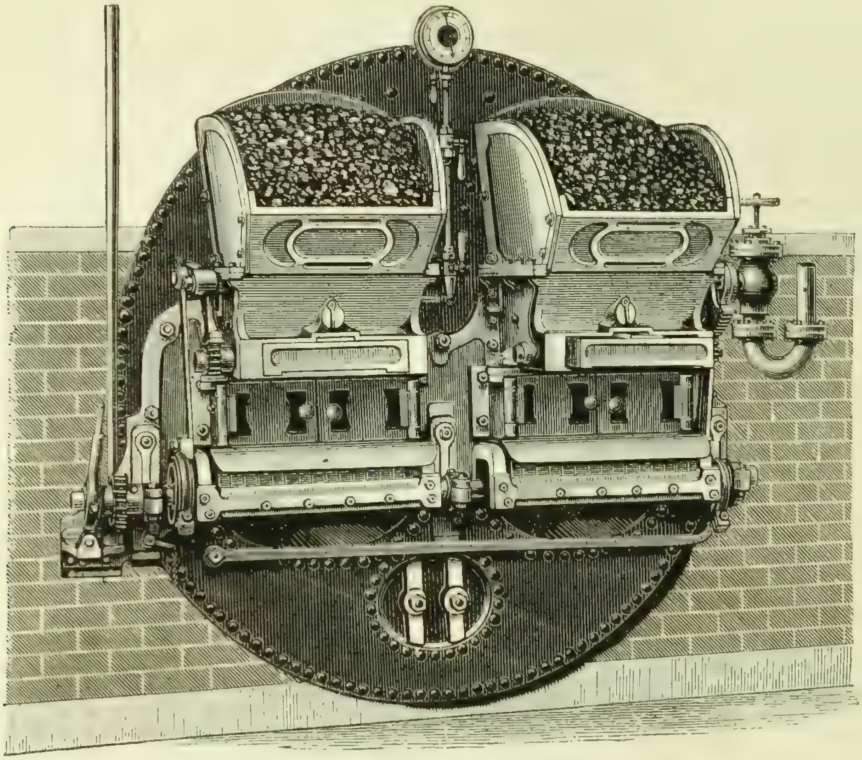
Another example of the double lever. The lengths are $a = 3$in., $b = 1\frac{5}{8}$in., $c = 1\frac{7}{8}$in, and $d = 2$in. Produce 3, 2 and cut off 2, P in the given proportion, as shown in the figure by Lesson VI. The ranges of movements of links *a* and *c* are found in the same way as in Ex. 187. With centre 1, radius $a - b$, cut the path of 3 at 3^1 and 3_1 and with centre 4, radius $c + b$, cut the path of 2 at 2^{11} and 2_{11}. Then 4,3^1 and 4,3_1 are the extreme positions of link *c*, 1,2^{11} and 1,2_{11} those of link *a*.

THE IRON ORE SUPPLIES OF THE UNITED KINGDOM.

According to the *Times*, the recently-issued report of the production of iron ores in the United Kingdom, under the provisions of the Coalmines Regulation Act, calls attention to a subject that is of the utmost importance to the future of the British iron industry—that is to say, the relative demand for home and foreign ores and the sources of supply. It is to some extent satisfactory to find that during 1888 there has been an increased demand for our own home ores to the extent of nearly a million tons. This increase represents ores that are of more or less low grade, and not such ores as are suited to the ordinary Bessemer process. Of the latter description of ores the United Kingdom has comparatively limited supplies, so that our ironmasters have been compelled for a number of years past to import increasing quantities from other countries. Begun less than twenty years ago, this trade in imported iron ores has now reached the respectable dimensions of about three and a half million tons a year. It has, in point of fact, come to this—that almost the whole of the blast furnaces in South Wales, and to a less extent the furnaces of other districts, are fed with minerals imported from foreign countries; so that, while we formerly used only home ores in the production of British iron, we now employ imported ores to the extent of about 20 per cent of our total requirements. This new departure has, of course, been brought about by the substitution of steel for iron, and by the extreme freedom from deleterious matters that is essential in ores used for manufacturing ordinary Bessemer and Siemens-Martin steel. The future of the supply of Bessemer ore is, however, causing some anxiety to the trade. Hitherto the chief source of supply has been the Bilbao district in the north of Spain. Smaller supplies have been received from the isle of Elba and from Algeria. All of these sources have become so far exhausted that the best ores are not nearly so plentiful as they were, and although the outlook in the immediate future is not one that need cause any real apprehension, seeing that Bilbao is probably good for at least ten years to come—although the ores there will have to be worked further inland, and may be supplied of inferior quality to that hitherto furnished—yet the trade would willingly see an extension of the sources of supply within a reasonable limit of price. Two such sources of supply are at present opening up. Of one—the Gellivara iron deposits in the centre of Swedish Lapland—a description has already appeared in the *Times*. This large field of ore is now being developed to some considerable extent, and some 70,000 tons of ore were delivered in England in 1888 by way of the Gulf of Bothnia. It will still, however, be a considerable time before the Gellivara ore can be delivered in England by way of Ofoten, on the Atlantic seaboard, and until that is done the supplies are likely to be interfered with by the rigour of the climate. It is therefore gratifying to learn that very large deposits of iron ore in the south of Spain are now being opened up and are likely before long to be worked on a large scale. The principal deposits of iron ore in this region are near Almeria and Cartagena, and it is probable that these two ports will furnish the bulk of our imported supplies in the not very distant future. The ores of this region have been neglected hitherto only because of the absence of railway facilities, but these are now being provided on a liberal scale, and, indeed, there is no European country that is at present making greater strides in the way of railway development than Spain. It is believed that, as these southern ores are somewhat richer than those of the north of Spain, their cost will not be sensibly more to the English ironmaster, and if this should turn out to be the case the future of our iron ore supplies and of our iron industry, so far as it is affected by this consideration, may be regarded as assured for a long time to come.

McDOUGALL'S PATENT MECHANICAL STOKER.

CONSTRUCTED BY THE CHADDERTON IRONWORKS COMPANY LIMITED, CHADDERTON, NEAR MANCHESTER.



As the result of twenty years' practical experience in the manufacture and working of mechanical stokers, Mr. McDougall has become convinced that no single method of mechanical stoking is adequate to meet all the varied requirements of steam users. The quality of fuel, as well as the rate of combustion and intensity of the draught, are all factors that require to be considered in deciding which is the most advantageous method to adopt.

These conditions are not always the same, and it is quite conceivable that an arrangement which may prove satisfactory in one case may be found very unsuitable in another. This, however, is not always realised, and the attempts which have been made by some makers of mechanical stokers to apply the same arrangement to every case, regardless of the variations which occur in the conditions of working, are responsible in a large measure for the disappointment that has occasionally attended their application, as well as for the disfavour with which mechanical stoking is by some steam users regarded.

In order to meet the varied conditions under which boilers require to be fired in practice, Mr. McDougall has designed several types of mechanical stokers, and has found it possible to comply with all the usual changes in the conditions to which we have referred by three distinct methods. One of those arrangements we illustrate here, and the second and third we shall have pleasure in illustrating and describing in a future issue. The first type is called by the Chadderton Ironworks Co., Limited, who manufacture the inventions, "The Level Reciprocating Bar Arrangement," which is illustrated on this page, and in it the coal is fed in regular and even charges on to the front of the grate by means of a ram situated at the bottom of the hopper, while the fire bars are kept in constant motion by a series of cams fixed on a shaft beneath the front of the grate, and so arranged that the whole of the bars are pushed in together, and drawn out in sections. By this means the fuel is slowly carried towards the back of the grate, where the clinkers and ashes are delivered over the fire bridge on to the bottom of the flue, whence they can be raked out through a door specially fitted beneath the bridge for the purpose.

When coupled with the patent air blast, this type represents the makers' and inventor's latest and most improved form of stoking, and is specially recommended where soft and clinkering coal is used, and where vigorous combustion, together with complete smoke prevention and economy of fuel, are the principal points of importance. The air blast is especially useful in cases where boilers require to be very heavily fired to meet a very great demand for steam, or where difficulty is experienced in coking the coal, and as by the patent forced-air blast, the steam-raising power of a boiler is materially increased, and its cost is but small, its addition to the stoker is recommended by the makers in all cases.

The whole arrangements for mechanical stoking in this manner are very complete and perfect, but the construction still allows of hand charging in the ordinary way, should circumstances at any time render it desirable. That this should be readily done is very necessary at times, when the engines are not at work, for instance, and the boilers are being fired to get up steam for a start. The lower doors seen below the hoppers in the illustration allow of this very readily.

The mechanism is of the simplest possible kind to accomplish the desired actions of the fire bars and supply rams. There are no springs and tappets employed, but the shaft is driven in the simplest way from the vertical shaft seen in the illustration, which may receive motion in any convenient manner.

The whole details of this mechanical stoker have been thought out in the most careful way, and carried into practice with an experience in this branch of engineering extending over many years.

From a test made at the Millwall Docks, by F. E. Duckham, Esq., engineer, comparing hand firing and stoking by one of Mr. McDougall's mechanical stokers, it appears that a saving of 25 per cent was readily attained by the mechanical stoker by allowing the use of an inferior and cheaper coal, which gave the same evaporative results per pound as the more expensive fuel. The mechanical stoker allowed the use of small coal at 11s. 3d. per ton, instead of "hard steam" coal at 15s. 3d., and only used the same quantity for equal work, thereby reducing the coal bill by a trifle over 25 per cent.

The makers of Mr. McDougall's invention, the Chadderton Ironworks Co., Limited, Irk Vale, Chadderton, near Manchester, will be pleased to give any further information required.

ON OIL-CARRYING STEAMERS.*

When I was asked by our secretary, a short time ago, to prepare a paper for the present meeting of the institution, I selected as my subject the stability of oil-carrying steamers, partly because I had previously been requested to investigate the stability of two such vessels built for the trade between the United States and Europe, and to draw up regulations for their loading and discharge, on which account I had to give a great deal of consideration to the subject, and partly because the construction of such vessels has already become an important branch of the shipbuilding industry, and promises to be in the future of still greater importance.

Although the oil trade between the United States and Europe and other parts of the world has been for some time one of the most important in which that country is engaged, not until a few years ago were the difficulties, and perhaps I may add the prejudices, attending the oversea carriage of petroleum in bulk wholly overcome. This is the more remarkable seeing that the bulk trade has been carried on with great success on the Caspian Sea, between Baku and the South-east of Russia, for ten years past, and might be said to have in a measure demonstrated the feasibility of the same method of carriage across the North Atlantic.

Naturally, the methods of transporting American oil which first suggested themselves were by means of barrels to Europe, and tin cases covered with wood to the Eastern countries, and these methods of carriage, while still employed in the bulk of the trade, practically monopolised it down to two or three years ago.

As with most other reforms, the change from barrel to bulk has been brought about slowly and in a tentative way, for although as long ago as 1863—a date anterior to the general adoption of carriage in bulk even on the Caspian Sea—some iron sailing vessels were specially built for the purpose of carrying oil in this manner, they do not appear to have ever entered upon the trade, probably on account of the difficulty of discharging cargo in the absence of those storage tanks which are rapidly being set up at the present time in Northern Europe, while the dubious success of the few small wooden vessels, specially fitted for the same purpose later on, was not of such a nature as to encourage the general adoption of the plan.

It is not my present purpose to enter into the history of the many unsuccessful attempts that have been made to carry oil in bulk across the North Atlantic, or to detail the steps by which the transition from barrel to bulk has been accomplished. Those who desire fuller information on this point will do well to consult a most valuable and opportune paper on the subject, read by Mr. Martell, before the Institution of Naval Architects, at the summer meeting of that body, at Liverpool, in 1886. I will only say that, as might have been anticipated, attempts to form oil-tight compartments extending to the ceiling in wooden vessels in most cases failed, and that the fitting of specially constructed iron tanks, distinct from the hull itself, preceded in practice the plan which has now become general of making the vessel herself the tank and carrying the oil directly in contact with the outside plating, in association, in some instances, with separate water ballast compartments, while in others the oil compartments themselves are used as water ballast tanks on the return journey to America, the oil being carried throughout in contact with the outer skin.

As soon as the practicability of the carriage of oil in bulk across the North Atlantic had been demonstrated, a great number of orders for new steamers of the type were booked, and the construction of such vessels has been carried on with great activity up to the present time. Through the kindness of my friend, Mr. Martell, who foresaw the great future that lay before this branch of the shipping industry, and who devoted a great deal of time and attention to the question with a view to the satisfactory construction of such vessels for classification in Lloyd's Register Book, I am able to place before the meeting, in the form of an appendix to my paper, some statistics regarding the vessels built and building for the purpose of carrying oil in bulk. The Appendix contains the names, gross tonnages, and dimensions of the vessels already built, together with such particulars as are known regarding those now under construction. From this table it appears that thirty-one vessels, having a total gross tonnage of 56,490 tons, are already engaged in the trade, and that twenty-seven other vessels are now under construction. The latter have probably a total tonnage of about 72,000 tons, making in all 128,490 tons. Most of the above vessels have been built or are being built in this country, and the return of prosperity to the shipbuilding industry must have been due in a great measure to the placing of the numerous orders for vessels of this class within the past two years. Nor, so far as I can see, is there any reason to doubt that the activity in the construction of vessels of this type will continue for at least a few years to come. Those fortunate enough to own petroleum carrying steamers are now reaping a rich harvest, and there is, I think, no doubt that when such vessels have become sufficiently numerous to bring freights down to an ordinarily remunerative rate, the old wooden vessels which up to two or three years ago practically had the whole of the carrying in their hands will be forced out of the trade. At the same time it is proper to observe that the risks attending over-building are greater in this branch of trade than in any other. Vessels built to carry oil in bulk would be unfitted, by reason of the style of construction, to embark upon the general carrying trade without first undergoing great and expensive alterations, and even then they would be greatly handicapped on account of the weight of hull being greater than that of other vessels.

I have been favoured by Dr. Underwood, the United States consul, with the following information as to the quantity of petroleum and its products exported from the United States during the past five years :—

Year.	Number of gallons exported.
1884	513,660,092
1885	574,628,180
1886	577,781,752
1887	592,803,267
1888	578,351,638

One would naturally suppose that the economy in labour during loading and unloading, as well as the saving upon barrels and in respect of leakage, would have shown itself in an increase in the quantity of oil exported. Such does not appear, however, to be the case. The quantity exported has been practically constant during the past four years. Probably this may be due to the fact that carriage in bulk has not had the effect of cheapening the product for the consumer. When freights fall, as they must in time, an increase in the export, which is the natural effect of greater economy in carriage, will follow. Meanwhile the figures teach us this important fact, that some of the wooden sailing vessels previously engaged in the trade have not been able to compete with the steamers, and have been forced to seek other employment.

It may be of interest if I add that the shipment of Russian petroleum from Batoum amounted last year to 30,421,800 pud, or over 135,000,000 American gallons. I am indebted for this figure to Mr. A. R. Meer, the Russian vice-consul.

The construction of vessels to carry oil in bulk introduced some new problems to the notice of British shipbuilders. The first and most important of these involved the question of the possibility of securing oil-tightness in the material of the hull itself. If this could not have been accomplished the experiment must have been abandoned. To fully appreciate the difficulty of securing oil-tightness, it is necessary to distinguish between the behaviour of oil and water in contact with iron or steel. As the members are aware, the occurrence of slight leakage during the testing of an ordinary ballast tank is not regarded seriously, because the rusting of the iron soon makes the joint water-tight. But with oil such is not the case. The oil destroys the rust which the water fosters. Hence the necessity for most careful workmanship and close riveting. The difficulty as to leakage had been successfully overcome by the builders of the comparatively small vessels engaged in the Caspian Sea, but it by no means followed that similar results would attend the construction of larger vessels, built of much thicker material, and subject to all the rigours of the North Atlantic winter. Very scant information was to be obtained on this head from the builders of the Caspian boats, who, perhaps naturally, viewed with anything but favour attempts by others to enter a field which they had made their own. But the difficulty has been overcome, and that which was at first a matter of doubt has now become a matter of certainty. Experience here and on the East Coast has abundantly demonstrated that with careful workmanship and sufficiently close riveting no danger of leakage need be apprehended. Satisfactory results are obtained in practice by spacing the rivets in the landings of the outside plating 3½ diameters apart from centre to centre, and in the butts from 3 to 3¼ diameters apart. Similar spacing is adopted in some instances in the laps and butts of the transverse bulkheads, while in others the rivets are reeled and spaced 4 diameters apart in each row. In addition, the bulkheads require, however, to be made more numerous and much stronger than is customary in an ordinary merchant steamer. In the latter the strength of a bulkhead is, of course, liable to be severely tested only by grounding, or in the event of injury to the hull, by which a compartment is flooded, whereas in the former the bulkheads which bound the cargo hold, as also those which limit the water ballast carried in the return journey to America, are constantly required to resist the fluid pressure, and as in practice it is proper to make a structure which has only occasionally to bear a given maximum stress less strong than one that has to sustain the constant repetition of such stress, so the bulkheads of oil steamers are properly made stronger than is usual in an ordinary merchant steamer. Nevertheless, I think that, in their desire to secure safety from accident or danger, owners, in requiring all the bulkheads in the vessels of the size now commonly built to sustain without leakage a head of water of some 20ft. above the top of the tank, exclusive of the reserve tubes, have been insisting on tests which are more severe, at least so far as some of the bulkheads are concerned, than the circumstances require.

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* Paper read before the Institution of Engineers and Shipbuilders in Scotland, by Professor Philip Jenkins, Glasgow University.

Let us glance at the circumstances under which the bulkheads are subject to stress. During the process of filling or discharging, a bulkhead can never have to withstand the pressure of a greater head of oil or water than that corresponding with the level of the oil or water in the reserve tubes. At sea, so long as adjacent compartments are full, the dividing bulkhead can have very little stress to bear, as it is pressed about equally on both sides. The bulkheads which bound the oil hold have the oil only on one side of them, and are subject to considerable stress, and more especially the aftermost on account of its greater breadth, during the whole of the voyage from America to Europe. Also the bulkheads which bound the water ballast on the return journey are similarly circumstanced.

But the pressure due to the head of oil or water, as the case may be, does not represent the whole pressure which a bulkhead has to bear, and as I have nowhere seen attention drawn to the other causes of stress, it may be of interest if I refer briefly to them here. Let us suppose a vessel laden and about to start on her voyage. As she acquires onward motion each element of cargo has to acquire an equal velocity in the direction of motion. Ordinarily the force causing the onward motion is communicated to the vessel herself from the shaft through the thrust block to the hull, and from the ceiling and decks to the cargo by virtue of frictional resistance. But with liquid cargoes such cannot be the case. This will be well understood if we imagine a vessel containing free water to be set in motion. The water will not at first partake of the motion of the ship, but will move aft, heaping itself up against the aftermost bulkhead of the compartment, presenting to the eye of an observer an inclined surface. In such a case the bulkhead has to supply the necessary accelerating force to the water, and in doing so it is itself strained. Similarly in an oil vessel, owing to the fluidity of the cargo, nearly the whole of the force necessary to cause the oil to acquire onward velocity at the same rate as the ship herself has to be communicated through the medium of the bulkheads. As the vessel begins to acquire motion, the oil in each compartment lags behind, it presses against the bulkhead, the bulkhead is to some extent deflected, and when the increase of stress in the bulkhead is just that caused by a pressure great enough to communicate the necessary increment of velocity to the contained oil, it yields no more. It might at first sight be thought that the pressure on the bulkheads from this cause as we move aft will be intensified—that the pressure on the bulkhead on the afterside of the foremost compartment, for instance, in causing it to deflect, would be communicated to the next compartment, and so on, and that there would thus be an accumulation of pressure on the aftermost bulkhead. No doubt if the tanks were filled and sealed some such action as I have sketched would take place; but since the oil surface in each tank is free, the bulkhead is free to deflect, and any such deflection is measured by a slight rise in the level of the oil in the reserve tube. Practically, therefore, the increase of pressure on the aftermost bulkhead of each compartment from this cause is due almost entirely to the oil of that compartment. The effect of moving ahead is thus to increase the stress in the divisional bulkheads, although the increment is usually not great in amount. The aftermost bulkhead is in this way subject to a pressure greater than that due to the head of oil in the reserve tube, and the foremost bulkhead to a pressure somewhat less. A similar kind of action goes on when the vessel is being brought to rest, except that then the bulkheads separating the oil compartments are strained in the contrary way, and the actual stress on the foremost bulkhead is increased, that on the aftermost being diminished.

Again, if we suppose an oil vessel to be rolling in the trough of the sea, and to partake of the orbital motion which the sea water has, the effect of this motion is to increase the apparent weight of the contained oil when the vessel is in the trough of the wave by as much in some cases as 20 per cent, and to diminish it to a corresponding extent when the vessel is on the crest. Practically the effect of the alternate increase and decrease in the apparent weight affects only the bulkheads bounding the oil hold, increasing the pressure in the wave trough nearly into equality with that due to an equal head of water, and similarly decreasing it on the wave crest. In the same way on the return journey the bulkheads bounding the water ballast may be subject to stress due to the pressure of a liquid of proportionately greater density than water.

But although the stresses induced by the causes to which I have referred are important in themselves and deserve consideration, it is not, I take it, for the purpose of withstanding these alone that bulkheads of oil-carrying steamers need the strengthening usually applied to them. A more serious condition of affairs would be reached if by any accident a compartment became only partially filled at sea, owing to the longitudinal motion of the contained fluid caused by the pitching and 'scending of the vessel in crossing waves, and it is mainly to provide against this contingency that the elaborate arrangements to be seen in every oil steamer are supplied. In any case, however, as I remarked before, the bulkheads which should receive most attention and be most strengthened are the two which bound the cargo hold, as well as those which bound that part of the hold appropriated for ballast on the return journey. Whatever may be the condition of affairs, the intermediate bulkheads can never possibly be subject to straining action to the same extent as the ones in question.

So far as those vessels which carry water ballast in tanks below the oil compartments are concerned, I may remark that the tops of the tanks have to bear continuously the stress due to the head of oil resting upon them, and extending in these instances to some distance above the upper deck. In the trough of the wave, too, the tank top has to sustain the augmented pressure due to that increase.

(To be continued.)

A PRESENT NEED IN THE ENGINEERING PROFESSION.*

We have come together on this occasion, as so often before the members of the institute have met in friendly council, to hear and discuss whatever investigation, observation, and experience during the past months may have developed of value or interest to the many departments of knowledge and practice represented in this association. The member, possessed of the true scientific spirit which this institute is especially intended to foster, brings here the results of his experience and study, unrestrained by fear of giving undue advantage to competitor or rival. He appreciates, moreover, the responsibilities of membership, and his duty to the cause, and how much is to be gained by himself from the keen but friendly criticism of his fellow-workers, and even by the suggestions that may come of shrewd question or chance remark from those who labour in other but related fields.

On the more formal occasion of the annual meeting, the presiding officer, in giving place to his successor, after a year of attention to a great extent directed from the narrower limits of his own specialty to the more general field of the profession and the larger interests of the institute, contributes the results of his observation from this vantage ground, and points to the tendency of progress or the demands for special effort.

But it is not alone to written paper and formal discussion, council meeting or address, that the value of these gatherings is due. There are the benefits that come of personal contact with fellow-members, and the quiet exchange of experience and thought ; the opportunities for observation of varied practice and conditions ; the closer relations of institute and member with leading workers, and the important interests of the land—and with all these there are the informalities of excursion, and the good things given and taken on convivial occasions to brighten the more serious hours, and give a relish to the whole.

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* Presidential Address, delivered before the American Institute of Mining Engineers, by W. B. Potter, Esq.

For each and all, then, there may be found in these several meetings of the year some call of duty, some benefit to be gained.

Impressed with a sense of the responsibilities of the position with which I have been honoured, and the duty of calling attention to whatever opportunities may be offered for advancing the interests of the profession—mindful, too, of the benefits which your suggestion and criticism are sure to bestow, I venture to present, in a somewhat informal manner, on this occasion, a subject which seems to me worthy of your interest and consideration.

During the eighteen years of its existence, there has been no one subject which has so much engaged the attention of the American Institute of Mining Engineers as that of technical education. It has furnished material for many a paper, and served as text for presidential addresses not a few, besides calling for special committee report and joint discussion with other and kindred associations. The extent to which this subject has been considered is not only a proof of its vast importance, but an evidence of the earnest interest with which it is regarded by the members of the profession, those occupied with the absorbing cares of business life, as well as those engaged in professional work or duties directly connected with technical education itself. Surely it argues well for the increasing prosperity and usefulness of the institute, and the advancement and elevation of the interests it seeks to foster, when the great representative body of experienced and active workers of the profession exhibit such a regard for the training and development of those who are entering upon the work, and who must be responsible for the honour and achievements of our calling hereafter.

To appreciate the vast strides that have been made in this country in providing greater opportunities and better methods for the technical training of engineers, one has only to examine the earlier papers on this subject in our transactions, and compare the crude and limited conditions therein presented with the facilities now afforded, and so well set forth in a late address from a past president of this institute on American mining schools. From an absolute dependence in the early days upon foreign schools and foreign methods, and the crude beginnings in this country in later times—when rough lecture notes and ancient diagram, a limited routine in chemical laboratory, and cool reception at shop, and mine, and furnace plant were dealt out to the youth who sought the training of an engineer—we have come to the improved equipment and more searching methods of the present day. The working drawing is now produced and studied in detail, the training of the shop is an essential of the course, the laboratory affords not only a grounding in the principles of chemistry and physics, but experience as well in the practical application of these to commercial operations, and includes within its scope the test and trial of the metallurgist's process and appliance, and of the materials and mechanisms relating to engineering art. Field work and summer school give backing to the theories of lecture room. Ability to do as well as learn is becoming more and more the test of fitness for professional degree.

But although so much has been accomplished, there is much that remains to be done. The tireless energy and restless activity of the present age are constantly making new and more exacting demands. The specialisation that marks development in all knowledge and effort calls for a still greater division of labour if the work is to be well done.

The engineer of the past generation was to a great extent a general practitioner, called upon to undertake all cases within the wide range of the profession, for the knowledge demanded was comparatively superficial, and the practice limited to a few set forms of treatment. He has now given place to a multitude of specialists spurred on to secure new and greater developments in special lines of the profession, by an uncompromising competition and the host of new facts and their applications which a crowd of investigators and inventors are constantly pouring upon the world.

The development of technical training to meet these ever new and more exacting demands must keep pace with that of practice and profession, or education will be looked upon in the future as it has, not without some reason, often been regarded in the past, as the study of ancient history likely to swell the head of the youthful victim rather than enable it to direct a ready hand. To secure such wise and timely development as new exigencies demand requires the untiring and united effort of everyone concerned. To the labours of the technical guide and instructor must be added the encouragement and means of obtaining keen practical insight which the actual workers can so well supply, and with these must go the material support and assistance—fitting tributes from such as have been blessed in their endeavours and more or less indebted to the work of the engineer.

It is not, however, for the purpose of discussing the general subject of technical education that I would detain you on this occasion—important though that subject is, and of such interest to one connected with the responsible duties of training the would-be engineer, yet somewhat busied with the more active practice of the profession. It is rather to call your attention to some needed opportunities likely to be felt by such as have by their labours and experience earned a place in the profession, and to report the results of some recent efforts made to meet the growing demand.

There is surely no branch of the comprehensive profession of engineering which calls for so much technical instinct and sound judgment as that relating to the broad fields of mining and metallurgy. In the many other divisions of the profession the bench marks have been more clearly established or the bounding stakes have been set in more limited areas or in fields more fully cleared. The problems that are presented for solution either contain a smaller number of variables or may be made to yield to fewer formulæ and to such as can be applied with wider limits of application in new cases that arise. There are not many mining engineers but have felt how few constants have been determined in their special branches, and in what general terms these must be applied. It is not only in dealing with theoretical and purely technical questions that one may feel handicapped in his work. Indeed, it is more frequently in the treatment of practical problems that special data are required, and the means of determining these fully are so seldom within reach. From the examination to determine the nature and extent of mineral deposit to utilising the properties of the useful substance this supplies, there is no step in the many complex operations in which the scarcity of exact knowledge and definite laws does not magnify personal equation, and especially call for the exercise of that sound judgment which comes of keen technical instinct, backed by large experience well profited by. How lacking in detail, for instance, is our knowledge of the laws and their complex operations relating to the origin and development of mineral veins, and yet how important such detailed knowledge to the practical results we seek to obtain. The exact conditions under which rock deposits have been laid down—how they have been moved, what strains have been produced, the origin of these, and how they have acted upon each kind of rock ; whence the solutions and mineral salts contained ; what journeys these have made ; what storage room is found and how produced—whether by leaching, fracture, fault, enlargement, shrinkage—and the extent of these, besides the complicated question of the filling of this open ground, the various causes, rates, and times of deposition. In a general way we know much of these, but how little of the detail we require for reducing the commercial problem to finished plan or complete estimate.

In the exploitation of mineral ground the lack of detailed knowledge such as this and of other facts and principles affecting its position, extent, and relation to adjacent rocks, is likely to prevent the best advantage being taken of natural conditions in laying out the work and providing for the most economical extraction. With the present means, too, how difficult to formulate the strains and stability of materials met with underground or to determine sufficiently to ensure complete control of imprisioned water, gas, the effects of heat, and such conditions as affect economy of work and even the life and health of those who labour in mines.

And further, in the treatment of the minerals produced, whether in preparatory dressing or metallurgical attraction, how much there is to learn of law and fact to enable us to get the needed data in each case on which to base and regulate the plant and process to obtain the best results.

And even when the extracted metal is in hand, how much we grope about in using it and in applying the many properties it has. On the slender basis of a few inaccurate physical tests, for lack of better means, or the crude inquiry which is all that chemistry at present suggests—*ultimate* analysis—neglecting the *proximate composition*, upon which so much the metal's qualities depend—upon such slender basis and imperfectly digested fact, elaborate structures are developed, necessitating a safety factor, often of huge extent.

There is, of course, a vast amount of knowledge bearing on all these points, as anyone in trying to master it would confess, and each day brings some addition to the store, but in the critical investigation of some special case the limitations of this knowledge are soon made plain.

In these days of rapid progress in all fields of activity, there is a wonderful improvement in the conditions which favour the increase of this much needed knowledge of law and fact. Books of reference, current literature, and other special means of reporting the progress that is made in discovery or new application, are coming more and more within the reach of all. Cabinets and museums are increasing in number and growing rich in stores of mineral, rock, and fossil specimens, and in casts and preparations, and such other objects as are found most useful for comparison and study. Physical and chemical laboratories are developing constantly new facilities of special apparatus and better method to spur on investigator and aid the manufacturer.

All these are admirable, and contribute in no small degree to the benefit of many. But that which is of especial importance, in these days, to the engineer and the vast field of activity in which he labours, is what might be included, for lack of better term, under the general name of engineering laboratory, where materials, machinery, appliances, and processes might be tested and experimented with in detail—not with reduced laboratory sample, but on a working commercial scale. It is not meant by this that each individual establishment should necessarily include all the varieties of test here implied, although under favourable conditions such comprehensive duty might be brought under one control. Local circumstances, special needs or advantages would serve as a guide to the wiser foundations on which to build.

I am by no means unmindful of the many laboratories already in existence for the chemical and physical test of engineering and other materials, or of the metallurgical laboratories for trial of ores and their methods of treatment. These all serve useful purposes in their way, and are encouraging advances over old-time opportunities. They have contributed largely to the developments of recent years and paved the way for another step forward, but to meet the demands that are now pressing this step should be taken with little delay.

Such laboratories as have been established for making physical tests are either provided with appliances of too limited capacity to yield the most important results, or in the few instances where testing machines of sufficient power are at hand they are not available for use by the profession. The Government testing machine at the Watertown Arsenal seems unlikely to fulfil the mission for which it was constructed and is so well adapted, while the only other important machines in the country are to be found at private works, where they are mainly used for routine tests to serve as a guide in special work. The laboratories where practical trial and test of metallurgical material and processes may be had are confined to work on a limited scale, and are not adapted for the solution of many of the problems that arise.

What we especially need in these days are large public testing works, where not merely the unreliable turned down specimen or trimmed fragment can be tested (which are well enough in many instances as a general guide), but where full-size timber and beam or girder, truss or construction member, large blocks of stone and piers of masonry, as well as the many other materials and structures used by the engineer, may be made to yield a more accurate record of their strength and limits of useful application. In such testing works we should find a full equipment of machinery and appliances especially adapted for testing ores and fuels and other mineral substances and products of manufacture on a commercial scale, by carload or lot of larger size, in all the processes and operations connected with mechanical preparation, extraction, or development of power. Here, too, if provided with abundant space and good margin of boiler and engine power, new machinery and apparatus could be tested to prove their practical usefulness and the working power required.

Time would fail were I to attempt on this occasion even an enumeration in detail of the manifold advantages and opportunities likely to result from such establishments and the judicious use of them. Every engineer, and especially mining engineer, whatever his training or his field of labour, must, and many from hard experience will, appreciate the practical value, and even necessity, of securing such means of obtaining full knowledge for safer guidance and control. The manufacturer, and corporation, too, and all such as operate or invest in mine, or mill, or furnace plant, or many another enterprise, will be made more secure against loss and disappointment, since we have here the means of reducing wild and hazardous schemes to definite business plan and safe estimate.

(*To be continued.*)

The North American engineers who are at present in Nicaragua engaged in drawing up plans for the projected canal have made improvements which will reduce considerably the length of the excavations that will be necessary. It is expected that a vessel will be able to pass from ocean to ocean in twenty-five hours, and that the construction of the canal will occupy five years.

UNDERGROUND RAILWAY VENTILATION.

The unventilated condition of the London underground railways (says the *Times*) is a matter of public notoriety, and the sulphurous fumes emitted from the locomotives doubtless deter many from using those otherwise excellent means of transit. It is true that an attempt was made some years since to mitigate the evil by making openings at various points along the line of route of the Metropolitan District Railway, through which the obnoxious vapours are now largely discharged. It is true, also, that on the Metropolitan Railway there are a few openings which slightly relieve the tunnel of the products of combustion. The fact, however, remains that our underground railways, in spite of their blow-holes and street disfigurements, are a source of great discomfort, if of nothing worse, to passengers using them. Numerous projects have been devised for remedying this evil, but none appear to have been found sufficiently practicable for adoption. We have, however, recently inspected a system of extracting the noxious vapours from a locomotive directly they are formed, and of discharging them into the air, which appears to meet the case of underground railways, inasmuch as these vapours never enter the tunnel at all. This system is the invention of Mr. Chris. Anderson, of Leeds, and the desired object is, it is said, accomplished by making a connection between the smoke-box of the moving locomotive and a stationary exhausting flue by means of a long sliding box placed under the locomotive, and working with its open underside in contact with the upper surface of the flue. The flue is fitted at intervals with valves over which the sliding box travels, and which are opened by it, the box being of such a length as to enable it to cover a second valve before it has quite passed over the previous one. The flue is placed in the centre of the road between the rails, and is exhausted by fans situated at intervals along the line, and driven by stationary engines. The exhausting fan having been set to work and the train started, as the locomotive passes over the valves the steam and products of combustion are sucked from the engine through the valves in the exhausting flue, and are drawn from it and discharged into the atmosphere through suitable shafts. By this means it is claimed that the fouling of the atmosphere of underground railways by the products of combustion would be entirely prevented without any prejudice to the working of the traffic or detriment to the running of the engines or trains. A working model of this invention was recently inspected by us, as applied to a 60ft. length of line, and the feasibility of the system was so far fully demonstrated.

BIRMINGHAM ELECTRICAL EXHIBITION.

One of the great curiosities of the exhibition (says the *Electrical Review*) will be Edison's phonograph. It is hoped to secure the presence of the famous inventor himself at the opening ceremony, or, should that prove impossible, on some subsequent date convenient to him. In any case, the benefit of Mr. Edison's patronage will be enjoyed, as if he cannot attend in person he has promised to "phonograph" over a few words for the opening function, so that people on this side of the Atlantic with something of a desire to hear the famous inventor's voice will, if they happen to be present at the inauguration, have their wish gratified. Another novelty of the exhibition will be the working of the whole of the moving machinery in the building by electricity, and great interest is certain to be evinced in such a practical application of the new motor to industrial machinery, especially by manufacturers who may be thinking of trying it.

The electrical section, it goes almost without saying, will afford scope for an interesting and attractive display. The exhibits will be grouped in three sections. One of them will consist of a complete display of electric lighting upon all known systems and combinations, and of all systems of electric transmission of power. This should prove a highly interesting section to those who feel any deep concern in the local electric lighting question. Another section will embrace dynamos, arc and incandescent lamps, switches, electroliers, motors, &c.; and the third, telegraph and telephone apparatus, phonographs, electric bells, and all kinds of electric machinery and appliances. Altogether there should be a vastly interesting display of the fruits of a science said to be yet in its infancy. Since the Paris and Crystal Palace Exhibitions rapid strides have been made in electricity as regards its practical application, all which improvements, it is understood, will be shown in the section.

PAPER TORPEDO BOATS.

It is stated that Mr. Joseph Bergmann, of Lansingburg, Germany, builder of paper boats, is now engaged on the construction of paper torpedo boats, under the countenance of the Navy Department. The trial boat is nearly ready, and is a peculiar construction, measuring nearly 11ft. in length, and about the same dimensions in breadth, with a depth of only 16in. Its shape at either end is that of a cigar that has been somewhat flattened in the box. Any cross section, at right angles with its longitudinal axis, is an oval, and it tapers to a sharp point at each end. It is made of twelve folds of paper, is one-seventh of an inch thick, and though it contains no braces, is so hard and strong that one by pressing against it might presume that it was solid. Its greatest beam is about 4ft. from the bow. The craft is constructed in halves, so that each half is a keelless paper boat, its lines converging to two points, at stem and stern. Within the shell are three cleats, to which an electric dynamo will be fastened amidships. This dynamo will turn a light propeller at a high rate of speed. In the bow, in a space of 2ft. long, will be stored 25lb. of dynamite, enough to blow the biggest turret ship in the German navy into a "cocked hat" before Bismarck could say "sour kraut." The contact of a pointed block of brass protruding through the bow of the torpedo with the side of the vessel will discharge the dynamite. The torpedo boat will be steered by means of electric wires connecting its stern with the ship from which it is sent out. The shell, which will be water-tight, will be so ballasted that it will run along under the water at the necessary depth.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

Sir,—I have read the several letters upon this subject with considerable interest, and I am much obliged to "Chalkline" for the amount of valuable information he has given us. At the same time I cannot entirely accept his conclusions on the alleged defects of the water-tube system, as so many boilers are now at work under widely varying conditions, as pointed out by "G. T. P.," that it is difficult to imagine why they should continue to exist and sell in considerable numbers unless there are some points of advantage over other types. The very widespread attempts to adopt various forms of this type indicate at least a belief on the part of many competent engineers that something is to be gained. It is difficult to imagine an engineer so successful as Mr. Thorneycroft going in for this mode of steam raising on insufficient grounds, and yet the complex-looking mass of tubes illustrated in your last week's *Practical Engineer* is adopted by him for torpedo boats, and is said to work admirably.

The attempts of Herreshoff also, in somewhat the same direction, were fairly successful, and in view of all this it seems to me unwise to condemn so unsparingly the whole species, as is done in "Chalkline's" letter. There must be good points under certain circumstances to account for the number and power of water-tube boilers in actual use. No doubt there are disadvantages, with bad water more especially, and when very bad water is in use I have little doubt but that the Lancashire is the best. Rapid circulation by pumps and filtering have been often tried and failed, so far as scale prevention is concerned, so that "G. T. P." need not hope for advance in that direction. The worst scale does not form by settling down of sediment, but adheres to the plates at the heated portions just at the moment of evaporation, when the steam is formed. Sediment which remains in suspension is easily removed by forced circulation and filtering, but not the scale.—Yours, &c., C. D.

QUERIES AND REPLIES.

29. Cementing Rubber to Metal.—Can any reader give me information as to the best cement for fastening a rubber stamp to metal. The cement must stand frequent pressure upon the rubber without being loosened.—J. A. L.

Answer.—Take powdered shellac, with ten times its weight of strong ammonia. This will give a transparent mass, and in three or four weeks become fluid without using hot water. This liquid makes indiarubber weak, but after the evaporation of the ammonia it will become hard and impenetrable to gases or liquids.—P. M.

37. Steam Joints.—Which is best for steam joints, such as valve box covers and steam pipes, indiarubber, asbestos, or thin wire gauze? Is there any reason for preferring any one of them in special cases?—Subscriber.

Answer.—For cylinder covers and other faced joints where it is desirable to bring the facings close together, and where the covers require to be removed occasionally, red lead putty (white lead mixed with a sufficient quantity of dry red lead to bring it to the consistency of putty) is simple and effectual. The putty is placed round the flange, inside the bolts, in form of a cord about the thickness of one's little finger. The slightest smear of tallow or boiled oil before applying will cause the putty to adhere to the facing while making the joint. When re-making the joint, all the old putty must be well scraped off. For steam-chest and manhole covers, thin lead gas piping is often used, and does not require renewal each time the joint is broken. For steam-pipe or other permanent joints (assuming the flanges are faced), there is nothing better than the thin "insertion" of indiarubber and canvas.—C. T.

Answer.—I have found in my experience that a mixture of indiarubber and asbestos is best and cheapest for all kinds of steam joints. For very high pressures a layer of thin gauze wire interwoven with the indiarubber and asbestos is advisable. Indiarubber, it is well known, is destructive to faces when used by itself, and the same may be said of asbestos, owing to its permeability. Gauze wire is unsuitable where the joint has to withstand any springing, as in steam pipes, and is rarely used a second time. I know of boiler manlid joints made with the above combination, supplied by Messrs. Bell over five years ago, and still in use.—L.

16. Setting Corliss Valves.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—Engineer.

23. Light Mixing Mill.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—Eastern.

35. Locomotive Driving Wheels.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

36. Nut Cast on Iron Screw.—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and ⅜in. pitch.—Subscriber.

38. Duplex Mining Pump.—Which is the best duplex action mining pump for use with compressed air, taking into account compactness and first cost as well as economy?—S.

39. Separate Condenser.—Which is the best separate condenser for use with high-pressure engines, and state advantages?—H.

40. Barffing Cast Iron.—Can any of your readers inform me whether cast iron which has been subjected to the process known as "Barffing" will withstand the action of a boiling solution of weak sulphuric acid? Also, can you give me the name and address of any firm where this process is carried out?—Works Manager.

41. Hot-water Pipes.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft.? What book may I get on arrangement of greenhouse?—Water-heater.

42. Burnishing Brass.—Will some practical reader kindly inform me of the best way of burnishing brass?—Smith.

43. Slack Crank Pin.—I have an engine of about 25 horse power nominal, and I find that the crank pin has become slack. What is best to be done? Should I put in a new one; if so, what is my best method of proceeding?—Crank Pin.

TO CORRESPONDENTS.

Alpha, Cumnock.—Formulæ for the bursting and working pressure of Lancashire boilers, together with complete discussion on details of construction and metal used, are given in "Boilers, their Construction and Strength," by T. W. Traill, published by Messrs. Griffin and Co., London. It would require a complete treatise to answer your question fully.

G. G., Limerick.—Apply at the Peninsular and Oriental Steamship Offices, Leadenhall Street, London; they will doubtless inform you if there is a vacancy.

R. H. H., Hyde.—An illustration is being prepared to answer your query on marine boiler furnace.

B. L., Dudley.—You cannot construct a fountain in the way you mention which is entirely self-acting; motive power of some kind is required, and compressed air or some other method of storage of power must be adopted. Such fountains have been made with small air reservoirs, in which air is compressed by a small hand pump or syringe, but they only act so long as the air lasts, and have to be pumped up at intervals.

M. O. W., London.—There is no fund for assisting engineers of the nature you mention. The Institute of Civil Engineers has a fund of the kind, but it is available for members only.

W. W. S., Bury.—The substance generally used for toy pistol caps is fulminite of mercury. It would be exceedingly unsafe for you to attempt to make it, as it requires considerable experience.

Student, Glengyvon.—A rough and ready rule for ascertaining the breaking strain of a wire rope is, for iron wire, square the circumference in inches and multiply by 1·5, which gives the breaking weight in tons; or if of steel, square circumference in inches and multiply by 2·5. Thus a ½in. diameter iron wire rope has a circumference of 1·57in. $1\cdot57^2 = 2\cdot47$ nearly; multiplying this by 1·5 gives 3·7 tons, which is the breaking strain for ordinary iron wire rope. For steel it would be 6·17 tons. The working load should not exceed one-sixth of these amounts.

E. B., Bolton.—It is sometimes stated in the text books that friction is independent of the extent of surface, and this would no doubt be true under some circumstances, but in practice friction increases with extent of surface within certain limits without increasing pressure upon the surface. The friction would be greater on a broad than on a narrow rail with a broad wheel bearing on it, and the train would stop quicker down an incline on the broad rail. This is subject to the pressure exceeding a certain intensity per square inch; if less than that the friction diminishes. The laws of friction are very complex, and are not entirely understood even yet.

SHIPBUILDING.

Messrs. R. Irvine and Co., of West Hartlepool, launched on Tuesday evening, 16th inst., a steel steamship, which measures 240ft. over all, 32ft. beam, and 15½ft. depth of hold, and is fitted with all the latest improvements for quick loading and discharging. She has a short poop for the accommodation of officers, raised quarter-deck, long bridge extending to foremast, and topgallant forecastle for crew. She is to the order of Messrs. Orders and Hanford, of Newport (Mon.), and was named the Reggie.

A smart spar-decked steamer was launched on Tuesday, the 16th inst., by Messrs. Wigham, Richardson, and Co., from the Neptune Shipbuilding Yard, Newcastle-on-Tyne. She is a sister ship to the Félix Touache, which was launched from the same builders' yard a month ago, and is now loading in the river, and both steamers are additions to the fleet of the Compagnie Anonyme de Navigation Mixte, of Marseilles, for their Marseilles and Algerian passenger service. The dimensions of the steamers are 260ft. by 32ft. by 25ft., and the engines, which are triple-expansion (Tweedy's patent), are by the same builders. The vessel was named the Rhône.

On Tuesday afternoon, the 16th inst., Messrs. Robert Thompson and Sons launched from their shipbuilding yard at Southwick an iron screw-steamer, built to the order of Messrs. T. A. Jaques and Co., Newcastle-on-Tyne. The dimensions of the vessel are: Length, 230ft.; breadth, 32ft. 6in.; and depth, 15ft. 4½in.; and she has been built under Lloyd's special survey to class 100 A1. She has a raised quarter-deck, with bridge and forecastle; is fitted with water ballast. She has large self-trimming hatches, with three steam winches, patent steam-steering gear, patent windlass, and all the latest improvements. The cabin is placed aft, and fitted up for the accommodation of the captain and officers, and the engineers are berthed under the bridge. The crew are in the forecastle. The engines are by Messrs. Black, Hawthorn, and Co., Gateshead-on-Tyne. The vessel was named the Hazelmere.

On Wednesday, the 17th of April, Messrs. Ropner and Son launched a steel screw steamer of the following dimensions: Length, 269ft.; breadth, 36ft.; depth moulded, 20ft. 1in. This steamer has been built under special survey to class 100 A1 at Lloyd's, and will carry 2,600 tons cargo and fuel, on Lloyd's summer freeboard. She has a short full poop, in which is fitted accommodation for captain and officers, raised quarter-deck, long bridge extended to foremast, short well and T.G.F., cellular bottom for W.B. She is built on the web-frame principle, and having very large hatches is well adapted for carrying heavy cargoes. She will have four steam winches, Meredith's patent multitubular boiler, Davis's steam-steering gear, Hastie's screw gear aft, Emerson, Walker, and Co.'s patent windlass, &c., and all the latest improvements for a first-class cargo steamer. Her engines are by Messrs. Blair and Co. Limited, on their improved triple-expansion principle, of 800 H.P., with two steel boilers working at 160lb. The steamer has been built to the order of Messrs. R. Ropner and Co., West Hartlepool. It was named Thornaby.

The steamship Maltby, a new vessel, 313ft. 8in. by 40ft. 6in. by 22ft. 1½in., built by Messrs. Ropner and Son, Stockton, for Messrs. Ropner and Co., West Hartlepool, left the Tees on the 17th inst. for her trial trip. Her engines are of the triple-expansion type, of 210 horse-power nominal, having cylinders 23, 38, and 62½ by 42 stroke, and working at 160lb. pressure of steam, by Messrs. Blair and Co., Limited, Stockton. The trip proved highly satisfactory, and the vessel obtained a speed of about 11 knots.

MISCELLANEA.

The New Webb Compound.—The *Railroad Gazette* gives a short account of a trip on the new Webb compound, which has been acquired by the Pennsylvania Railroad Co. for experimental purposes. To give the engine a perfectly fair trial this company have engaged an English driver. The account states that the engine handled its load easily, even on steep inclines, and states that owing to its arrangement of firedoor very little smoke was produced. The design of the tender is also commented on very favourably.

Deepening the Suez Canal.—Our shipowners would do well to take note of a remark in Consul Burrell's report. He says that the necessity for "increasing the depth of the Canal becomes more apparent every day, and last year several steamers had to complete their coaling at Suez in order to avoid taking too much coal at Port Said," and so exceed the limit of draught. That limit is now reached by several steamers traversing the Canal, and the shipowners should agitate now for the early deepening of that famous waterway.

The Race to the North.—A "flying Scotchman," the first of the new locomotives built for the fast Scotch traffic on the London and North-Western Railway, was turned out of the Crewe Railway Works recently. It is the finest locomotive on the railway, and has three cylinders, a new departure in locomotive building. It has also a seven-foot driving wheel, and is several tons heavier than the others. It has been constructed specially for high speed with heavy trains. The preliminary trial showed exceedingly satisfactory results.

A New Air Brake.—A new air brake has been patented by Mr. Joseph S. Lapish, American Fork, Utah Ter. Combined with two auxiliary reservoirs on each car, connected by a pipe, is an operating pipe connected with the reservoirs, a valve and a coupling connected by a rod with the valve, with other novel features, the pipes being connected in the usual way with the main reservoir on the locomotive.

Manchester Ship Canal.—At present the Irlam section of the Manchester Ship Canal at Flixton Ees is the scene of great activity. A large and deep cutting has been made, extending from near Kalamanca Locks at Flixton to the Cheshire Lines Railway, which is to be diverted, and the abutments for the railway bridges are now being put in. Here about a dozen locomotives and five steam navvies are constantly at work. In the second "graft," which is being cut, red sandstone is showing itself. A temporary wooden bridge has been constructed across the Irwell, where the Irlam ferry boat used to ply, which connects Flixton village with Higher Irlam. The course of the canal is being cut through red sandstone at Hulme's Bridge, on Stickins Island.

The City of Paris.—The initial trip of the City of Paris is a remarkable one. She beat the record of first trips of ocean greyhounds, with her run of 6 days 18hrs. 53mins., in spite of the two days of heavy wind and sea, and two more of fog. The machinery worked smoothly, and she burned less coal than the City of New York. The daily runs from Queenstown to quarantine were April 5th, 371 miles; 6th, 415 miles; 7th, 402 miles; 8th, 390 miles; 9th, 410 miles; 10th, 498 miles; 11th, 344 miles, to Sandy Hook on the afternoon of the 8th. The port engine of the vessel gave way, owing to faulty packing of the piston rod. It required the services for five hours of all the hands in the engine-room to effect the necessary repairs. That was the only stoppage of the machinery on the voyage, everything working with surprising smoothness for a first trip.

A New Use for an Old Product.—We learn that an Italian engineer, Colonel Potto, recently made some interesting experiments respecting the employment of sugar as an agent to obviate the incrustation of steam boilers. The experiments were made in a boiler of 20-horse power and containing 126 tubes, and the results proved highly satisfactory. Two kilos. of sugar were introduced into the boiler every week. Formerly the same boiler used to become incrusted in a period of about six weeks; but at the end of a like period after the sugar had been employed it was found to be but slightly coated. After the boiler had been working continually for upwards of four months with sugar introduced into the water, a thin film of incrustation was found to be formed, but this was easily removed by washing.

An Immense Terrestrial Globe.—The immense terrestrial globe which is being constructed for the forthcoming Paris Exhibition will have many points of interest. It will be one-millionth the size of the earth; a millimetre on the globe will represent a kilometre on the surface of the earth. The globe will be about 30 metres (nearly 100ft.) in diameter. On this scale it will be possible in most cases to give geographical details their true dimensions; Paris will occupy just about one centimetre, and may serve as a unit with which to compare the dimensions of other features. All the great lines of communication by land or by sea can be shown in detail. In the enormous cupola under which the globe will be placed, it will be possible by means of a clockwork arrangement to turn the globe on its axis and convey a precise notion of the diurnal rotation of the earth. A point on the equator will move at the rate of half a millimetre per second. The many educational uses to which such a globe could be put are evident. The globe, we understand, is well advanced towards completion.

The Development of Steel Production in Gratz.—Although the Bessemer process of producing steel has now been introduced into many countries on both sides the Atlantic, the managers of the Gratz Works, in Austria, were among the first to adopt it, they having done so so far back as the year 1864. Since that period the production from that important establishment has greatly increased. In 1885 the Gratz Works possessed three 12-ton Martin furnaces, the operation lasting 12 hours, the waste amounting to 5 per cent, and the consumption of lignite to 470 kilos. per ton of steel produced. With a view to the utilising of old rails and other scrap, it was decided in 1886 to adapt the furnaces to the basic process; and, although their capacity is still 12 tons, the duration of the charge now varies from five to five and a half hours, the consumption required for producing 1,000 kilos. of steel, consisting of about 260 kilos. of white pig, 740 of scrap iron, 50 of spiegel iron, containing 32 per cent of manganese, and 10 kilos. of ferro manganese and ferro silicate. The cost of lining the furnaces is certainly considerably greater with the new method; but, on the other hand, besides the advantage of being able to use scrap iron, white pig, costing only 38 florins per ton, can now be employed instead of grey, which could not be obtained for less than 45 florins. The consumption of lignite per ton of steel has been reduced from 470 to 300 kilos., and the production per man during 12 hours has been raised from 700 kilos. to 1,250 kilos. The quality of the steel produced at present is also far superior to what it was formerly, and rails 30 metres long are now rolled at the Gratz Works, which would have been quite impossible according to the old process.

A Japanese Canal.—The Japanese Government has now under construction a canal, the principal object of which is to carry the water of Lake Biwa to the city of Kioto, to be used there for domestic purposes. The main canal, however, has been made of sufficient size to be used by boats, which will carry freight from the towns on the shore of the lake to Kioto. The main canal, which is about six miles long, leaves the lake at Otsu, and ends at a point on high ground adjoining the city and at a level of about 138ft. above the plain upon which the town is built. It has a depth of 6ft., and varies in width from 10ft. to 28ft. The entrance from the lake is through a lock, which was rendered necessary by the variation of the level of the water in the lake, which is as much as 10ft. between a dry and a wet season. There are five tunnels on the main canal, the longest being about 8,000ft. from end to end ; the others are generally short. The section of these tunnels is 16ft. by 14ft. ; wherever necessary they are arched with brick. There is one short aqueduct on the canal, constructed of brick arches. From a point near the terminus of the main canal at Kioto a branch canal diverges and is carried down by a circuitous route to a junction with the old canal already existing in the city, which runs through its whole length and then connects with the Kamo-Gawa River. This branch canal is not intended to receive boats, but is merely a conduit for carrying water, and is only 8ft. wide by 4½ft. deep. The length of this branch canal is 4¼ miles, and there are on it two short tunnels, which are circular in form, 6ft. in diameter. The total cost of this work, which is nearly completed, is 1,250,000, which appears low to us ; but account must be taken of the extremely low price of labour in Japan. The work has been designed by a Japanese engineer, Mr. Yanabe, and is being executed under his direction.

Mining and Mechanical Engineers.—A meeting of members of the North of England Institute of Mining and Mechanical Engineers was held on Saturday, April 13th, at Neville Hall, Newcastle, under the presidency of Mr. John Marley. The scheme for the federation of mining institutes was laid before the meeting and approved, and several alterations in the bye-laws of the institute were read, and they will be considered at the next meeting. The following institutes are taking part in the federation movement : North of England Institute of Mining and Mechanical Engineers ; Midland Institute of Mining, Civil, and Mechanical Engineers ; Chesterfield and Derbyshire Institute of Mining, Civil, and Mechanical Engineers ; South Staffordshire and East Worcestershire Institute of Mining Engineers ; and the North Staffordshire Institute of Mining and Mechanical Engineers. The federation is intended principally in connection with the publication of the papers read at meetings of the various associations. Mr. Charles Z. Bunning read a paper on "Coalmining at Warora, Central Provinces, India." A paper by Mr. J. M. Liddell on "The Goldfields of the Valley of De Kaap, Transvaal, South Africa," was next read. Mr. N. Walton Brown read a paper on "The Pieler Spirit Lamp as a Fire-damp Indicator." Mr. Brown stated that this lamp affords probably the simplest method of roughly estimating the proportion of fire-damp present in the air of mines. It consists essentially of a large Davy lamp constructed to burn alcohol. When the burning lamp is placed in a mixture of fire-damp and air, the flame shows a conspicuous cone of light, very much larger than that produced by the flame of an ordinary oil lamp. The paper gave in detail the results of certain experiments made by Dr. K. Brockmann in the laboratory of the Prussian Fire-damp Commission as to the phenomena produced by pit gas on the flame of this lamp.

A New Steam Generator.—Recently Messrs. Nicholson Brothers, Hebburn, made a trial of Mr. Robert Scott's patent steam generator, of which great things are expected. This system of generating steam is based, says the inventor, upon the dynamic principle that heat is a mode of motion, and that the nearer the centres of energy of the heat are to the furnace plates, the greater is the amount of heat transmitted to the water. The nearer, therefore, the combining points of the atoms are to the furnace plates, the greater will be the efficiency of the boiler. To secure the full benefits of this law, the fire bars are entirely dispensed with, and the fuel is burned upon the furnace plates. It has been scientifically demonstrated that there is a cold zone upon the surface of metals that have water behind them. No heat, however powerful, can penetrate this zone. No injury can therefore be done to the plates by this method of generating steam. Combustion is supported to any extent desired by the introduction of concentrated currents of air direct to the fuel. Two boilers constructed upon this system have been practically tested. The first boiler had two flues 18 inches in diameter each, and the second boiler had one flue 36 inches in diameter. While the tests of the large flue demonstrated a large saving in quantity of fuel, the saving in the system with small flues represents 30 per cent in quantity of fuel ; but as the system can thoroughly consume the most inferior kinds of fuel, including duff coal, &c., the saving in money value varies from 40 to 75 per cent, according to the price of fuel consumed. At previous trials most satisfactory results were obtained. In the case of a Cornish boiler, with a 36in. flue, the evaporative efficiency of the boiler was found to be 9·107lb. of water per lb. of smallest duff coal, costing 1s. 6d. per ton. Since then considerable improvement has been made in the supply of air to the furnace, and a further trial on behalf of the Admiralty demonstrated that the evaporative efficiency was equal to 10·164lb. of water from 212 deg. Fahr. per lb. of the duff coal, costing 1s. 6d. per ton. Trials upon a two-flued boiler, the flues being 18 inches in diameter, represented the evaporative efficiency to be upwards of 14lb. of water from 212 deg. Fahr. per lb. of duff coal. Steam may be generated rapidly or slowly, as desired, and boilers can be converted to Mr. Scott's system. The system may be seen in practical operation at Messrs. Nicholson Brothers, Hebburn-on-Tyne, from ten a.m. to one p.m. daily. The trial was said to be entirely satisfactory.

Lecture on Colliery Explosions at Stoke.—Under the auspices of the North Staffordshire Institute of Mining and Mechanical Engineers, Professor Frank Clowes, D.Sc. University College, Nottingham, delivered a lecture on Monday evening, the 8th of April, at the Town Hall, Stoke, on the subject, "Colliery Explosions—Safe Lights—Safe Methods of Getting Coal." Mr. James Heath, president of the institute, presided, and there was a very good attendance. The lecture, as the subject indicates, was a most interesting one, and, being illustrated, was listened to with very great attention. Professor Clowes prefaced his lecture by giving a brief history of the origin of safety lamps, and described the Davy and Stephenson lamps, and the improvements made subsequently by Clanny and Mueseler. The highest point of safety had been reached, he believed, that could be reached by oil lamps. Everyone who had worked with these lamps understood there were dangers even in the safest forms, and it was not possible absolutely to insure risk against the glass of the lamp cracking or breaking. The direction which improvement would take in lamps was likely to be made in electric lighting. The lecturer then showed some specimens of electric lamps, and said he thought electric lamps would ultimately supersede oil lamps. One advantage was that the electric lamps could not be tampered with. In the first place, if the front glass, which was very strong, was broken, then there was an inner glass to be broken, and the moment that was broken the light would be immediately extinguished. Therefore there was no such risk with electric lamps as sometimes occurred by the tampering with the oil lamps. His opinion was that the electric lamp, with the testing apparatus, would be the form of lamp adopted in the future when the inventor had completed his work. The lecturer then proceeded to deal with the safe methods of getting coal. He said the ordinary means now adopted were by gunpowder and blasting by shots. There was a certain amount of risk in handling and storing these explosives, and always sufficient care was not used, and people were not sufficiently cautious. Explosions, they all knew, followed blown-out shots, and attempts had been made to prevent the flame from escaping. If explosives could be dispensed with altogether and gentler means used, the risk of working in a colliery would very much indeed be decreased. Attempts had been made to get coal by cutting it with machines, but it was doubtful whether collieries could be worked with a profit if such measures were adopted. Another method known was blasting by lime, which seemed to be absolutely safe. In conclusion, the lecturer said the direction in which safety had been promoted by recent discoveries in lighting and the getting of coal seemed to be the possibility of making almost safe the oil lamp, and the possibility in the future of replacing it with an electric lamp, and, in the getting of coal, a method of absolutely safe lime blasting. The adoption of safe methods for bringing down the coal seemed, therefore, to be in the very near future. These attempts of lessening the danger had been successful, as was proved by the decrease of mortality in mines. The average annual number of deaths caused by fire-damp explosions from 1850 to 1880 was 246 per annum. From 1880 to 1888 it was 153, the actual number in 1888 being 47, which showed that rapid improvements were being made with regard to the safety of working mines.

ILLUSTRATED PATENTS.

16,326. Duplex Steam Engines, A. G. Brooks, London. *(C. C. Worthington, Irvington, New York, U.S.A.)*

Relates to a method of obtaining cushioning by the application of supplementary exhaust valves in duplex engines of the "Worthington" type, in which the main valve has neither inside nor outside lap. The supplementary exhaust valves consist of blocks oscillating in a cylindrical cavity either in the exhaust passage or in the main valve. The former is the arrangement illustrated in the Specification and the figures above. In these the main valve is shown at 4, 4, fig. 2 (duplicated merely in order to avoid the use of a long valve), and the exhaust valves at 5, 5. These are operated from the cross-head of their own engine by the system of links and levers shown in fig. 1; their exact position admitting of adjustment while the engine is running by means of the screwed unions 11, 11.—November 28, 1887. [8½d.]

FIG 1.

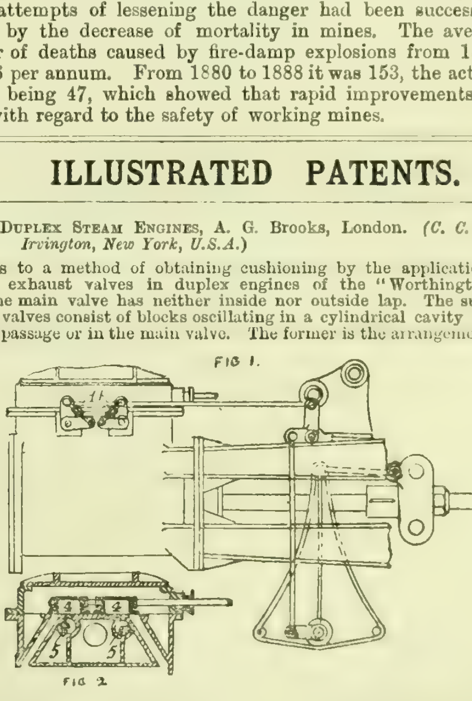
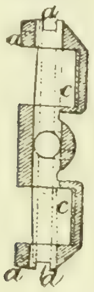


FIG 2.

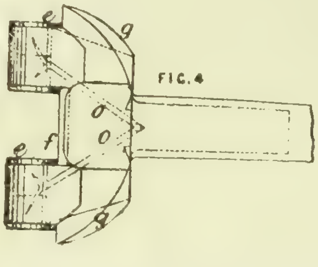
16,420. Spherical Engine, R. H. Heenan, Manchester.

Relates to details of construction in the piston diaphragm and blades used in the "Tower" type of engine. In the case of the former, it is bored through by two holes at right angles for the reception of the hinge pins. One of these is entire, while the other is in halves screwed together, one half passing by means of its reduced threaded portion through a hole in the former pin. The ends of the pins are covered with caps having tongues that enter slots *a* in the piston (fig. 2), and the periphery of the latter is grooved at *d* for a packing ring. Packing strips *c* in the piston and *f* in the blades (fig. 4) keep the hinge joints steam-tight, and the outside surface of the blades are packed by strips *g*. Flanged bushes *e* are inserted in the pin holes of the blades. The interior of the engine is lubricated by means of passages *o* in the blades which communicate with the shaft bearings and which distribute the lubricant by centrifugal action. In a less durable engine,—*e.g.*, as applied to a torpedo—the hinging of the blades is accomplished by screwing eye-bolts into the blades, the eyes of which project into holes in the piston; pins are then inserted through holes bored radially from the periphery.—November 29, 1887. [8½d.]

FIC 2.

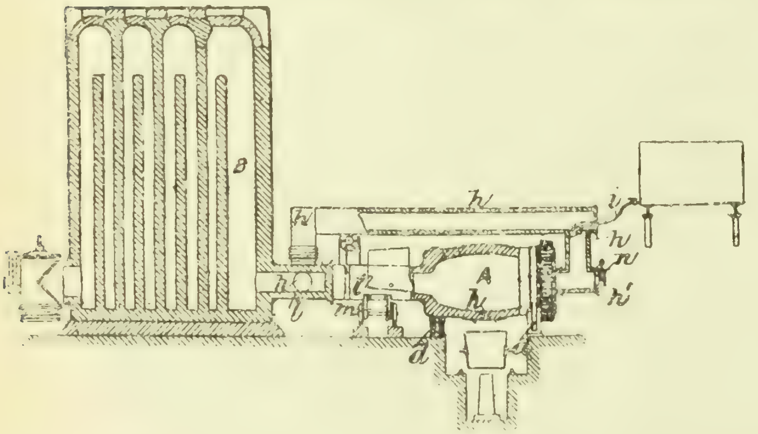


FIC.4



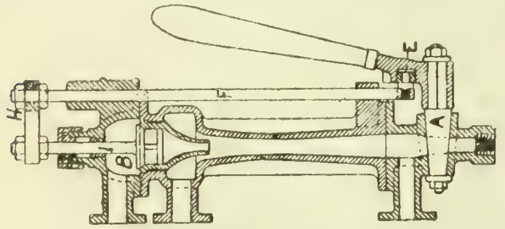
16,436. Steel, G. J. Snelus, Workington, Cumberland.

Steel is manufactured in a rotating furnace heated by the combustion of oils or producer gas and heated air. The figure shows a longitudinal and central vertical section of the rotator and flues, and one regenerator. The rotator A, lined with basic or other materials, is mounted to turn upon anti-friction wheels *d*, and rotated by a steam-engine or other motive power. One end, bottle-necked in shape, rotates about the fixed lined tube *h*, through which heated air from the regenerators B, together with oil-spray from the perforated pipe *i*, pass into the rotator. The sight-hole h^1 in tube *h* is closed by a sliding door *n*; *k* is the tap-hole of the furnace. The products of combustion pass from the opposite end of the rotator, along the flue *l*, l^2, and enters one of the regenerators B. The part l^2 of the flue is removable on a carriage *m* to enable the furnace to be charged, fettled, &c. The charge worked in the furnace consists of pig iron, and iron oxide or iron ore, a basic lining being used when treating phosphoric materials.—November 29, 1887. [8½d.]



16,655. Injectors, E. Körting, Hanover, Prussia.

The plug of the overflow cock is connected to the steam valve so that as the former is closed the latter is opened, and *vice versâ*. A mode of attaining this is shown, which may be modified as regards the relative arrangement of the parts.



The key of the plug A has a lateral extension in which is a cam groove. A pin E, provided with an anti-friction roller on the end of the longitudinally sliding rod F, moves in this groove. The rod F is connected by a bar H at the top to the spindle I of the steam valve B, so that it is moved by the rotation of the handle of the cock.—December 3, 1887. [6½d.]

Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

April 8th.

5948 Type Writers, H. B. Cox and J. W. Gordon, 15, Barton Street, Westminster.
5951 Covering for Steam Boilers, J. Sutherland, R. Youille, and R. Bird, 263, Argyle Street, Glasgow.
5954 Damping Warps, G. Huck, 72, St. James' Street, Burnley, Lancashire.
5957 Steam Boilers, J. W. Boulton, Ashton-under-Lyne, Lancashire.
5966 Breech-loading Small-arms, T. Green and J. Green, 6, Livery Street, Birmingham.
5970 Steam Engines, P. M. Parsons, Melbourne House, Blackheath, Kent.
5973 Screw Presses, E. J. Yates, 46, Lincoln's Inn Fields, London.
5974 Lubricating Vapour Motors, D. S. Hawks, Dolcorsllwyn Hall, Cemmes, Montgomeryshire. (E. L. Brady, United States.)
5975 Lock Nuts, J. Whiteley, 8, Quality Court, London.
5994 Iron and Steel Sheets, J. H. Darby, 44, Chancery Lane, London.
6003 Shearing Machines, J. Steidl, 623, High Holborn, London.
6014 Locking Nuts on Bolts, T. Stevenson, 55 and 56, Chancery Lane, London (R. R. Dobell and Co., Canada.)
6019 Fire-alarms, A. Lucien, 40, Chancery Lane, London.
6020 Drilling Machines, G. G. M. Hardingham, 191, Fleet Street, London. (J. T. Halsey, United States.)
6024 Gearing, W. J. Brower, 1, Queen Victoria Street, London.
6026 Treating Ores, F. W. Rose, 45, Southampton Buildings, London. (T. K. Rose and D. Dennes, United States.)
6027 Adjusting Hydraulic Motors, W. J. L. Hamilton, 77, Chancery Lane, London.
6030 Rotative Axle Wheels, G. Johnson, 55 and 56, Chancery Lane, London.*

April 9th.

6039 Gut Belting, J. Griffin, 9, Westland Row, Dublin.
6046 Roving Frames, R. Belshaw, 8, Quality Court, London.
6050 Scale Rules, T. G. Barron and J. C. Harding, 16, Finkle Street, Stockton-on-Tees.
6056 Marine Engines, W. H. Northcott, 7, St. Mary's Road, Peckham, Surrey.*
6057 Gas Lighting, W. H. Northcott, 7, St, Mary's Road, Peckham, Surrey.*
6058 Boring Bars, B. S. Weston, 5, Parkholme Road, Dalston.
6065 Electric Motors, H. H. Lake, 45, Southampton Buildings, London. (E. Thomson, United States.)*
6067 Surface-grinding Machines, E. R. Hyde and R. C. Horner, 45, Southampton Buildings, London.*
6078 Electric Arc Lamps, F. A. Gobert, 3, Deronda Road, Herne Hill, London.*
6079 Compressed Fuel Blocks, W. Hubbard, 433, Strand, London.
6080 Wind Motor, T. Parensen, 433, Strand, London.
6085 Steam Motors, A. J. Boult, Middlesex. (F. X. Komarek, Austria.)
6086 Valve Gear, A. J. Boult, Middlesex. (F. X. Komarek, Austria.)
6089 Railway Rails, W. P. Thompson, Liverpool. (R. de Saussure Bacot, United States.)
6090 Manufacture of Water Gas, F. H. Briggs, Liverpool.
6097 Preventing Incrustation in Steam Generators, C. Bradbury, London. (Grimme, Natalis, and Co., Litd., Germany.)*
6098 Fire Engines, A. Troetzer, London.*
6100 Rotary Pump, R. Krasselt, London.
6107 Frictional Gearing, G. F. Evans, Middlesex.*

April 10th.

6134 Gas Governor, Thomas Sturgeon, London.
6136 Firebars for Boiler Furnaces, N. Downing, Stockton-on-Tees.
6143 Hydraulic Packing Apparatus, H. S. Booth, Manchester.
6146 Regenerative Heat Engines, J. Atkinson, London.
6156 Heating Furnaces and Boilers, J. B. Orr and G. Young, London.
6161 Starting Gas Engines, M. Partridge and R. H. Brutton, Middlesex.

April 11th.

6188 Expandable Gear Wheel, F. E. Lange, London.
6190 Type-writing Machines, H. H. Lake, London. (F. D. Taylor and J. A. White, United States).
6192 Changeable Bushes, J. Mackie, Berkshire.
6194 Lubricators, J. Bastable, Staffordshire.
6196 Heating Water, H. G. Payne, London.
6202 Self-acting Couplings, R. Wilson, Glasgow.
6207 Super-heating of Steam, J. B. Hamond, London.
6211 Machines for Ornamental Turning, T. Cutlan, London.
6215 Rack Railways, T. Hunt, London.
6217 Centrifugal Machines, W. Bergh, London.
6226 Gas Engines, S. Griffin, London.

April 12th.

6235 Saw-sharpening Machines, A. Titscher, London.
6238 Reeling Machines, W. Dean, Manchester.
6252 Riveted Joints, P. M. Parsons, Kent.
6256 Toothed Gearing, A. J. Jarman, London.
6264 Cutting Screw Threads, W. W. Hulse, London.
6269 Pump, T. M. Rhys, London.
6270 Propellers, O. Phalp, Cardiff.
6278 Furnaces, J. E. Sherman, Middlesex.
6281 Ferry Boats, A. Brown, London.
6294 Gas Stoves, G. Ulrici, London.
6295 Furnaces, Josef von Ehrenwerth, London.*
6296 Valve Motion, D. Bánki and J. Csonka, London.*
6298 Switches, R. Haddan, London. (N. Belcher, United States.)

April 13th.

6303 Tramway Lines, J. Burrow and R. Johnson, Manchester.
6326 Gas Fires, R. B. Main, A. P. Main, and H. Darwin, Glasgow.
6329 Grinding Machinery, J. Adair, Cumberland. (A. Adair and J. G. Cruikshank, South Africa.)
6337 Steam Generator, A. Socher, London.*
6370 Flour-dressing Machines, J. Higginbottom, Liverpool.
6373 Saw-sharpening Machines, F. Schmaltz, London.*
6387 Metallic Aluminium, L. Q. Brin and A. Brin, London.
6390 Rapid-firing Guns, T. Nordenfelt, London.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

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We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE
PRACTICAL ENGINEER,
MAY 3RD, 1889.

THE USE OF THEORY.

It has frequently been remarked that the theory of a machine has followed the invention of the machine itself, and in no case has this been more notable than in that of the steam engine; and at the present time, notwithstanding all the thought that has been bestowed upon it by many of the most acute physicists of the past and present generations, we cannot confidently point to any completely satisfactory theory of the steam engine. Where, for instance, can we find a conclusive reasoning as to the effect of jacketing the cylinders of steam engines? Practice shows that undoubtedly economical results accrue from the adoption of the steam jacket; but theory has not decided in what way this economy is brought about, and the improvement thus effected is brought about by tentative experiment. It is not our intention to enter at any length into this particular illustration of our opening remark, as the matter has only recently been very freely discussed; and, furthermore, it is our object at present to show wherein theory is indisputably of the first importance, and where its application is in no way dubious.

In structural work the stresses on the various parts admit of very exact determination theoretically, and without such means of ascertaining the duties of each element we should be unable to determine the proportions of our works. Whatever elements of doubt may appertain to this class of construction will be brought in in connection with the data to which the theories are applied. It therefore behoves us very carefully to examine our data before basing any calculation upon them. In the first place, it is to be assumed that the safe working strength of the materials to be used has been accurately ascertained in relation to the various kinds of strain to which it may be subjected, for any error as to this point might lead to disastrous results; and, on the other hand, the intensity and mode of imposition of the load must be estimated with the greatest care.

The effects of loads, independently of their intensities, will be very varied. Thus, a beam supporting a permanent load has merely the dead weight acting on it, and producing a constant unvarying stress; a bridge has, in addition to its load, to withstand the disturbing action of vibration due to the movement of such load; while parts of steam engines are subject to constant reversals of direction of stress, being thus placed in tension and compression alternately, this last being the most destructive kind of stress, and therefore calling for the greatest margin of strength.

However the load may be disposed—uniformly or otherwise—the direct stresses upon each element of the structure or machine are readily ascertained by means of simple formulæ derived from mathematical analysis of the conditions under which they are produced, and it is with these direct stresses and their resultants that we have to deal; but the mode of application of load will materially affect the calculations.

In the first case, that wherein a permanent unvarying load is sustained, procedure is very simple when the intensity of the load has been ascertained and its distribution. The weight of materials being known, that of the load is easily calculable from its dimensions; but what are the correct dimensions may not always be obvious at first sight. Take, for example, the case of a girder carrying a dead wall over a passage: it becomes a question to decide how much of that wall the girder will be required to carry. Assuming the wall to be built of brick, in ordinary mortar, it is evident that during its erection, and until the mortar has set, the load will be equal to the span of the beam multiplied by the height and thickness of the wall and specific weight of the material; but after the mortar has set, the girder might be removed, and only a portion of the wall would come away, which would be in a more or less triangular form. Hence it is evident that if the girder is designed to carry the whole of the wall above it, metal will be wasted in regard to the load to which it will be permanently subject. If, therefore, the greater load be taken as the basis for calculation, a stress closely approaching the limit of elasticity of the girder material may be allowed, as we know that with the consolidation of the brickwork the load on the girder will be reduced. The difficulty that may appear if another course is taken—that of designing the girder to carry its permanently settled load—the difficulty of determining the actual amount of such load confronts us. It is not easy to say exactly what are the boundaries of that portion of the wall which, unsupported, would fall away, but this matter can be disposed of by putting in an arch over the girder, and so limiting the area of wall resting upon the latter. It may appear that the arch might be used instead of the girder, but we are assuming that there is not room for an arch below the top of the opening, of which the beam would form the lintel.

In works such as bridges, which are subject to loads causing much vibration, the stability is to be ensured by the introduction of stiff lateral bracing, but the proportions of these are usually determined from practical considerations, as the actual amount of strain due to load can seldom be fixed. The injurious effect of a rapidly-moving load will, in an ill-designed structure, be exhibited in deteriorated joints, on account of the unequal shearing action on the different rivets; hence at least 10 per cent more rivet area than the direct strains require should be put into joints at which the connected elements—such as lattice-bars—tend to alter their angles under a load. For roadway bridges, carrying heavy mixed loads, the calculations should be made for the actual maximum load, plus 20 per cent of the moving load.

Passing from structures to machines, a quite different set of conditions is found, the strains on most of the moving parts being constantly changing in character, in which case each element must be designed to resist that class of strain for which its material is least suited. Thus, cast-iron elements must be designed to resist the tensile forces to which they will be subject, and those of wrought iron for compressive forces, as cast iron is weakest in tension, and wrought iron in compression. Percussion has also to be considered in proportioning some classes of machinery.

The simplest forms of stress with which the engineer is called upon to deal are the tensile and shearing. In these the stress determined by theory and the working strength of the material are all that have to be considered; but when compressive force comes into action the length of the element in proportion to its width must be considered. The resistance of materials to crushing strain has not been brought under any abstract law, probably on account of our imperfect knowledge of the exact relations of the intermolecular forces. It is easy to frame hypotheses, but these really must be based upon assumptions of a state of things that is necessarily imaginary. Under tensile force it can be clearly seen that the number of molecules to be pulled asunder will vary as the cross sectional area of the body operated upon, and therefore its strength will vary as that sectional area; but when the material is under compression the molecules must be wedged apart, or else the body bent and broken across by giving more on one side than the other, and as we do not know which occurs, we can form no conclusive theory. Under these circumstances, it is necessary to have recourse to empirical formulæ—*i.e.*, formulæ derived from experiment—of which many have been determined for different sections of iron. These are to be found in most engineers' pocket-books. There are some cases in which the question of ratio of length to breadth need not be considered, as, for instance, in the rigidly-formed flanges of plate girders, though for the elements of lattice and trussed girders and similar work the appropriate formulæ must be used.

The piston and connecting rods of steam engines, and reciprocating rods of various machines, will require to be treated as struts when of wrought iron; and such parts being liable to shocks on changing direction and from other causes, not more than one-tenth the breaking strain should be allowed for working stress. This is what has been found satisfactory in the best modern practice.

In dealing with the stresses caused by impact, a blow cannot be compared to a load at rest. There is no such thing as the weight of a blow; it can only be measured by the "work" done; and to compare its effect with that of a load upon, say a beam, it must be done by calculating the deflection it would be capable of producing, and ascertaining the load that would produce a similar deflection.

MR. WARREN DE LA RUE.

We learn with regret the death of Mr. Warren de la Rue, which occurred on Friday, the 19th ult. He was well known —a commercial man, and the head of the London firm of De la Rue and Co., as well as a distinguished scientific worker, and the inventor of many processes of great practical utility. He was born in Guernsey, in the year 1815, and educated in Paris; he succeeded his father as the head of this firm, from which he retired in 1880.

He has done a great deal of good scientific work in astronomical photography, and on solar physics, and in 1860 he accompanied the Himalaya expedition to Spain to observe the phenomena accompanying the total eclipse of the sun, and was successful in obtaining an admirable series of photographs, the results of which formed the subject of the Bakerian lecture delivered to the Royal Society in April, 1862. In conjunction with the late Professor Balfour Stewart and Mr. B. Lowry, he published "Researches on Solar Physics."

In 1874 he fitted up a private physical laboratory, where, employing a battery of 15,000 chloride of silver cells, he has, in conjunction with his friend, Dr. Hugo Müller, carried on an elaborate series of researches on the electrical discharge. The results of the researches have been from time to time communicated to the Royal Society and the Académie des Sciences, Paris. "The Phenomena of the Electric Discharge" was also made the subject of a most interesting lecture, illustrated by a great number of experiments, at the Royal Institution in 1881. Nearly all the results of Dr. De la Rue's scientific work have been embodied in papers and memoirs, which will be found in the "Transactions" of the Royal Astronomical, Chemical, and other learned societies. He acted as juror and reporter in the Department of Class XXIX. in the Great Exhibition of 1851, was a juror in Class X. of the Paris Exhibition of 1855, and presided over Section B, Class XXVIII., of the Exhibition of 1862. He was a member of the International Electrical Congress, consisting of all the most eminent physicists of all countries assembled in Paris, and of the jury of the Electrical Exhibition held there in 1881. He was also a member of the Consulting Council of the Electrical Exhibition held at the Crystal Palace, Sydenham, in 1882. He has held office in several societies. He acted for some time as honorary secretary of the Royal Astronomical Society, of which he was also president from 1864 to 1866. He was president of the Chemical Society from 1867 to 1869, and again in 1879-88, and was till his death one of its vice-presidents. He was for many years president of the London Institution, from which he retired and became secretary of the Royal Institution in 1878, on the retirement of Mr. Spottiswoode, who was elected president of the Royal Society, but resigned the post in 1882. He was a corresponding member of the French Académie des Sciences for the department of astronomy;

also of the Imperial Academy of Sciences, St. Petersburg, the Philomathic Society of Paris, the Royal Society of Upsala, the Society of Agriculture and Commerce, Caen, the Society of Natural Science, Cherbourg, and the Berlin Chemical Society.

DANGERS OF NEW YORK STREETS.

A correspondent of the Manchester *Examiner and Times* states that New York is becoming unpleasant as a place of residence. Danger hovers not only overhead, but lurks also underground, and a stroll through the principal thoroughfares of the city frequently furnishes as much excitement as a walk along the edge of an active volcano. Not a day passes without a break in the mains of the Steam-heating Company, which supplies both heat and power to all the principal buildings of the city. The pipes form a perfect network under the streets, and, owing to the enormous pressure of steam, constantly explode with a loud noise, hurling fragments of stone and quantities of mud, mingled with steam, into the air, for all the world like a miniature Mount Etna. The eruption continues until the steam in that particular quarter of the town is shut off, leaving all the elevators and many of the printing and cutting presses without motive power. Occasionally a tramcar horse tumbles into the hole, and is quickly boiled to death by the escaping steam. Last Wednesday afternoon I counted no less than three of these escapes within a five minutes' walk. Nor is this all. The great mains of the metropolitan gas companies are so defectively put together that there is an enormous amount of leakage. In fact, the whole soil becomes impregnated with gas, which invades the subways of the electric companies to such an extent that the line-men of the latter have to use the utmost precaution before venturing underground. Of course, if there is the slightest break in the electric conduits, and an arc is generated, the gas is bound to become ignited, and disastrous explosions result therefrom. Thus, in the explosion which occurred on Broadway last week, right in front of the Fifth Avenue Hotel, the coblestones and pavement were torn up thereby for a distance of over 200ft., while the enormously heavy iron caps and covers of the manholes were blown up into the air like so many skyrockets. When one saw the wreck produced by the explosion, it was impossible to comprehend how there had been no loss of life. But should such an accident occur during the parades in honour of the centennial celebration at the end of this month, when both Broadway and Fifth Avenue will be densely crowded with the people, not only of the city, but also from all parts of the country, the consequences will be appalling. Of course, the only means of obviating the present danger is to construct huge subways under every street large enough to contain, not only the electric wires, but also all the gas, steam, water, and sewage mains, so that they might be subjected to daily inspection, and be repaired without tearing up the whole street. Of course, this would demand an enormous expenditure of both time and money. Meanwhile Jay Gould and the other proprietors of the Western Union Telegraph Company, together with the Electric Light Corporations, have seized upon the explosion in front of the Fifth Avenue Hotel as a pretext for refusing to comply with the municipal regulations which demand that their wires should be run underground instead of overhead. The fact is, that not only are the huge telegraph poles which line every street exceedingly ugly and ungainly, but they also constitute a great danger. The wires are constantly breaking, and, especially in the case of the electric light and telephone lines, which carry a powerful current, have caused the death of numerous men, as well as horses, who have inadvertently come into contact with the broken circuit. Another plea put forward by Jay Gould for his refusal to comply with the municipal demands for the burial of his wires does great credit to his casuistry, but is somewhat strained. The Charter of Incorporation granted by the United States Government to the Western Union Telegraph Company authorises the latter to run its wires, strung overhead, along all the post and mail roads of the Union. Jay Gould contends that the streets of the city of New York are all nothing but United States post roads, and that, therefore, he is entitled to disregard the municipal laws. Nor do the wires constitute the only danger which hovers in the air. There are the railroad trains hurtling along overhead on slender iron columns. Although the greatest care is exercised, yet iron nuts and bolts, hot cinders, and oil are constantly dropping on the heads of the people in the street. If ever a girder gives way, or a wheel or an axle of one of the trains breaks, there is absolutely nothing that can prevent the cars and the passengers from being precipitated down into the streets below.

ANOTHER NIAGARA SCHEME.

Just now the schemes for utilising the great power of Niagara are almost numberless. The following, from the *Tribune*, may be found of interest: It is a law of hydraulics that the power at the bottom of a column of falling water may be obtained at the top as well, provided the column falls through an air-tight shaft or pipe. The suction is equal to the momentum. A turbine wheel, in other words, receiving the inflow into a suction pipe, will run as much machinery as one receiving the outflow.

By utilising this law, Mr. Cristian J. Zeitinger, mechanical engineer, proposes to get rid of the inconveniences of placing and operating a power plant under Niagara Falls. His scheme is to locate a plant in the river above the precipice.

Mr. Zeitinger will undertake to swing by means of cable a coffer into the American channel about 150ft. from the edge of the falls, where the depth is from 10ft. to 12ft. The coffer is to be 120ft. long by 35ft. wide, and 25ft. or more in height. It will be constructed of three steel walls, the outer two supporting each other as a breakwater, and the space within the inner housing eventually the machinery and operatives. Its upstream end will be pointed like the prow of a boat. Sunk to the bed of the stream, the bottom of the coffer will be removed, and the space between the inner and next walls filled with concrete, which, with steel plate supports, will be extended into the irregularities of the bed rock, so as to make an effective dam against the outside water. The water in the interior will then be pumped out. By building in a bulkhead of masonry, set in a suitable excavation, the coffer will be permanently anchored to the bed rock.

From the stern of the dry interior a shaft 18ft. in diameter will be sunk vertically downward through the 90ft. of limestone. The shaft will then be run horizontally down the stream until it opens on the face of the precipice. A suction pipe put through the shaft, inlet openings connecting with the pipe made in each side of the stern of the coffer, turbine wheels placed between the two openings and the head of the pipe, and the plant will be ready to convert the power of Niagara to use. Dynamos of from 350 to 500 H.P., located in upper stories of the coffer, will receive the power from the turbines. An underground tunnel leading from the shaft will conduct it ashore. By duplication of the coffers a practically unlimited power may be obtained.

PROPOSED MEMORIAL TO W. SYMINGTON.

A committee—of which the Earl of Hopetoun is president, and Mr. John Williamson, of Leadhills, Lanarkshire, hon. secretary and treasurer—has been formed with the object of raising funds with a view to the erection of a memorial at Leadhills, his native place, to William Symington, the inventor of the present system of steam navigation. Symington was born in 1764, and was intended for the ministry; but his taste for mechanics defeated that intention. In the circular which they have issued appealing for subscriptions the committee point out that before completing his twentieth year, and while employed at the Wanlockhead mines superintending one of Watt's engines, Symington conceived the idea that the steam engine could be rendered available for the propulsion either of land carriages or boats—an idea he afterwards embodied in a working model, which was exhibited at Edinburgh, where it was seen by Mr. P. Miller, of Dalswinton. The result of this interview with Mr. Miller was Symington's partially successful experiments in propelling a boat on Dalswinton Loch in 1788; and again, on a larger scale, on the Forth and Clyde Canal in 1789, when Mr. Miller's interest in the experiments suddenly ceased. In 1801 Lord Dundas, who was a large proprietor in the Forth and Clyde Canal, employed Symington to make a series of experiments on steamboats to enable them to be substituted for the horses then used to draw the vessels on the canal. The result of these experiments was the production of the "first practical steamboat," named the Charlotte Dundas, in honour of his lordship's daughter. In this vessel there was an engine with the steam acting on each side of the piston (Watt's patented invention), working a connecting rod and crank (Pickard's patented invention), and the union of the crank to the axis of Miller's improved paddle-wheel (Symington's patented invention). "From the establishment of this combination of machinery to a boat no material improvement has," says the committee, "even to the present time been effected either in this or any other country. Therefore the steamtug Charlotte Dundas may justly be termed 'the herald of a new and mighty power'—the pioneer of those magnificent fleets of steamers that plough every ocean and connect all lands, alike vastly developing the commerce and the intercourse of the world."

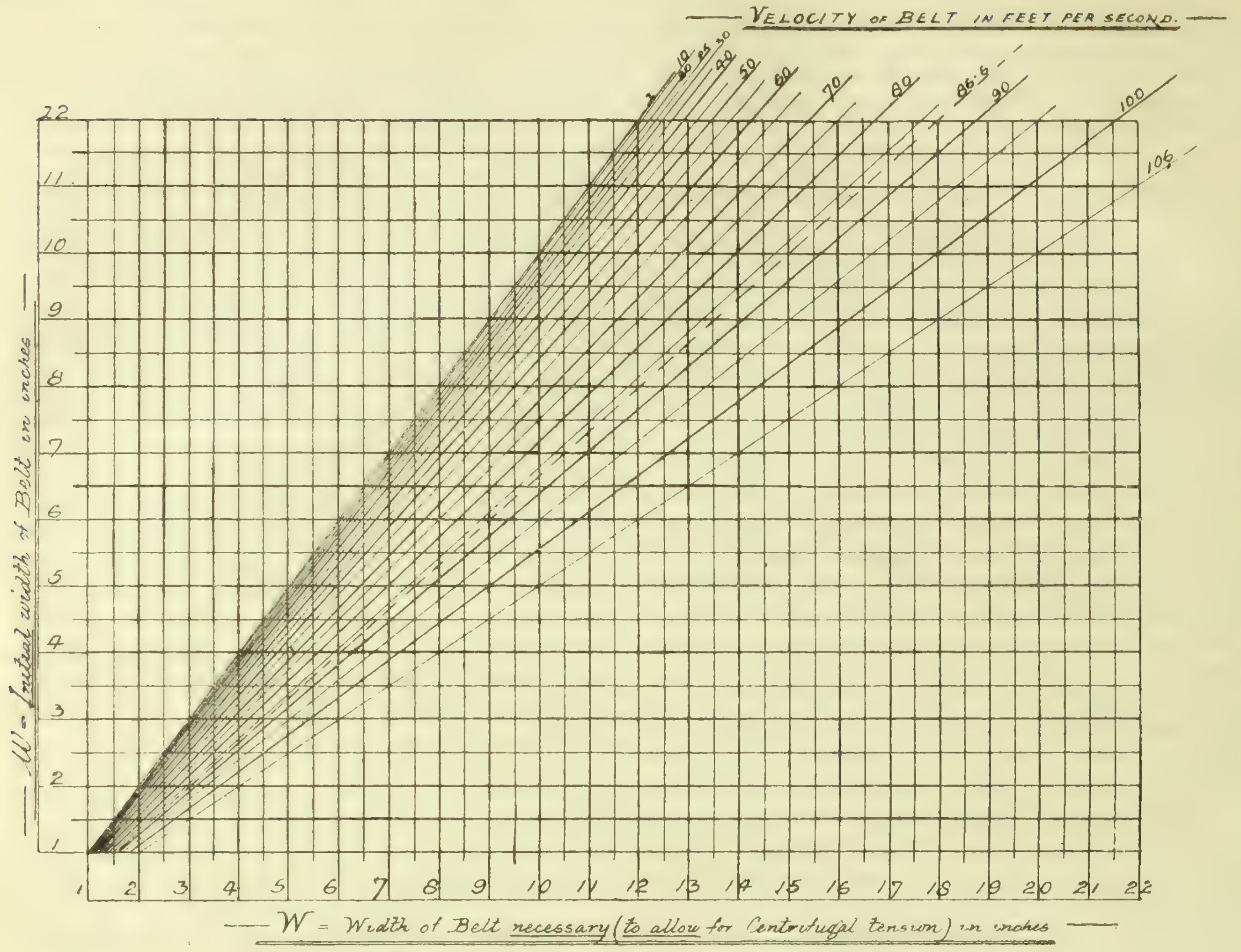


DIAGRAM No. 3.

BELT AND ROPE GEARING.—VI.

RULE FOR WIDTH OF BELT.

THE following rule will be found useful for the purpose of finding the width of belt necessary when the effect of centrifugal force is taken into account:—

Let w be the width of belt, as calculated from formulæ (23) or (25), which neglect the centrifugal tension, then the increased width W necessary—to allow for centrifugal tension—will be, when S = 300.

$$W = \frac{22{,}500}{22{,}500 - v^2} \times w = M \times w. \qquad (39)^*$$

In Table 2 will be found a number of values of M for different linear velocities of the belt. Or in preference, we may, with the aid of diagram (3) read off at once the width W when the linear velocity v and the lesser or initial width w is known.

Thus it will be seen that when $w = 10$in., and
$v = 50$ft. per second, that W = 11·25in.
$v = 100$ft. „ „ W would require to be 18in.
and if $v = 106$ft. „ „ W „ „ 20in.

TABLE No. 2.—For use when the nfluence of centrifugal force is considered.

LEATHER BELTING.

1. Velocity in feet per sec. v	2. Multipliers for sectional areas or widths. M.	3. Centrifugal Tension *per square inch* $=\frac{v^2}{75} = T_c$.	4. Reduced value of the stress (s) per sq. inch. S_a.	5. Product of columns 4 & 1, available stress × velocity $= S_a \times v$.	6. Col. 5 ÷ 550 $\frac{S_a \times v}{550} = y$.	7. Reciprocal of col. 6, $\frac{550}{S_a \times v} = z$.
		lbs.	lbs.			
0	1·00	0·0	300	0·0	0·00	—
5	1·0011	$\cdot\dot{3}\dot{3}\dot{3}$	$299\frac{2}{3}$	$1498{\cdot}\dot{3}\dot{3}$	2·72	·367
10	1·0044	$1{\cdot}\dot{3}\dot{3}\dot{3}$	$298\frac{2}{3}$	$2986{\cdot}\dot{6}\dot{6}$	5·43	·184
15	1·011	3·0	297	4455 00	8 10	·123
20	1·018	$5{\cdot}\dot{3}\dot{3}\dot{3}$	$294\frac{2}{3}$	$5893{\cdot}\dot{3}\dot{3}$	10·71	·0933
25	1·0285	$8{\cdot}\dot{3}\dot{3}\dot{3}$	$291\frac{2}{3}$	$7291{\cdot}\dot{6}\dot{6}$	13·25	·0755
30	1·0416	12·0	288·	8640·00	15·71	·0637
35	1·0575	$16{\cdot}\dot{3}\dot{3}\dot{3}$	$283\frac{2}{3}$	9928 33	18·05	·0554
40	1·0765	$21{\cdot}\dot{3}\dot{3}\dot{3}$	$278\frac{2}{3}$	$11146{\cdot}\dot{6}\dot{6}$	$20{\cdot}2\dot{6}$	·0493
45	1·0989	27·0	273	12285·00	22·34	·0448
50	1·125	$33{\cdot}\dot{3}\dot{3}\dot{3}$	$266\frac{2}{3}$	$13333{\cdot}\dot{3}\dot{3}$	24 24	·0412
55	1·155	$40{\cdot}\dot{3}\dot{3}\dot{3}$	$259\frac{2}{3}$	$14281{\cdot}\dot{6}\dot{6}$	25·96	·0385
60	1·19	48·0	252	15120·00	27·49	·0364
65	1·2311	$56{\cdot}\dot{3}\dot{3}\dot{3}$	$243\frac{2}{3}$	$15838{\cdot}\dot{3}\dot{3}$	28·79	·0348
70	1·278	$65{\cdot}\dot{3}\dot{3}\dot{3}$	$234\frac{2}{3}$	$16426{\cdot}\dot{6}\dot{6}$	29·86	·0335
75	$1{\cdot}\dot{3}\dot{3}\dot{3}$	75·0	225	16875·00	30·68	·0326
80	1·397	$85{\cdot}\dot{3}\dot{3}\dot{3}$	$214\frac{2}{3}$	$17173{\cdot}\dot{3}\dot{3}$	31·22	·0321
85	1·473	$96{\cdot}\dot{3}\dot{3}\dot{3}$	$203\frac{2}{3}$	$17311{\cdot}\dot{6}\dot{6}$	31·47	·03177
86·6	1·5	100·	200	17320·00	31·49	·03174
90	1·5625	108·	192	17280·00	31·42	03182
95	1·67	$120{\cdot}\dot{3}\dot{3}\dot{3}$	$172\frac{2}{3}$	$17068{\cdot}\dot{3}\dot{3}$	31·03	·0322
100	1·8	$133\ \dot{3}\dot{3}\dot{3}$	$166\frac{2}{3}$	$16666{\cdot}\dot{6}\dot{6}$	30·30	·033
150	Infinity.	300·0	0	0·00	0·00	∞

NOTE.—This table has been calculated on the basis of S = 300lb. per sq. in.

The necessary allowance for the effect of centrifugal tension may also be made in the following manner: Having arrived at a

---

If S = maximum stress allowed.
S_a = available stress (after deducting centrifugal stress). See Table 2, column 3, and formula (40).

That is,

$$S_a = S - \frac{v^2}{75} = \frac{75S - v^2}{75};$$

and for any given thickness in each case it may be seen that

$$S \times w = W \times S_a = W \times \frac{75S - v^2}{75}$$

Therefore,

$$W = \frac{75 \times S}{(75 \times S) - v^2} \times w \qquad 38a)$$

iving S a value of 300, we obtain

$$W = \frac{22{,}500}{22{,}500 - v^2} \times w \qquad 39)$$

values for

$$M = \frac{22{,}500}{22{,}500 - v^2}$$ being given in Table 2.

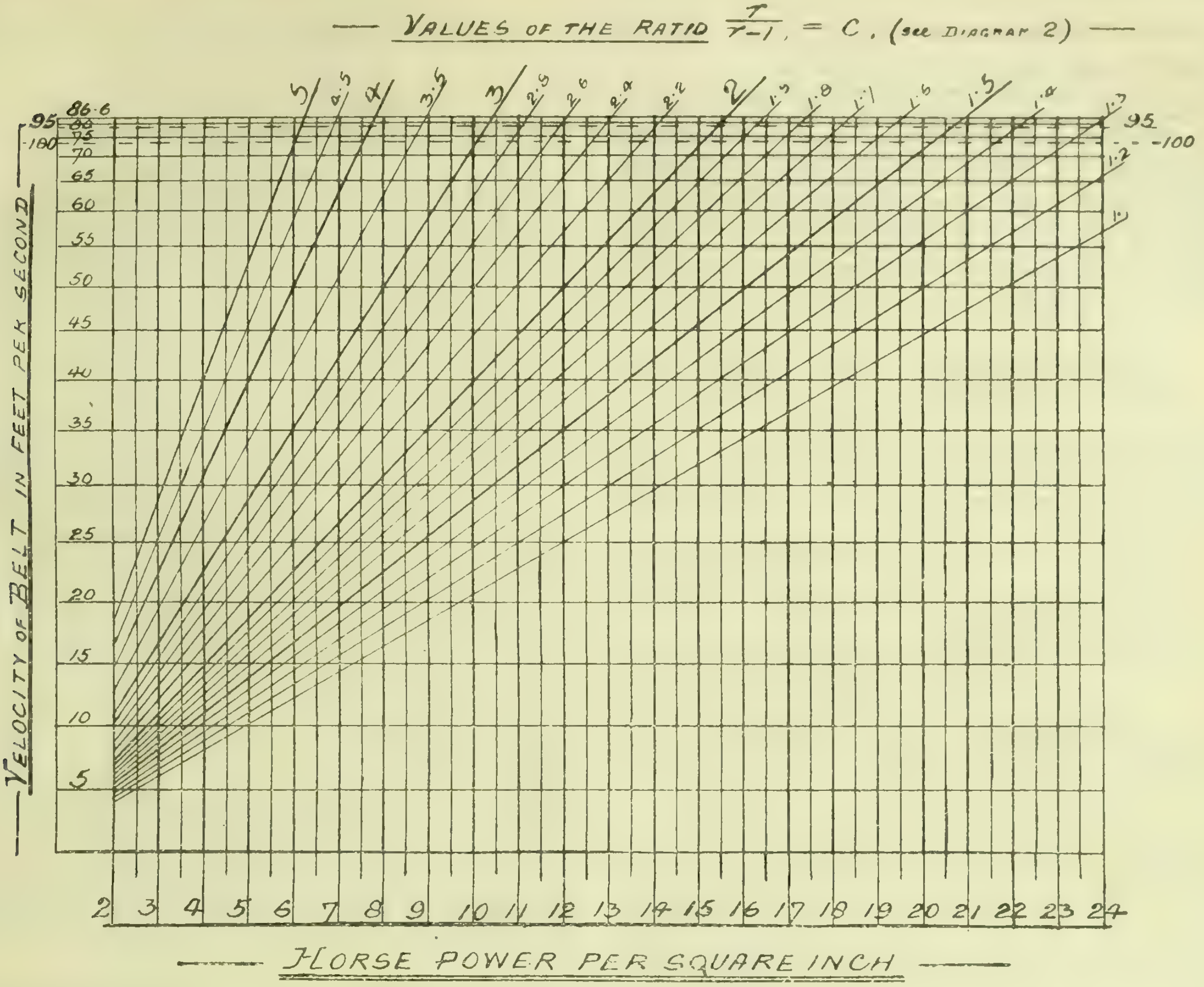


DIAGRAM No. 4.

determination of the greater tension T, in the manner shown in formula (20), we may then find very readily the necessary area of belt, when centrifugal force is neglected, by dividing the tension T by the maximum allowable working stress s; but on considering for a moment the effect of the said force upon a belt one square inch in sectional area, we may arrive at a just conclusion that the stress available for work is equal to the difference between the allowable working stress and the stress due to centrifugal tension, so that the available stress—

$$s_a = 300 - \frac{v^2}{75} \qquad (40)$$

where 300 is the allowable working stress, and v represents the linear velocity in feet per second.

In Table 2, column 4, will be found the values of this available stress for different velocities.

So that, when using formulæ (22) and (24), if we substitute for s the proper value of the available stress (S_a)—due to the velocity—we may obtain the required area of belt when due allowance has been made for the effect of centrifugal tension; that is to say—

$$\text{Area of belt A} = \frac{T}{S_a} = \frac{T_2}{S} \qquad (40a)$$

Taking formula (22), and substituting s_a for s, we may write

$$A = HP \times c \times \frac{550}{S_a \times v},$$

and therefore, as we may for the sake of simplicity put z in the place of the fraction $\frac{550}{S_a \times v}$ (see column 6, Table 2), we may say

$$\text{Area A} = HP \times c \times z, \qquad (41)$$

or,

$$HP = \frac{A}{c \times z};$$

and as z = the reciprocal of y (see Table 2), we obtain

$$HP = \frac{y}{c} \times A;\ i.e., = \frac{y}{c} \text{ per square inch of section,}$$

the values of y being got from Table 2, and those of c from Diagram II.

Diagram IV. gives at sight the horse power per square inch of section for different values of c and various velocities v.

"CREEP" OF BELTS.

The loss of velocity or "creep" due to the elasticity of the belt should not be confounded with that due to a want of adhesion between the belt and the pulley, the latter being "slip" of a more positive nature, similar, in fact, to that of the driving wheel of a locomotive when working upon a wet or greasy rail.

From a number of carefully-made experiments on leather, the amount of creep has been found to average about 3 per cent, under more or less ordinary conditions, although in some cases a loss of velocity as high as 5 per cent, and in others as low as 1 per cent, has been observed. I am of opinion that an allowance of about 3 per cent for creep will in most cases be a favourable one, and probably within the mark, as theoretical deductions give a value far less than this.

In order to make the subject under this head a little more clear, I have endeavoured to reason the matter out, and as a result of the investigation I am of opinion that the velocity of rim of driven pulley is equal to the velocity of rim of driving pulley multiplied by

$$\frac{t_s + E}{T_s + E} \qquad (45)$$

Where E represents the modulus of elasticity 24,300lb.,*

T_s = stress per square inch on the driving or tight side.
t_s = stress per square inch on the following or slack side.

This may be reasoned out thus:

The strain, or stretch, produced on the slack side is equal to $\frac{\text{stress } t_s}{E}$; and on the tight side by $\frac{\text{stress } T_s}{E}$; the increase in a unit length of band, therefore, would be $1 + \frac{t_s}{E}$ and $1 + \frac{T_s}{E}$ respectively, the latter being of course the greater.

---

* This is value given by Professor Rankine. Other authorities place the value of E as low as 9,500 for new belts.

Now, as the weight of belt received by the driving pulley must be equal to that received by the driven pulley—*i.e.*, each receive equal weights of band—and as the surface of the driving pulley travels at the same velocity as that of the tight side, while the velocity of the surface of the driven pulley is the same as that of the slack side; and again, as a unit weight of band must in the case of the tight side be longer than that of an equal weight on the slack side, it follows that the velocity of the driving pulley must be greater than that of the driven in the proportion of $1 + \frac{T_s}{E}$ to $1 + \frac{t_s}{E}$; that is to say—

$$\frac{\text{Velocity of driving pulley}}{\text{Velocity of driven pulley}} = \frac{1 + \frac{T_s}{E}}{1 + \frac{t_s}{E}} = \frac{E + T_s}{E + t_s} \qquad (46)$$

From this the above formula (45) is readily obtained.

On working out a hypothetical case—viz., where $T_s = 300$lb. per square inch, $t_s = 113{\cdot}33$lb. per square inch, and $E = 24{,}300$—we obtain as a result

$$\text{Relative speed of driven pulley} = \frac{113{\cdot}33 + 24{,}300}{300 + 24{,}300} \qquad (45)$$

= 99·24 per cent of that of the driving pulley, or a loss due to creep of less than 1 per cent.

If E be taken at the lower value, viz., 9,500, we should have

$$\text{Relative speed} = \frac{113{\cdot}33 + 9{,}500}{300 + 9{,}500}$$

= 98·1 per cent (nearly), or a loss of about 2 per cent.

This loss of velocity or creep will, it will be apparent on consideration, result in a corresponding loss of power.

Rigidity or Stiffness of Belts or Cords.

In determining the various losses of power which affect the theoretical investigations that have been considered, the influence which the rigidity of the belt or cord has upon the efficiency of the system should not be lost sight of, as it may be easily shown that the rigidity of the conductor, be it rope or belt, cannot but have a diminishing effect upon the power transmitted, but the loss under this head may be materially lessened by the use of large pulleys, as they materially lessen the curvature of the rope or belt.

The loss of work from the rigidity of a belt varies in direct proportion to its width and the square of its thickness, and inversely in proportion to the diameter of the pulley on which it is wrapped; that is to say,

$$\text{Rigidity} \propto \frac{\text{width} \times \text{thickness}^2}{\text{diameter of pulley}}.$$

In the case of ropes—

$$\text{Rigidity} \propto \frac{\text{diameter}^3 \text{ (of rope)}}{\text{diameter of pulley}}.$$

MEXICAN RAILWAYS.

According to an official report, Mexican railways have been costly undertakings, owing to the engineering difficulties met with in constructing them, but they have contributed greatly to the prosperity of the country by making its resources available and opening new districts for colonisation. The oldest line in Mexico, the Mexican Railway, connects the capital city with Vera Cruz, and is some 300 miles in length, and is laid in a manner that would compare favourably with any railway in England for finish and solidity of construction. The line with greatest mileage is the Mexican National Railway, extending about 2,000 miles, but its usefulness is greatly impaired by the narrow gauge which has been adopted, thus putting it practically out of touch with other systems. The next in importance is the Mexican Central Railway, connecting Paso del Norte with Mexico, with a main line of 1,223 miles in length. Like the other lines, it is well constructed. The other railways are the Mexican International Railway, open from El Paso to Torreon, a distance of 517 miles, but with easier gradients than the lines previously named; the Inter-Oceanic Railway, intended to connect the Atlantic and Pacific through the capital, of which 240 miles were open when the report was compiled; and the Mexican Southern Railway, with which small progress has been made up to the present time.

ELECTRICITY ON TRAMWAYS.

The Problem of the Gearing.

A paper on this subject was read before the Institution of Civil Engineers' Association of Birmingham Students, on March 13th, by Mr. T. Arnall.

In commencing, the author pointed out the difficulties in transmitting the force exerted by the motor to the axles of the car, and stated that several methods had been tried, but all proved more or less unsatisfactory. The motor, without being exactly a delicate piece of machinery, was liable at times to get out of order, as the shocks to which the cars were subjected were greater on tramways than on railroads, owing to the rigid foundations of the rails. The simplest solution of the difficulty seemed to be to get the driving spindle low down, and as nearly as possible on the same level with the car axle which had to be driven, and drive it by means of a pitch chain. The chain was perhaps of more importance than the wheel; many forms had been used, but the one practical form was that consisting of a series of flat links spaced half an inch or so apart, and connected together by rivets or pins, which the teeth of the driving wheel engaged. There were two types of chain used at present, viz., the Gall chain and the Renold chain. The methods of taking up the play in the chain were next described, and several instances were given. Chains were objectionable, as the links stretched and the joints worked loose, but they had to be used in default of something better. Ordinary spur wheels were not generally used on account of the motion of the car on the springs; but the author had known them used in Wilkinson's steam engines for some years. As an alternative where spur gearing is used the motor might be suspended from the car at the other end, as was extensively done in America in tramways made on the Sprague system. Instead of plain spur teeth, however, V-shaped helical teeth should be used, as these were so much smoother and silent in their action. The author then spoke of driving by means of screw and worm wheel gearing. This, although it absorbed a large amount in friction, yet for reducing the quick motion of the armature to the slower motion of the car it seemed well adapted. About five years ago Mr. Reckenzaun used the screw and worm gear on his experimental car in London, and it was used at first on the Blackpool cars, but had since been relinquished in favour of the chains.

The only other gearing which had been practically applied was that used on the Elieson electric engines on the North London tramway at Stratford, in which the spindle of the armature carried a pinion which geared into a circular fixed rack, and so the rotation of the armature carried the motor bodily round on a vertical axis, and the motion was transmitted by means of bevil wheels. Engines with this gearing had run over 50,000 miles, and had never failed. The only objection to it was that it took up so much room, and could not conveniently be placed underneath an ordinary car.

The author then returned to the question of chain and spur wheel gearing, and the points which were necessary in their working.

The principles of several kinds of electrical trains were described, among which were the Bessbrook and Newry, and the Bentley-Knight, in which latter only a single motor was used, a double motor truck never being used only when there was exceptionally heavy work to be done.

In cases where both axles were driven from one and the same motor, there was an extra amount of friction brought into play, as the wheels, though made the same size at first, did not wear equally, and he showed that if the hind wheels were only $\frac{1}{10}$th of an inch larger than the leading wheels, these hind wheels would travel, or try to travel, 3·14in. in ten revolutions; but since they were geared up so that they must revolve together, the hind wheels would be pushing the front wheels forward, and *vice versa*, and therefore some of the power which should be used in making the wheels roll was being wasted in making them slide, and in extra wear and tear. These sources of wasted energy could be avoided by using two motors, and driving each axle separately; but there were also many objections to two motors, such as increased friction surface, and two sets of gearing to keep oiled and cleaned.

In conclusion, the author stated that although screw wheels had proved unsuccessful on the Blackpool tramway, yet they had proved successful on Mr. Reckenzaun's cars. At Blackpool, all the work was thrown upon one screw; and bearing in mind the quality of the platelaying, the result, under such circumstances, would be decidedly unfavourable to the use of screw gearing.

HIGGINSON'S SPEED REGULATOR.

The invention and design of efficient forms of steam-engine governor have much occupied the attention of many able and not a few distinguished engineers; indeed, we can recall but few names of inventors of note in mechanical matters who have not at one time considered the problem of producing a perfect engine governor. The problem is an exceedingly difficult one, and notwithstanding so great an amount of sustained effort it is still a matter upon which the best trained and most practical engineers differ considerably. The centrifugal governor of Watt forms the basis of the best types, although many attempts have been made to introduce other modes of speed regulation. We have examined for instance, engines governed by means of an air pump compressing air into a small chamber and actuating a piston communicating motion to the throttle valve. Any change of speed increased the pressure of the air, and so forced the throttle valve piston against a weight or spring, and gave power to open or shut it; an adjustable blow-off allowed the pressure to leak off the reservoir, so that when running too slow the air pressure fell, and when running too fast it rose again. We have also examined the "Chronometric governor" at work, one of the earlier inventions of the late Sir C. W. Siemens, a most ingenious contrivance, but too expensive and complex for commercial success. Sir William Thompson's friction governor, although admirable in theory, is not well adapted for practical work, at least in the control of engines. All these methods have failed to displace the Watt governor, from difficulties mostly of a practical and commercial kind. Theoretically it is possible to make a centrifugal governor perfectly isochronous, but practically too great sensitiveness produces hunting, a trouble too well known to engineers, and difficult to avoid except at the expense of loss of rapid control.

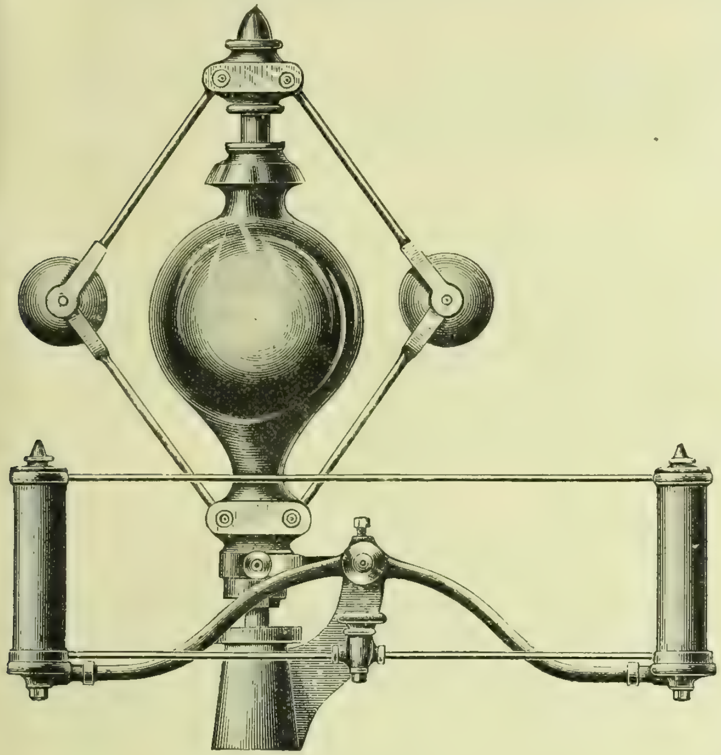


Fig. 1.

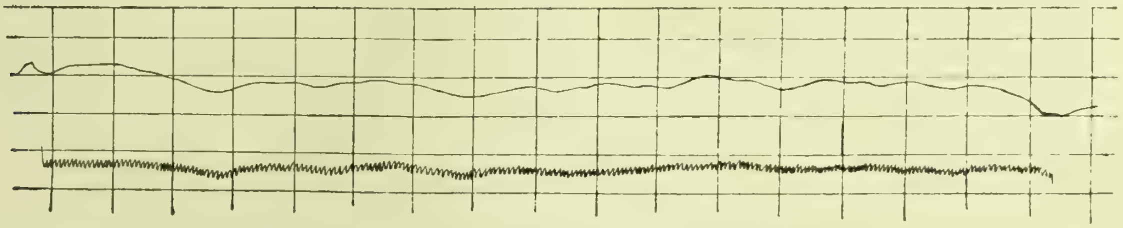


Fig. 2.

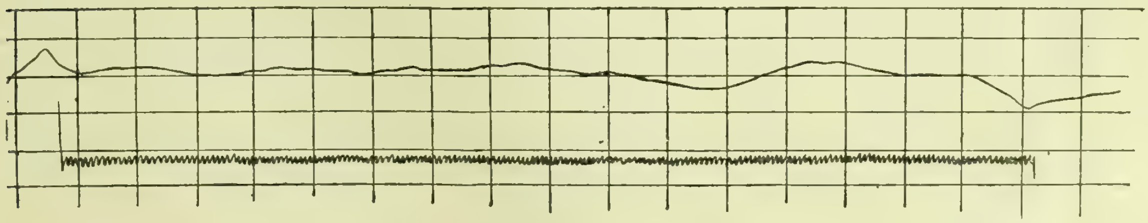


Fig. 3

We have recently examined a very ingenious and clever speed regulator, which is exceedingly simple and admirably efficient in its action. It is the invention of Mr. J. Higginson, and is easily applicable to all centrifugal governors at a very slight cost. Mr. Higginson does not seek to invent a new form of governor, but in the simplest possible manner he corrects the defects of the ordinary governor, and raises it from a somewhat inefficient regulator to a very powerful and efficient one, which has a complete and rapid control of the rate of the movement of the engine entrusted to its care.

In all practical forms of engine governors the speed must change to some extent to produce change in the position of the governor balls. At a constant load, and with a constant steam pressure, the speed of any engine will remain constant, and the balls will revolve in one plane without change. If, however, a greater load be placed upon the engine, the speed will fall until the change of position of the governor balls is sufficient to allow enough steam for the required additional power; that is, if the greater load be kept on continuously, then the speed will remain continuously less than with a light load. If some weight could be added to the governor balls, if an ordinary Watt governor—or to the weight, if the loaded or Porter type—then the speed could be made to rise to the same rate as with the light load. The first effect of adding weight to the governor balls is to admit more steam, by causing the balls to fall, and therefore the speed of the engine increases. To make it perfectly plain; suppose we have an engine with a throttle valve, controlled by a Porter governor, as in fig. 1, running with a load of say 500 horse power, at 65 revolutions per minute; increase the load to 700 horse power, and the engine slows down slightly until it settles at a speed when the supply of steam is sufficient to indicate that power. Suppose the speed to be 62 revolutions per minute. The governor balls have now fallen a certain amount in order to open the throttle valve sufficiently. If a weight be now added by hand to the governor, as can be done in some engines, then the balls will fall still further, and increase the opening of the steam. The speed of the engine will at once increase, and when the balls have risen to the same position as before adding the weight, with the throttle opened to the same extent, the speed will be higher than before, and if sufficient weight be added, the speed can be raised to the same as existed with the load of only 500 horse power. In the same way, if the load be reduced from 700 to 500 horse power, or from 500 to 300 horse power, the speed will increase until the governor is in such position that the throttle is sufficiently closed; but here, also, the speed can be reduced by taking off the added weight, when it would become the same as at first.

Within the limits of the power of the engine the speed can be increased for any position of the governor balls by increasing the load which the balls require to move, and diminished by diminishing that load. Mr. Higginson clearly saw that if an automatic method could be devised to do for the governor that which we have just described as being accomplished by hand—namely, to add weight to the load resisting the governor balls when the engine ran too slowly, and to abstract weight when it ran too fast—then very much greater regularity would be attained; and he has succeeded in accomplishing this in an exceedingly simple and efficient way.

Referring to our illustrations, fig. 1 is a general view of Higginson's new speed regulator, and fig. 4 a sectional view, showing its action as applied to the Porter or loaded type of governor. Two cylindrical vessels, closed at the top and bottom, communicate with each other by small tubes top and bottom, as shown. They are firmly connected by a balanced double-ended lever, which has at its centre a boss bored out to fit the governor rocking shaft, to which it is keyed or attached in any other suitable manner. Mercury is placed in them, but not in such quantity to fill both.

When the governor is in its central position, intermediate between the extreme positions of its travel, the forked lever causes the rocking shaft to bring the two cylinders vertical and the pipes connecting them level. The level of the mercury then stands to fill each cylinder equally. But any deviation from this position causes the mercury to fill one or other of them the more completely, and although in all positions the level of the mercury remains constant, the weight varies. When the speed falls, and governor balls fall, to open the throttle valve, then the increased weight of mercury in one cylinder acts to increase the load upon the governor balls, and the speed keeps nearly constant. On the other hand, when the speed increases and the balls rise, the mercury flows more and more into the empty vessel, and thus diminishes the weight acting against the balls, and so diminishes the speed. A stopcock is placed upon the lower tube to adjust the rate of flow, so that the mercury may not run too rapidly from one vessel to the other, and the upper tube serves to allow free displacement of air from one vessel to the other. When the governor makes a change in position, the mercury rapidly diminishes or increases the weight acting against the rise or fall of the balls, and so adjusts the speed that it is very nearly constant in all positions.

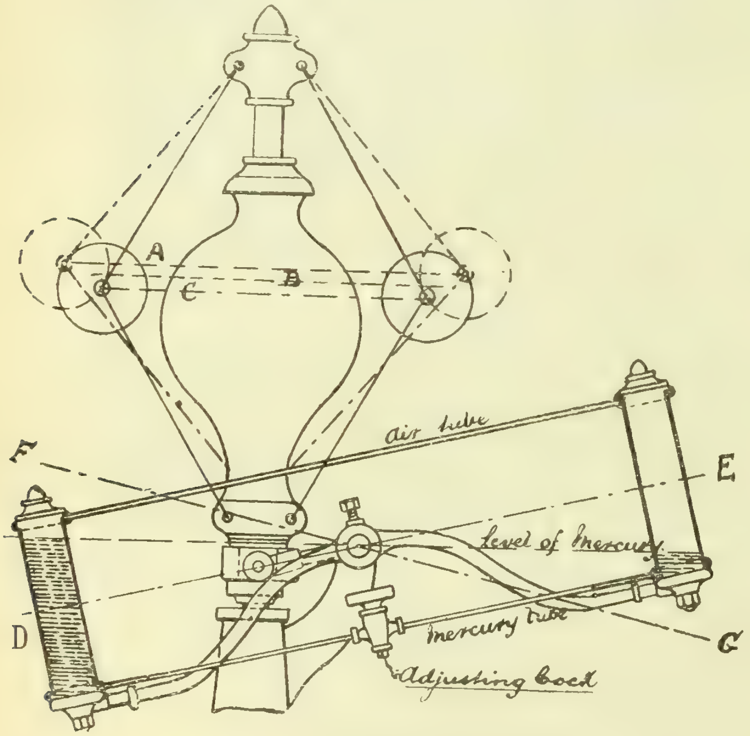


Fig. 4.

The three positions indicated are shown by the lines A, B, C on fig. 4, in which position A corresponds to F, G of the mercury vessels, and C to D, E.

The advantages of this apparatus over mechanical contrivances to effect a similar end are very obvious, as there is no mechanism and no moving parts to wear or get out of order. Its cheapness, simplicity, and efficiency are so great that we are not surprised to hear that ninety are now at work, notwithstanding the short time elapsing since its invention. Fig. 2 is a "Moscrop" diagram taken from an engine before applying Higginson's regulator, and fig. 3 a diagram after its application. They prove that a variation of 5 per cent can be readily reduced to ½ per cent; a most satisfactory result to be accomplished by such a simple method.

Perfect regularity of speed is guaranteed whatever the variation of steam pressure and load within the power of the engine.

Further particulars may be had from Mr. James Williams, 80, Deansgate, Manchester, who is now manufacturing the regulator.

THE TRANSMISSION OF POWER BY ELECTRICITY.

(Continued from page 253.)

Let me give a practical illustration. Suppose we have a motor, the efficiency of which is 90 per cent at 400 volts electro-motive force and when developing ten horse power, and that we wish to transmit this ten horse power 5,000ft. from a station, and elect to lose about nine per cent on the line.

Our initial electro-motive force will be 440 volts, and we would have

$$\mathrm{C\,M} = \frac{15666 \times 10 \times 5000}{400 \times 40 \times \cdot 90} = 54396$$

which is about equal to a No. 4 B. W. G.

Again, suppose we wish to transmit five horse power over a distance of one mile on a complete metallic circuit of 45,000cm., allowing five per cent increase of length for sag., and no leakage. Suppose further that the initial line potential be 300 volts, and that we wish to have 250 volts at the motor terminals, it is required to find the commercial efficiency which the motor must have.

Transposing our formula we have

$$a = \frac{15666\, n\, l}{\mathrm{E}\, v\, \mathrm{C\,M}}$$

and substituting

$$a = \frac{15666 \times 5 \times 5544}{250 \times 50 \times 45000} = 76 \text{ per cent.}$$

This formula is useful in determining what we cannot as well as what we can do. For example, if we made the condition ten horse power, all others remaining the same, the commercial efficiency of the motor would have come out 152 per cent, a most excellent machine indeed, and yet it is precisely this absurd thing that people practically say they will do in many of the statements which are made in relation to this subject. No science admits of more easy determination of conditions by plain and simple laws, and none brooks less violation of them.

In considering the transmission of power, some very curious and valuable facts may be demonstrated by a formula for determining the minimum cost of plant, where the amount of power at the generating station is practically not limited, and where there is no line loss from leakage, the line loss being measured simply by the fall in potential.

The cost of a plant of this character can be divided into five parts, that of the motors, the conductors, the line erection, the dynamos, and the power plant, whether water or steam. I will assume that the cost of the dynamos and motors is the same per horse power or other unit, no matter what the electro-motive force used. While this is not strictly true, for all practical purposes with large units, and speaking from the commercial standpoint, it can be so assumed. This being the case, for any given power the cost of the motor is a constant, independent of the potential used. With any given motor potential, the greater the loss on the line the less the cost of the conductors, but the greater the cost of the generators. On the other hand, the less the loss on the line the greater its cost, but the less the cost of the generating plant. It follows, then, that the least cost to the contractor is determined when the variation in the cost of the generator is equal to that in the cost of the line, and it is to a consideration of this fact that I wish to call your attention.

We have the formula—

$$\mathrm{C\,M} = \frac{1492\, n\, m\, l}{\mathrm{E}\, v\, a}$$

Let *d* equal weight of one mil-foot of copper. Then the weight per foot of the copper of our conductor would be

$$\frac{1492\, n\, m\, l\, d}{\mathrm{E}\, v\, a} \qquad (3)$$

and the total weight for 2 *l* would be

$$\frac{2984\, n\, m\, l^2\, d}{\mathrm{E}\, v\, a} \qquad (4)$$

If b is the cost in cents per pound of copper (the cost of insulation being added to cost of copper), we have for the cost of the wire in the line—

$$\frac{2984\, n\, m\, l^2\, d\, b}{\mathrm{E}\, v\, a} \qquad (5)$$

It is to be noted here that this cost b must be expressed so much per pound of copper. It may be that we have a line covered by an insulation of such character, that for every dollar's worth ofcopper there may be 3 dols. or 4 dols. worth of insulation. For example, suppose that a $^1/_0$ B.W.G. wire be used, covered with an insulation that should make it cost say 150 dols. a thousand feet. The actual weight of copper in the line would be only 350lb., which, at 150 dols. market price, would make the wire cost forty-three cents per pound of copper. It is this cost, plus the cost of freight and handling, which must be used as the value of b.

Let E equal the E.M.F. at the terminals of the motor ; e, the motor electro-motive force ; v, the fall of potential on the line ; β, the commercial efficiency of the dynamo ; E″, the E.M.F. of the generator ; and n the number of H. P. developed by the motor. Then we have evidently

$$\frac{e}{\mathrm{E}''}$$

as the ratio of the Watt capacity of the motor and generator ;

$$\frac{n}{a}$$

the horse power of electrical energy delivered at the motor terminals ;

$$\frac{\mathrm{E}+v}{\mathrm{E}} \times \frac{n}{a}$$

the horse power of electrical energy delivered to the line, and

$$\frac{\mathrm{E}+v}{\mathrm{E}} \times \frac{n}{a} \times \frac{1}{\beta}$$

that delivered to the generator.

I think it advisable to make use of the term horse power and commercial efficiency, for it is partly from the commercial aspect I wish to look at the problem, and it is the side which in business we must confront.

Let us further make K equal the cost in cents of the generators per horse power required to drive them, and L the similar cost per horse power of the steam or water plant, all of course erected in place, that is with the cost of freight, handling, insurance, and erection added to the factory or shipping cost. Then the cost per horse power of the generating plant complete would be—

$$\frac{\mathrm{E}+v}{\mathrm{E}\,a\,\beta}\, n\,(\mathrm{K}+\mathrm{L}) \qquad (6)$$

If M is the cost of motor per horse power developed similarly erected in place, the cost of the receiving plant would be n M.

We now have one element which is somewhat indeterminate, and is dependent chiefly upon distance and local conditions, and that is the cost of pole and line erection, and we call this P.

Summing up our cost, we have the general expressions for the cost per horse power delivered—

$$\mathrm{C} = \frac{\mathrm{E}+v}{\mathrm{E}\,a\,\beta}(\mathrm{K}+\mathrm{L}) + \frac{2984\, m\, l^2\, d\, b}{\mathrm{E}\, v\, a} + \mathrm{M} + \frac{\mathrm{P}}{n} \qquad (7)$$

It is evident that this is variable, and since the costs of the motor and the line erection are arbitrary, the variation is narrowed down to the cost of the generating plant and the material in the line. It is here apparent, as already pointed out, that if we diminish the cost of the line by increasing the fall of the potential, we must at the same time increase the cost of the generating plant, and on the other hand, that if the loss on the line is reduced, its cost will increase, while that of the generating plant will diminish.

Differentiating with v as the variable, we have—

$$\frac{d\,c}{d\,v} = \frac{\mathrm{K}+\mathrm{L}}{\mathrm{E}\,a\,\beta} - \frac{2984\, m\, l^2\, d\, b}{\mathrm{E}\, a\, v^2} \qquad (8)$$

or equating to zero—

$$\frac{\mathrm{K}+\mathrm{L}}{\beta} = \frac{2984\, m\, l^2\, d\, b}{v^2} \qquad (9)$$

which is the condition of least cost.

From (9) we have—

$$v = 54{\cdot}6\, l \sqrt{\frac{m\, d\, b\, \beta}{\mathrm{K}+\mathrm{L}}} \qquad (10)$$

That is, with fixed conditions of cost and efficiency of apparatus, the number of volts fall to get the minimum cost of plant is a function of the distance alone, and is independent of the electro-motive force used at the motor, a somewhat startling conclusion.

Substituting the equivalent value given by equation (9) in (7), we now have for the equation of least cost—

$$\mathrm{C} = \frac{\mathrm{E}+v}{\mathrm{E}\,a\,\beta}(\mathrm{K}+\mathrm{L}) + \frac{v}{\mathrm{E}\,a\,\beta}(\mathrm{K}+\mathrm{L}) + \mathrm{M} + \frac{\mathrm{P}}{n} \qquad (11)$$

The first element representing the cost of the generating plant and the second the cost of the wire per horse-power developed by the motor. The cost of the wire is given as a ratio of the cost per horse power of the generating plant. From this equation we have the relation—

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{v}{\mathrm{E}+v} \qquad (12)$$

This is not, however, in a very useful form, and since the commercial efficiency is that with which we are concerned, we will introduce a term, designating it λ.

We have for the horse power delivered to the generator—

$$\frac{\mathrm{E}+v}{\mathrm{E}\,a\,\beta}\, n$$

and n that taken out of the motor ; hence we have—

$$\lambda = \frac{\mathrm{E}\,a\,\beta}{\mathrm{E}+v} \qquad (13)$$

or

$$v = \frac{a\,\beta - \lambda}{\lambda}\,\mathrm{E} \qquad (14)$$

Substituting the value of v in equation (11), we have a new form of the cost equation as follows :

$$\mathrm{C} = \frac{\mathrm{K}+\mathrm{L}}{\lambda} + \frac{a\,\beta - \lambda}{a\,\beta\,\lambda}(\mathrm{K}+\mathrm{L}) + \mathrm{M} + \frac{\mathrm{P}}{n} \qquad (15)$$

a still simpler formula. We also have the relation—

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{a\,\beta - \lambda}{a\,\beta} \qquad (16)$$

That is, *with any fixed couple and commercial efficiency, the cost of the wire should bear a definite and fixed ratio to the cost of the generating plant.*

But the query arises at once, Is this so, no matter what the cost of the copper ? And the answer is an affirmative one, and why this is so will soon be apparent.

Referring to the equation (10), and substituting for m its approximate value, 10·5, and for d its value, ·00000302705, we have—

$$v = {\cdot}308\, l \sqrt{\frac{b\,\beta}{\mathrm{K}+\mathrm{L}}} \qquad (17)$$

Combining this with (13), we find that

$$\mathrm{E} = \frac{{\cdot}308\, l\,\lambda}{a\,\beta - \lambda} \sqrt{\frac{b\,\beta}{\mathrm{K}+\mathrm{L}}} \qquad (18)$$

We now see what influence the cost of copper has when the commercial efficiency is maintained constant, which is to vary the value of E as it increases, but only as the square root of such increase. It will be noticed also that a variation in K + L inversely affects *E* and v likewise as the square root.

It follows from the above that if we do not limit ourselves in the E.M.F. *used, the cost per H.P. delivered exclusive of line erection, is, for least cost and for a given commercial efficiency, absolutely independent of the distance.*

We are met at times with the condition that the motor potential shall not be above a given amount, and from the formula,

$$\mathrm{E} = \frac{{\cdot}308\, l\,\lambda}{a\,\beta - \lambda} \sqrt{\frac{b\,\beta}{\mathrm{K}+\mathrm{L}}}$$

transposed to

$$\lambda = \frac{\mathrm{E}\,a\,\beta}{{\cdot}308\, l \sqrt{\dfrac{b\,\beta}{\mathrm{K}+\mathrm{L}}} + \mathrm{E}} \qquad (19)$$

we find at once what the efficiency of the transmission must be with a given distance, and therefore whether it is worth while to attempt the operation. On the other hand, if, for example, we make our lower limit of commercial efficiency 50 per cent, $a\,\beta$ = 80 per cent, and β = 90 per cent, we have a limiting equation.

$$\mathrm{E} = {\cdot}487\, l \sqrt{\frac{b}{\mathrm{K}+\mathrm{L}}} \qquad (20)$$

(*To be continued.*)

JOHN ERICSSON.

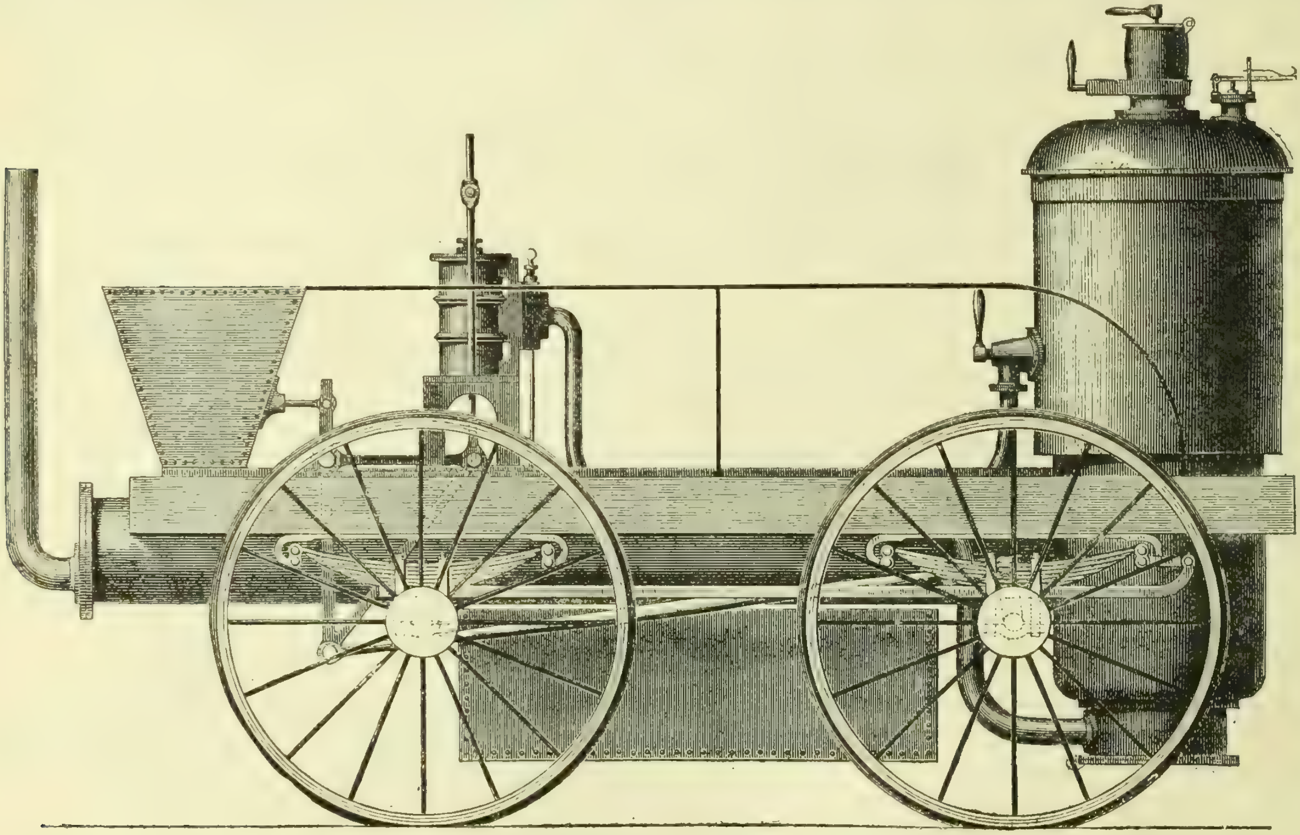
Captain John Ericsson, engineer, late of his Swedish Majesty's service, and since 1839 resident in the United States, died on Friday, March 8, at his house in Beach Street, New York City. All who were acquainted with the work of this remarkable man, on hearing the announcement of his death, must have felt that one of the great men of the age had passed away. With the remarkable development of science and engineering, and the growth of the modern means of transportation, it is hard to realise that a person whose life has just ended was a participant in that early and remarkable trial of locomotives on the Liverpool and Manchester Railroad in 1829, which may be regarded as the beginning of the railroad development of the past half-century. This development has been so rapid that a single life has covered the period, from its infancy to the present time.

Captain Ericsson was born in Wermland, in Sweden, July 21, 1803, so that he was in his 86th year at the time of his death. His father was a proprietor of mines, and his mother was the daughter of an ironmaster. In early life John Ericsson developed a taste and genius for mechanical pursuits, and at the age of 12 he was made a cadet of mechanical engineers, and the following year a leveller on the canal. At seventeen Ericsson entered the army as ensign, and rapidly reached a lieutenancy, in consequence of his beautiful military maps, which had attracted the special attention of King Charles John (Bernadotte).

At this early period of his life he had acquired a mastery of drawing, or means of representing his ideas graphically. But mechanical drawing is not only a vehicle for expressing thoughts, it is an important instrumentality to aid and systematise thought, just as algebraic symbols and formulæ assist the mathematician. Ericsson was said to be a master of graphical means of developing his ideas. He spent much of his time over a drawing-board, and took great pains to have his ideas completely and even artistically elucidated by drawings, some of which were matchless examples of the draughtsman's art.

His wonderful career as an engineer was in great part due to his remarkable capacity for thus expressing his ideas in tangible form. Mechanical drawing bore the same relation to his career that language does to that of an orator or statesman. Many men think great and wise thoughts, but cannot express them ; others have the gift of words, but nothing else. It is also true that few of us know how incomplete and incoherent much of our thinking is until we put it into language. It is equally true of inventors and engineers that they never know how imperfect and undeveloped their crude ideas are until they represent them on paper, and their capacity or rather incapacity for working them out often puts a limit to their usefulness. It is true that many men are good draughtsmen who never become great engineers or inventors, but it is perhaps equally true that without the capacity to represent his ideas definitely and clearly a person can never reach the highest rank as an engineer or inventor.

Ericsson was a man of surpassing originality and of boundless mechanical resources and expedients, with the logical faculty of drawing deductions from the data and phenomena presented to him ; and, moreover, he had the ability, which is perhaps rare with such men, of being able to express and work out graphically his deductions and conceptions into tangible form. To sum up the whole matter in other words, he was a good designer.



BRAITHWAITE AND ERICSSON'S LOCOMOTIVE, "NOVELTY," 1829.

In 1826 he went to London, on leave of absence, to introduce what is called a "flame engine." No description of this invention is within reach as this account of his life is being written, but probably it was some form of what afterward was developed into the famous caloric engine. Once in England, he resigned his commission in the Swedish Army. His resignation was accepted, but he was first promoted to a captaincy. He never returned to his native country, but received many honours from his countrymen. In an account of his life, which originally appeared in *Scribner's* (now the *Century*) *Magazine*, it is said :

> The records of the London Patent Office show how rapidly his inventions succeeded each other, and a list of his engineering works during the thirteen years he spent in England bears testimony to his achievements. Among these works were a pumping engine on a new principle ; engines with surface condensers and no smoke stack, blowers supplying the draught, applied to the steamship *Victory* in 1828 ; and an engine consisting of a hollow drum which was rotated by the admission of steam, and continued to rotate for some hours after shutting off the steam, at the rate of 900ft. per second at the circumference, or the speed of London moving around the axis of the globe. Apparatus for making salt from brine ; mechanism for propelling boats on canals ; a variety of motors actuated by steam or hot air ; a hydrostatic weighing machine, to which the Society of Arts awarded a prize ; an instrument now in extensive use for taking soundings independently of the length of the lead line ; a file-cutting machine ; and various others are included in this list to the extent of some fourteen patented inventions and forty machines, all novel in design.

In 1829, when the Liverpool and Manchester Railway Company offered a prize of £500 for the best locomotive engine for their road, Ericsson entered to compete for it. The conditions were that the engine must burn its own smoke, and if it weighed six tons must draw a train, including the tender and water, weighing 20 tons, at a rate of 10 miles per hour, with a pressure of steam of 50lb. per square inch.

The locomotives which appeared on the ground were—

1. The Novelty, by Messrs. Braithwaite and Ericsson, of London, weight, 2 tons 15 cwt.
2. The Sans Pareil, by Mr. Hackworth, of Darlington, weight, 4 tons 8 cwt. 2 qrs.
3. The Rocket, by Mr. Robert Stephenson, of Newcastle-upon-Tyne, weight, 4 tons 3 cwt.
3. The Cycloped, by Mr. Brandreth, of Liverpool, weight, 3 tons, worked by a horse.

The drawing for the engraving of the Novelty, given on page 310, was furnished some years ago to the *American Artisan* by Mr. Ericsson himself, and is therefore authentic. It was published in that paper and in the *Railroad Gazette* in 1875.

Accounts of this celebrated trial have been published very often and, as is well known, the prize was awarded to Stephenson's Rocket.

The *Times*, of October 8, 1829, said that the Rocket, without a train, ran at the rate of 24 miles in the hour, shooting past the spectators with amazing velocity. . . . Cars weighing, with its own weight, upward of 17 tons were then attached to it, and the trial proved that the carriage (locomotive) can, drawing three times its own weight, run at the rate of more than ten miles an hour. . . .

But the speed of all the other locomotive steam-carriages in the course was far exceeded by that of Messrs. Braithwaite and Ericsson's beautiful engine from London. It was the lightest and most elegant carriage on the road yesterday, and the velocity with which it moved surprised and amazed every beholder. It shot along the line at the amazing rate of 30 miles an hour! It seemed, indeed, to fly, presenting one of the most sublime spectacles of human ingenuity and human daring the world ever beheld.

But the swift Novelty, notwithstanding her superior speed, did not win the prize. The stipulated sum of £500 sterling was awarded to Messrs. Stephenson's Rocket, which engine accomplished a distance of 70 miles (by running backward and forward on the Rainhill level), at the rate of 13½ miles an hour, with a train of cars loaded with stone, gross weight in motion 17 tons. Much has been said pro and con respecting the fairness of the award made by the appointing judges and their determination to test a locomotive engine constructed solely for speed, and weighing only 2¾ tons, as if designed to carry goods at a slow rate. We feel no disposition to criticise the manner of conducting the trial, nor do we question the propriety of the award made by the judges appointed by the Board of Directors of the Liverpool and Manchester Railway; but we deem it fair to our professional readers and to Captain Ericsson to record the following opinion, which speaks for itself, expressed by a reflecting mechanic: "The constructor of the Novelty exhibited far greater engineering knowledge than the constructor of the Rocket. In the first place, when Stephenson presented his locomotive engine for trial, he depended on chimney draft to support the combustion in the boiler furnaces, while Ericsson, who had theoretically considered the matter, knew that sufficient air could not be supplied by natural draft. He therefore employed a blowing apparatus, which being operated directly by an engine, regulated the combustion to suit the speed of his locomotive engine. So well was this blowing apparatus proportioned, that, while running at the rate of 40 miles an hour, the supply of steam seemed to be ample. Fortunately for Stephenson, Timothy Hackworth, the builder of the Sans Pareil, discovered the efficacy of the steam blast in time to enable the constructor of the Rocket to apply the same before the termination of the competitive trial. Secondly, Ericsson, fully comprehending that durability of the steam machinery called for absence of jarring motion, placed his engine frame on four flexible carriage springs. Nor did he overlook the fact that the power of the engines must be applied in such direction as not to interfere with the free vertical action of the springs. Consequently, he resorted to such a combination that the connecting rods operated in a horizontal direction. And by employing bell-cranks, he dispensed with connecting-rod guides, thereby obviating the thrust and heating inseparable from their employment, unless constantly lubricated. He avoided, at the same time, the use of horizontal cylinders, so strongly objected to by most engineers of that period. Stephenson, on the other hand, employed cylinders placed at an angle of 45 degrees, in consequence of which fully two-thirds of the power of his engines lifted and depressed the carriage at each stroke. The resulting unavoidable tilting motion was aggravated by the necessary right-angular position of the driving-cranks, causing one side of the carriage to be lifted up while the other was being depressed. The consequent violent rocking of the Rocket during the competitive trial was observed by all, and admitted to be a defect which called for some effectual remedy."

In the same year the Novelty was tried, Ericsson constructed a steam fire engine which was used in putting out a fire in the Argyle Rooms, in London. Another was sent to the Liverpool docks the next year, and a third was sent to Berlin. Ten years later, in 1840, the Mechanics' Institute gave its large gold medal to Ericsson for the best system of fire engines.

Before leaving England, Ericsson applied the principle of condensing steam and returning the fresh water to the boiler on board the Victory, and in the steam vessel Corsair, built at Liverpool in 1832, he applied the centrifugal fan blowers now in use in most of the steam vessels in the United States. In 1834 he also used superheated steam in a steam engine. It is also said that he used a form of link motion in two locomotives in 1830. The link motion is usually attributed to Stephenson, but he did not use it until 1843. In 1837 Ericsson built a tug boat 40ft. beam by 80ft. long, with 3ft. draught, having two propellers of 5¼ft. diameter, and invited the British Admiralty to inspect it. The wise heads of that conservative body decided that as the propelling power was at the stern it could not be steered.

On the advice of Commodore Stockton, Ericsson went to America in 1839, and in 1841 began to build the Princeton. She is said to have been the first naval vessel that had her machinery below the water-line, out of the reach of hostile shot. Her engines were peculiar, the cylinders being made in the form of a sector of a circle, in which the pistons, which were connected to a shaft, oscillated. It was this ship that John Quincy Adams spoke of as "a gimcrack of sundry other inventions of Captain Stockton himself, was built under his directions, and is commanded by him." At a public exhibition of it one of the guns, the Peacemaker, burst and killed the Secretaries of State and of the Navy, and a number of other persons on board.

So full of wonderful achievements was the life of the remarkable man who is the subject of this article, and so multifarious were his achievements, that an account of them can be little else but a catalogue of what he did. This can be given perhaps best in his own words. When the great Centennial Exhibition, held in Philadelphia in 1876, was planned, through some oversight, Ericsson was not invited to exhibit his achievements, a neglect which apparently he resented. He therefore prepared a large book of 600 quarto pages in which his work was described. It was elaborately illustrated with admirable engravings, and is printed on thick, heavy paper. The following introduction to it will give a better idea of this wonderful man's achievements than anything else could:—

INTRODUCTION.

The Commissioners of the Centennial Exhibition having omitted to invite me to exhibit the results of my labours connected with mechanics and physics, a gap in their record of material progress exceeding one-third of a century has been occasioned. I have, therefore, deemed it proper to publish a statement of my principal labours during the last third of the century, the achievements of which the promoters of the Centennial Exhibition have called upon the civilised world to recognise.

The nature of the labours referred to will be seen by the following account of philosophical instruments, engines, and other structures described and illustrated in this work, viz.: Apparatus for measuring the intensity of radiant heat at given distances. Instrument for measuring radiant heat emitted by concave spherical radiators within exhausted enclosures. Instrument showing the rate of cooling of a heated body within an exhausted cold enclosure. Instrument showing the rate of heating of a cold body within an exhausted heated enclosure. Instrument showing the rate of cooling of an incandescent sphere within an exhausted cold enclosure. Instrument for measuring the dynamic energy developed by radiant heat at different intensities. Actinometer, for measuring the temperature developed by solar radiation. Solar calorimeter, for measuring the dynamic energy developed by solar radiation. Portable solar calorimeter, parallactic mechanism for measuring the intensity of radiation from different parts of the solar disc. Instrument for measuring the radiant power of the solar envelope. Instrument for measuring the actual intensity of the sun's rays. Solar pyrometer, for measuring the temperature of the solar surface. Apparatus for measuring the radiant intensity of the flames. Instrument for measuring the radiation from incandescent planes at different angles. Instruments for measuring the radiation from different zones of incandescent spheres. Calorimeter, for measuring the dynamic energy developed by radiation from fused iron. Apparatus for measuring radiant heat by means of the thermo-electric pile. Barometric actinometer, for measuring the temperature developed by solar radiation. Apparatus for ascertaining the conductivity of mercury. Concave spherical radiator, for testing the accuracy of the solar pyrometer. Instrument for measuring the reflective power of silver and other metals. Rapid-indication actinometer, for measuring the temperature developed by solar radiation. Apparatus for ascertaining the diathermancy of flames. Dynamic register, for measuring the relative power of currents of water and vapour. Distance instrument, for measuring distances at sea. Steam fire-engine, designed in 1841. Engines of the United States steamship Princeton, built at Philadelphia 1842. Twelve-inch wrought-iron gun and carriage mounted on board the Princeton, 1843. Iron-clad cupola vessel, designed in 1854. Surface condenser for marine engines patented 1849, built at New York. Experimental caloric engine, built at New York, 1851. Caloric engine for domestic purposes, extensively introduced in Europe and America. The iron-clad turret vessel, Monitor, built at New York, 1861. Turret vessels of the Passaic class, built at New York, 1861. Turret vessels of the Passaic class, built at New York and other places, 1862. The Monitor engine, applied to the entire iron-clad fleet of the United States during the war. The turret vessel Dictator, built at New York, 1862. Carriages for heavy ordnance, designed 1861, built at numerous mechanical establishments in the United States. Pivot carriages of the Spanish gunboats, built at New York, 1869. Rotary gun-carriage and transit platform, built at New York, 1873. Gun-carriage for coast defence, designed 1861, built at New York. Independent twin screw engines of the 30 Spanish gunboats, built at New York, 1869. New system of naval attack, published 1870. Movable torpedo, built at New York, 1873. Air compressor for the transmission of mechanical power, built at New York, 1873. Solar engine, actuated by the intervention of steam, built at New York, 1870. Solar engine, actuated by the intervention of atmospheric air, built at New York, 1872.

The foregoing, it should be observed, relates to work carried out by me on American soil. It has no reference to my labours in England from 1826 to 1839 connected with locomotion, steam navigation, motive engines, and other branches of mechanical and civil engineering. Nor does it contain a *complete* enumeration of the original mechanical inventions carried into practice by me in the United States—models of which would have been presented at the Centennial Exhibition had its promoters desired me to furnish a record of my share in the progress of mechanical engineering during the last thirty-seven years of the first century of the Republic.

As our space only admits of a brief reference to the mechanical inventions adverted to and not described or illustrated in this work, the following statement is appended, furnishing an outline of the principal structures omitted, viz.: Engines of the twin-screw steamship Clarion, built at New York, 1840, consisting of two vertical cylinders, placed fore and aft in the vessel, actuating the cranks of the screw-shafts by inclined connecting rods. Vertical single engines, actuating twin-screws, built at New York, 1842, applied to several freight vessels on the Delaware and Raritan Canal. Single horizontal back-action engine, built 1843, applied to the United States screw-steamer Legaré. Inclined screw engines, built 1843, applied to the steamship Massachusetts, the steam cylinders of which were placed near the deck of the ship's sides, secured to diagonal timbers bolted to the planking. Centrifugal suction fan, built 1843, operated by an independent engine, for producing draft in marine boilers by *drawing* the air through the furnaces and flues, and forcing the products of combustion into the chimney. Inclined engines, built 1844, applied to the bark Edith, the connecting rods operating at right angles to each other and coupled to a common crank-pin, in the propeller shaft. Vertical engines, built in 1844, applied to the twin-screw vessel Midas (the first screw-vessel to round the Cape of Good Hope), the power being transmitted to the propeller shafts by vertical connecting rods actuated by horizontal beams placed transversely under the deck. Vertical engines applied to numerous screw-vessels employed on the coast and inland waters of the United States, the cylinders being placed perpendicularly above the propeller shaft the connecting rods acting downward—a form of engine now employed in nearly all sea-going steamers, but at that time (about 1844) severely criticised by marine engineers. Engines of the twin-screw ship Marmora, built 1843, consisting of vertical steam cylinders, which, by means of beams working under the deck and vertical connecting rods, imparted independent motion to the propeller shafts. Horizontal high-pressure and condensing engine of the twin-screw steam tug, R. B. Forbes, built 1844, provided with detached condenser and air pump, actuated by an independent engine, a vessel which during a series of years rendered valuable service on the coast of Massachusetts by towing and relieving ships in distress. Compound stationary engine, actuated by very high pressure, in which the steam was expanded to the utmost extent, elaborately described by Dr. Lardner, who devoted much time to its theoretical consideration. Horizontal engine applied to the screw vessel Primero, actuated by a mixture of steam and atmospheric air. Stationary engines actuated by highly superheated steam, the pistons of which were single acting and thoroughly protected against the injurious effect of high temperature. Experimental street car, propelled by a double calorific engine. Hoisting machines, actuated by cold compressed air, applied to several warehouses in New York. Small motors, actuated by cold compressed air, successfully applied to the sewing machines of a large establishment in New York, intended to establish the fact that the present injurious physical exertion of sewing-women may be economically dispensed with.

Regarding descriptions and illustrations of the calorific engines contained in this work, it is proper to observe that they relate only to some of the engines which I have built, at least ten different types, unlike these described, having been constructed and practically tested. Nor have I yet wholly suspended the labours connected with this safe and economical engine. The fact that it requires no water, and that its principle is not incompatible with the desirable employment of a very high temperature—apart from the important circumstance that the use of atmospheric air admits of returning at each stroke, by the process of regeneration, the heat not converted into mechanical work during the previous movement of the working piston—justifying continued endeavours to perfect this remarkable motor.

New York, September 1, 1876. J. Ericsson.

The magnitude, variety, and importance of the work that was done by him makes comment and criticism of it almost impossible. The problem of the hot air engine engrossed much of his time, and his labours in that direction were spread over many years. It must be admitted, however, that the practical results of this work were insignificant compared with the work that was done. Some thousands of the smaller engines have been built and are now in use, but they have never been used for any considerable time where much power is required. Ericsson was an inventor and engineer and not a business man, and it seems now as though his life and labours would have been more useful if his own capacity had been supplemented with the assistance of a clear-headed and enegetic person with the commercial faculty of utilising the discoveries of the inventor.

The story of the memorable contest of the Merrimac and the Monitor has often been told. No event that ever occurred seems to have about it so much of the elements of romance and tragedy, and no story that has ever been written was so full of thrilling interest. Whether it did or did not change the destiny of a nation need not be discussed now, in the light of the lustre which it shed on the man whose deeds are being recited here, quite too briefly to do justice to his greatness.

Of the man himself little need be said. He devoted his life to his work, and lived almost like a recluse. He avoided society because it would absorb his time, which he seemed to value more than fame or money. He appeared, too, to shun notoriety, and he directed only a short time before his death that his diary, which had been kept through many years, should be destroyed. This wish was carried out, causing a loss much to be regretted.

He was a widower and childless, so that his life was a lonely one, and it may be that as the weight of years was laid slowly but surely on his shoulders, there came with it that longing which comes to many, perhaps at last to all, for rest.

ON OIL-CARRYING STEAMERS.

(Continued from page 294.)

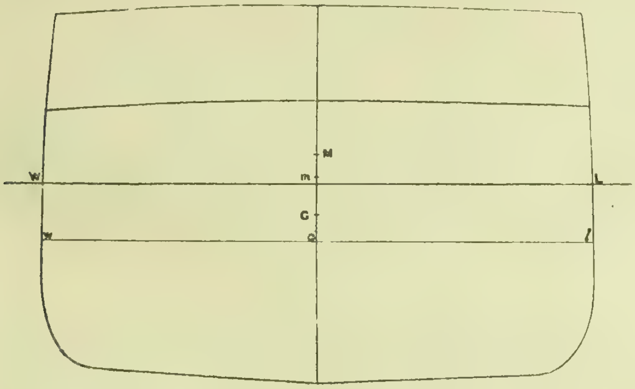
In those cases where the tank top slopes upwards from the sides towards the middle line, the rolling motion has effect in augmenting the stress in a way described by me in a paper on the shifting of cargoes, read before the Institution of Naval Architects in 1887. It will be obvious from the above that the tops of these tanks require most careful consideration, as well as the bulkheads, and in some of the earlier vessels I understand that the oil has been found to leak from the compartments into the ballast tanks.

Important though this branch of the general question involved in the consideration of oil-carrying steamers undoubtedly is, I do not propose to enter upon it more fully at the present time, but rather to confine my remarks to the subject of their stability.

The fact that the presence of free water in the hold of a vessel makes her more tender in the upright position has long been known to naval architects. Some years ago Mr. Barnes, late surveyor of dockyards, in H.M. service, to whose patient investigation at a time when the science of naval architecture may be said to have been yet in its infancy we are greatly indebted, accurately measured its effect for small inclinations of a vessel from the upright position. His method was more appropriate, however, for the case in which a small quantity of water finds its way on board than for that in which a free liquid is present in large quantities in the form of cargo, and rises to a great height.

Let us see how the presence of free oil or water in a vessel tends to incline her away from the upright position. Ordinarily, if a vessel be upright and at rest in still water, the common centre of gravity of the hull and cargo must be situated in the middle line plane, and must be below the metacentre corresponding with the draught at which she is floating. If a portion of the cargo be moved from one side of the vessel to the other, the common centre of gravity will in consequence move from its position in the middle line in a direction parallel to that in which the centre of gravity of the shifted cargo has been moved, and the vessel will incline away from the upright until a position of equilibrium is at length attained in which the centre of gravity and buoyancy are again in the same vertical line. In the case, however, in which a vessel contains water or oil having a free surface, she may not remain upright even though the common centre of gravity be below the metacentre, and this is due to the fact that the contained liquid is constantly ready to change its surface in order that it may remain horizontal, or parallel to that of the water in which the vessel floats. Take for example the vessel of fig. 1, M being the metacentre and G the common centre of gravity of hull and cargo when the vessel is upright. Let W L be the water line, and $w\ l$ the level of the liquid cargo in one of the compartments. If the vessel be forcibly inclined from the upright position through a small angle, so that W_1L_1 (fig. 2) becomes the water line, the free liquid surface will follow it and assume the parallel position $w_1 l_1$. This cannot be accomplished without some movement in the liquid, the quantity of oil on the emerged side being diminished by the wedge $w\,o\,w_1$, whose centre of gravity is at g_1, and that on the immersed side being immersed by an equal wedge $l\,o\,l_1$ whose centre of gravity is at g_2. Hence the common centre of gravity of hull and cargo must move from G to G_1, the line $G\,G_1$ being parallel to $g_1\,g_2$, and its length being to $g_1\,g_2$ as the weight of the wedge of oil shifted is to the weight of the laden vessel. The vertical through G_1 will cut the middle line at some point m, and through this point the weight of the ship and cargo acts at the given inclination. The point m is related to G in the same way as the metacentre to the centre of buoyancy; that is to say, whatever be the inclination of the vessel so long as it be small, the vertical through the new centre of gravity will always cut the middle line at the same point m. The resultant upward pressure of the water will of course act through M, and hence we see that if m be below M the vessel will return if released to the upright position, the wedge $l\,o\,l_1$, of contained liquid passing to its former position, $w\,o\,w_1$; if m coincides with M, the vessel will not so return, but will remain in neutral equilibrium; and if m be above M, the vessel will incline still further from the upright position, coming to rest only when the centre of buoyancy is drawn sufficiently far on the immersed side to be in the vertical line through the centre of gravity of hull and cargo. We see that the point m has the same property in determining the character of the equilibrium of a vessel containing liquid having a free surface, as the centre of gravity has in the case of a vessel containing cargo which does not shift. To the interval m M I have been accustomed to give the name "effective metacentric height," inasmuch as this distance affords a measure of the vessel's initial stiffness in the same way as the metacentric height does under ordinary circumstances. The righting moment at a small inclination θ from the upright is, in fact, $W \cdot m\,M \sin\theta$. It is not difficult to measure accurately the distance $G\,m$, which, as I said before, is constant for all small inclinations of the vessel, with a given extent of free surface.

Fig. 1.



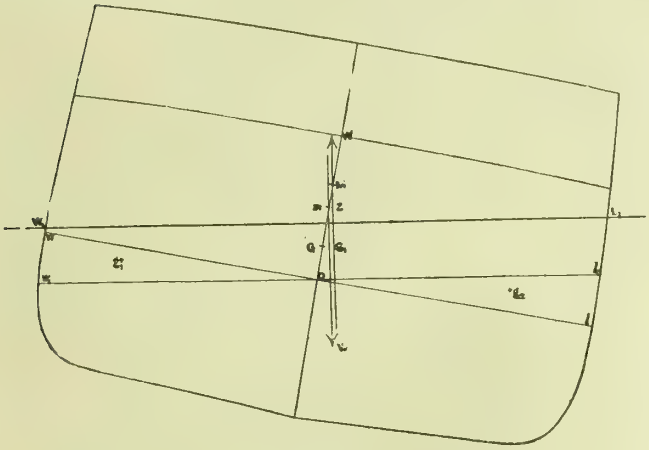


Fig. 2.

Let us assume that the compartment containing the free liquid is rectangular in form at the height of the oil surface, its length being l and half breadth y. Let W be the displacement of the vessel in tons. Suppose the vessel inclined from the upright through a very small angle θ (fig. 2). The volume of the wedge of oil, $w\,o\,w_1$, transferred to $l\,o\,l_1$, is $\frac{1}{2}\,y^2\,l\,\theta$, and the distance through which its centre of gravity is ultimately transferred is $\frac{4}{3}\,y$. If the contained liquid were salt water, the weight of the wedge would be $\frac{\frac{1}{2}\,y^2\,l\,\theta}{35}$, and its moment $\frac{\frac{1}{2}\,y^2\,l\,\theta}{35} \cdot \frac{4}{3}\,y = \frac{\frac{2}{3}\,y^3\,l\,\theta}{35}$, and from what has gone before this product must be equal to $W \cdot G\,G_1$. But since the density of petroleum is only about ·8 that of salt water, the weight of the transferred wedge will be but

$$\frac{\frac{1}{2}\,y^2\,l\,\theta}{35} \cdot \frac{8}{10},$$

and the moment

$$\frac{\frac{1}{2}\,y^2\,l\,\theta}{35} \cdot \frac{8}{10} \cdot \frac{4\,y}{3} = \frac{\frac{2}{3}\,y^3\,l\,\theta}{35} \cdot \frac{8}{10}.$$

Equating $W \cdot G\,G_1 = \frac{\frac{2}{3}\,y^3\,l\,\theta}{35} \cdot \frac{8}{10}$; and $G\,G_1 = G\,m \cdot \theta$ ultimately. Hence,

$$G\,m = \frac{\frac{2}{3}\,y^3\,l}{35\,W} \cdot \frac{8}{10}.$$

Now, $\frac{2}{3}\,y^3\,l$ is the moment of inertia of the plane of the free oil about the middle line: call it I_1, and we may then write

$$G\,m = \frac{8}{10} \cdot \frac{I_1}{35\;W}. \qquad (1)$$

As an example, take a vessel 40ft. broad, having a compartment 24ft. long admidships, in which oil is free to move from side to side, the displacement being 3,000 tons. Here $I_1 = \frac{2}{3}\,(20)^3\,24$, and by substituting in equation (1) we find $G\,m =$ ·976ft. Hence, in such a case, if the height of the metacentre above the centre of gravity be less than ·976ft., the vessel will not remain upright under the above conditions. If there be two such compartments of equal length partially filled, the height of m above G will be doubled, and the actual metacentre height must exceed 1·952ft if the vessel is to remain upright. Similarly as regards a greater number of compartments. It may be added that although equation (1) has been established only for the case in which the free surface of the oil is in form a rectangle, the equation is rigorously true whatever be the form, I_1 being then the moment of inertia of the plane of the free oil surface about the middle line.

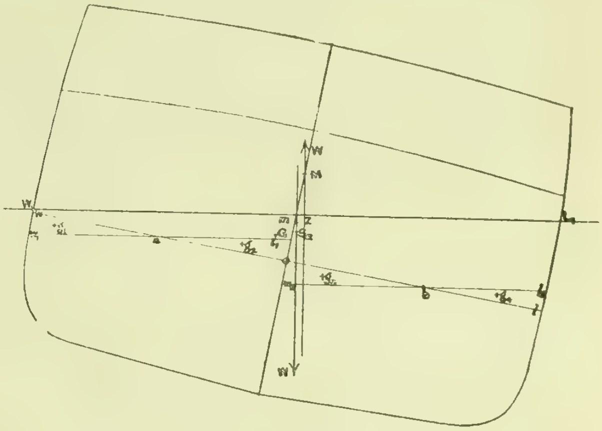


Fig. 3.

The above investigation is for the case in which the vessel has no middle line bulkhead, or a bulkhead perforated so as to admit of the passage of oil readily from one side to the other; let us now examine the case in which the compartments are divided by an oil-tight or practically oil-tight middle line bulkhead. In that case, if the vessel of fig. 1 be inclined through a small angle, the oil on the one side of the middle line bulkhead will change its surface from $w\;o$ to $w_1\;l_1$ parallel to $W_1\;L_1$, and that on the other side from $o\;l$ to $w_2\;l_2$ also parallel to $W_1\;L_1$ (fig. 3). Here we have one wedge $w\;a\;w_1$ shifted to $o\;a\;l_1$, and another wedge $w_2\;o\;b$ moved to $l\;b\;l_2$, and their combined effect is as before to make the centre of gravity G more away from its position in the middle line to some point G_2. The distance $G\;G_2$ is not, however, so great as $G\;G_1$ in the preceding instance. The wedge of oil shifted has only one-fourth the volume of the wedge of the previous example, and the distance through which its centre of gravity is moved is only one-half as great. On the other hand, two wedges are shifted here instead of one. Hence we shall obtain by the same reasoning as before

$$GG_2 = \frac{\frac{1}{2}\left(\frac{y}{2}\right)\theta\cdot\frac{2}{3}y\cdot 2}{35\,W}\cdot\frac{8}{10},$$

and

$$Gm = \frac{1}{4}\,\frac{I_1}{35\,W}\cdot\frac{8}{10},$$

or the loss of effective metacentric height is only one-fourth as great as when the oil is free to shift from side to side of the vessel. It follows that in the numerical example already quoted such loss would amount to only ·244ft. instead of ·976ft. Put in another form, the loss of effective metacentric height due to the readiness of the oil to shift in a vessel with four compartments only partially filled with oil, but having an oil-tight middle line bulkhead, is the same as in a vessel of the same displacement having only one such compartment filled, but having no middle line bulkhead, or one through which the oil may readily pass from side to side.

(To be continued.)

THE MINERAL WEALTH OF THE CAUCASUS.

THE naphtha trade is at present by far the most important in the Caucasus, and the production has steadily risen from 57,377 tons in 1873 to nearly 2,500,000 tons in 1887. The oil is found in several parts of the Caucasian territory, but principally at Balakhani, where 150 springs are now worked, 300 borings having, however, been abandoned owing to their comparatively small yield. The raw naphtha is distributed among 200 works established at Baku, where it is refined for exportation. The shipments for Russia are mostly made by the Caspian Sea in tank steamers, using the naphtha residue as fuel, and which discharge the oil into tanks that have been erected at Tzaritzin and Astrachan, while the trade with other countries is carried on by the Black Sea, the products being brought from Baku to Batoum in tank trucks and discharged into 48 reservoirs, containing altogether about 76,800 tons. The shipments from Batoum are effected in tank steamers for Europe, and in metal cases for Turkey, Egypt, and India. As soon as the means of transport have been sufficiently developed, fresh wells will be opened at Balakhani, when it is expected that the production will be as great as that of the United States, which is estimated at between 600,000,000 and 700,000,000 tons. The pipe line from Baku to Batoum will contribute greatly to the development of the trade, as it will be capable of conveying 3,000 to 4,000 tons of naphtha per diem. As the raw naphtha found in the Caucasus only contains about 33 per cent of petroleum, the 77 per cent of residue can be used as fuel on board the steamers, and may even become an article of exportation, which will eventually compete seriously with coal in certain countries; in fact, it is already utilised at the copper smelting works of Kedebec, near Elisabethpol. The Caucasus also contains important mines of copper, iron, argentiferous lead, zinc, and manganese, although they are only partially worked at present, on the banks of the Tchuruk river near Batoum, at Artani, 90 kilometres from Tiflis, at Chucha, Tchataku, Tchiaturi, and Rgani. The Tchuruk copper mines seem destined to become very important, as the mineral can be conveyed by river to Batoum, where smelting works are to be erected, and coal can be obtained from the neighbouring Tkibul mines at 9f. or 10f. per ton. Ironworks will also no doubt spring up in this district, since the heavy duty on rails and cast-iron pipes has completely checked the importation of such goods into Russia, while the demand in the Caucasus and Central Asia is rapidly increasing.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

SIR,—When this correspondence began I had no desire to enter into it, knowing that my personal experience, if published, could only be damaging; but being specially requested by a personal friend, I wrote, and am not surprised at the letters from "G. T. P." and "C. D.," both of whom have a perfect right to doubt my statements. I have taken care not to single out or name any one boiler or maker, but I am quite prepared to support my statements, and, if desired, will furnish the Editor with the names and particulars of the following cases: Eleven water-tube boilers practically out of use on account of trouble from joints and non-economical working; two boilers out of use except when Lancashire boilers have been overhauled and repaired, and during the few weeks this was on one of the water-tube boilers failed three times from burst tubes; one out of use because water level is so fluctuating that it is difficult to know where it really is; two out of use on account of cost of repeated making joints; one tested twice against a Lancashire boiler by the maker's own men and officials, and the representative of an engineering journal requested not to publish results; two put in to work at 120lb. to do a certain amount of work (previously known to makers), but found not equal to it; these boilers were for a long time not paid for on account of their being unsatisfactory, and were afterwards only worked at 50lb., and I now have a letter before me complaining of having to break and re-make 96 joints to clean a boiler each time it is laid off. I have not condemned them outright, as I believe they can be worked satisfactorily under easy conditions with good water. The Grosvenor Gallery, for instance, 656 horse power, is not much for four boilers to do. Two Lancashire boilers, 30ft. by 7ft., would do this easily, but all manufacturing firms cannot command the capital at hand. Their introduction into torpedo boats cannot be considered as a proof of their commercial success, as they would probably be at work under most favourable conditions (irrespective of cost) one or two days, and then laid off perhaps a week for overhauling. They have now been before the public for twenty years, and I would ask, Is there one works of importance where they have superseded the Lancashire boiler and are giving all-round satisfaction?—Yours, &c.,

CHALKLINE.

To the Editor of "The Practical Engineer."

SIR,—It has been interesting to the writer to peruse and note the correspondence on this subject, in your several issues since the 15th March last. Your first correspondent asks for information on seven points, but those replying seem to me to have afforded little or none, and, either by admission or from the tenour of their statements, I learn that they are not personally or practically acquainted with the subject.

To the seven questions put by "Manchester Engineer" may be added another, viz., Are these boilers highly economical? This question, which I will call number eight, is to the mind of the subscriber the most important. In addition to an extended personal experience with these boilers, I have had the opportunity of obtaining data from a very large number of users, firemen, and engineers working in connection with them. I shall reply very briefly to the questions raised, referring to the types named, and presuming all to be made of the best material. Replying to questions by "Manchester Engineer," in your issue of March 15th, 1889—

1. Defects, if any? (*a*) The first defect will soon be shown or produced by water heavily charged with lime forming scale in the tubes. (*b*) The production of wet steam where the steam and water chambers are small. (*c*) Rapid destruction of brick furnaces.

2. Where limy feed-water is used a scale forms on the inner face of the tubes, and if neglected would cause the tubes to burn through over the fire. This scale can be dealt with by being cleared out by scrapers specially prepared for the job, and should be attended to at reasonable intervals to prevent a thick formation. But a better plan of dealing with that is to purify the water, which can be and is being done efficiently and inexpensively by purifiers, in which the water is subjected to the temperature of steam at say 70lb. pressure; this gives sufficient a degree of temperature to precipitate the lime in the purifier, preventing its entry or deposit in the boiler. These purifiers will be of similar good service to any type of boiler; they are comparatively of small cost.

3. "Muddy water," with sediment of only soft or medium soft nature. This does not form rapidly in the tubes, and is not difficult to remove by the scrapers and brushes for the purpose. The water purifiers are here also the best way of treating the feed water.

4. "Intermittent and heavy demands of steam." This can be amply met by a large size steam and water chamber, with an additional steam drum.

5. "Up-keep of brickwork furnaces." This is a troublesome and expensive item, and will probably remain so until a different type of furnace is designed and applied to this class of boiler.

6. "Wet steam." In limited steam and water chambers, coupled with heavy firing, they are liable to produce priming, but this will be avoided by the same conditions as named in reply at No. 4, coupled with performing a light duty. But absolute security of dry steam is insured by the adoption of a recently improved and patented method of carrying the heated water and steam from the tubes over the furnace into and along the steam and water chamber, by which means the steam is freely separated in the driest possible state from the water. The patentee is prepared to guarantee, with the sale of the appliance, *absolutely* dry steam in every instance.

7. "As to remedies of any defects" named, the several replies above covers this question excepting that referring to brick furnaces; these remain a trouble and expense, and have to do with the question of rendering this type of boiler uneconomical. Further reference to this will be made in replying to No. 8.

8. From my personal knowledge, I can affirm that with the present way of firing these boilers they are not economical, and this fact is borne out by practically all users of the boilers who have taken the trouble and adopted proper means of obtaining a true record of the results these boilers give in point of economy.

This type of boiler, as well as all other externally-fired boilers, are wasteful in fuel and expensive in upkeep of the furnaces; but the modern water-tube boiler gives satisfaction in other respects, and provided a new kind of furnace be adopted, which can correspond with the conditions of an internally-fired tube boiler, utilising the best heat of the fuel in combustion, and at the same time entirely avoiding the annoyance and expense of frequent removals of brickwork furnaces, there is no reason why the boiler should not stand in the front rank as the safest and most economical of all boilers. The brickwork externally-fired furnaces are not so suitable to the best forms of mechanical stokers as the tube form of furnaces are, and they are very liable to produce heavy, black smoke.

Briefly replying to several correspondents, "Savery" refers to the many joints in the water-tube boiler as likely to be a source of trouble. Such was the case years ago, but the present method of putting in the tubes, and of making and fixing the caps, obviates this. And further, "he had heard it said" that the tubes boil dry and eject the water when generating steam rapidly, and burn out and burst in consequence. Such a result cannot take place in any of the boilers under discussion so long as a proper quantity of water is in the boiler; but if the supply of water is short and runs below the furnace level of the tubes, they will burn just as well as the crown of a tube furnace would when bare of water. "Chalkline," referring to firegrate being large, and an external one, firebrick lined, concludes the conditions are most favourable to complete combustion, but he omits the consideration of the close proximity of the groups of inclined water tubes just over the top of all the fire, which acts as a very powerful condenser by the comparatively cold water passing through, making a large cooling surface to the flames, and chilling them before complete combustion has taken place, and causing, as before stated, heavy, black smoke. As to wet steam, to which he refers: In addition to my replies at No. 6 question, I may add that I have been witness of the most complete tests ever made on boilers, and particularly on water-tube boilers of the types under consideration, in which case no apparatus for producing dry steam was used, simply having ample steam and water space, the results showing and proving, when not heavily worked, absolutely dry steam, and, when fairly heavily worked, from 2 to 3½ per cent of moisture in the steam. As to evaporative duty, the boilers are not the best in point of economy, nor are they likely to be with the present form and construction of furnaces; but with an improved form of furnace there is no reason why the highest economical results cannot be obtained. His reference to leakages from joints of caps, &c., which he says he considers the worst feature in these boilers, might apply to the earliest forms of caps used in connection with these boilers some fifteen or twenty years ago (perhaps in some of the cases he refers to, about 1870), but it certainly does not apply to some of those I know are now in use. It does not appear quite clear to me whether "Chalkline" wishes it to be understood that rapid circulation of water in boilers is advantageous or detrimental. Does he desire it to be inferred that the "wet steam" is produced by the circulation which is kept up? Your present subscriber believes it is, and was of opinion that circulation of the water was one of the most desirable objects to attain in working boilers. His reference to tube boilers made and put down in 1871 (nearly twenty years ago) is utterly inapplicable to present types, and outside the purposes of my present reply. The insurance companies might reasonably object to accept to insure those made twenty years ago, but most of the insurance companies are not refusing to accept those being put down at present, as I know nearly all of those put down in recent years are insured by the best companies.

In face of all that has been adduced to the contrary, I have the opinion that the water-tube boiler is destined to take a leading position in the future in production of high-pressure steam.

Most of the original defects or faults have been remedied, and the improved types now being made are safe, can be worked at any desired high pressure, will produce absolutely dry steam, which can be guaranteed. They are easy of transport by land or water; they occupy small space; the joints can be made to stand long and hard usage.

The only remaining defect is that of their want of economy. This is a most important item, and for this there is need of a remedy, and no doubt we shall soon have one devised.—Yours, &c., LANCASHIRE.

LEAKAGE IN STEAM BOILER.

To the Editor of "The Practical Engineer."

SIR,—Some weeks have now elapsed since we heard from "Engineman." Are we to understand the boiler is now tight? I would just remind him that he did not say whether or not the flanged seams touched the shell. Seeing that the boiler is working at 90lb., and the shell plates are ½in., and the boiler made in Bolton, can he say what kind of riveting machine was used in making the boiler? If the boiler is now tight, what steps were taken to make it so?—Yours, &c.,

CHALKLINE.

QUERIES AND REPLIES.

37. STEAM JOINTS.—Which is best for steam joints, such as valve box covers and steam pipes, indiarubber, asbestos, or thin wire gauze? Is there any reason for preferring any one of them in special cases? SUBSCRIBER.

Answer.—I should not recommend indiarubber in any case; I have been accustomed to using insertion while the faces are good, and asbestos when they get bad.—MARINE ENGINEER.

16. SETTING CORLISS VALVES.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—ENGINEER.

23. LIGHT MIXING MILL.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—EASTERN.

35. LOCOMOTIVE DRIVING WHEELS.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

36. NUT CAST ON IRON SCREW.—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and ⅜in. pitch.—SUBSCRIBER.

38. DUPLEX MINING PUMP.—Which is the best duplex action mining pump for use with compressed air, taking into account compactness and first cost as well as economy?—S.

39. SEPARATE CONDENSER.—Which is the best separate condenser for use with high-pressure engines, and state advantages?—H.

40. BARFFING CAST IRON.—Can any of your readers inform me whether cast iron which has been subjected to the process known as "Barffing" will withstand the action of a boiling solution of weak sulphuric acid? Also, can you give me the name and address of any firm where this process is carried out?—WORKS MANAGER.

41. HOT-WATER PIPES.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft.? What book may I get on arrangement of greenhouse?—WATER-HEATER.

42. BURNISHING BRASS.—Will some practical reader kindly inform me of the best way of burnishing brass?—SMITH.

43. SLACK CRANK PIN.—I have an engine of about 25 horse power nominal, and I find that the crank pin has become slack. What is best to be done? Should I put in a new one; if so, what is my best method of proceeding?—CRANK PIN.

44. RESISTANCE OF PIPING TO WATER.—Will you kindly permit me through the medium of your paper to ask if any of your correspondents will answer the following question, viz.: In a rising main of 3in. per yard, 400 yards long, composed of 200 yards of 4in. and 200 yards of 2½in. pipes, a pump is required to force through those pipes 30 gallons of water per minute. Will the resistance offered to the pump vary, and, if so, how much in each case, if the pipes were laid in the following order—

1.—200 yards 4in. pipes next the pump.
200 ,, 2½in. ,, delivery end.
400

2.—200 yards 2½in. pipes next the pump.
200 ,, 4in. ,, delivery end.
400

3.—100 yards 4in. pipes next the pump.
100 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
100 ,, 2½in. ,, ,,
400

4.—100 yards 2½in. pipes next the pump.
200 ,, 4in. ,, the above.
100 ,, 2½in. ,, ,,
400

5.—100 yards 4in. pipes next the pump.
200 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
400

6.—If the pipes were laid alternately—one 4in. pipe and one 2½in. pipe—throughout the entire range?—MEDIUM.

TO CORRESPONDENTS.

SUBSCRIBER.—We shall publish an article on the locomotive you mention in an early issue.

J. G. B., Haslingden.—We propose publishing a series of articles upon the gas engine very soon, by a well-known writer upon that subject.

G. P., Leeds.—In Wardle's Reference Book of Practical Mining some mention is made of the means of laying out signalling bells electrically and otherwise for use in mines.

E. T. R., Tewkesbury.—We are interested to learn that the metallic packing answers so well. Metallic packing put in on September 29, 1887, and still at work without giving trouble, or scoring the piston rod in any way, has done exceedingly well, and will have paid any extra first cost over fibrous packing long ago.

CALEB, Chesterfield.—In the case you mention, a lever 12ft. long over all, one end moving ¼in. and the other 12in., the ratio of the two ends working upon opposite sides of the fulcrum will be as 1 to 48. Therefore the fulcrum is 3in. from one end and 11ft. 9in. from the other. It depends, however, upon the method of linking the break-blocks to the end of the lever whether this is accurate. The break-blocks could be so connected that although one end of the lever travelled 12in., the other end might move much more than ¼in. although the blocks only moved that amount.

T. A. & SON, Cookston.—Mr. Sprague, the author of "Transmission of Power by Electricity," is an American, but we have forwarded your query *re* cost to him. It is answered, to some extent, in this issue.

MISCELLANEA.

The Chelmsford Town Council has accepted a tender to light the public thoroughfares of the borough for five years with eighteen arc lamps of 1,000-candle power each, and 200 incandescent lamps of 32-candle power each, at a total inclusive cost of £873 6s. 8d. per annum. The council, however, have granted the company the exclusive privilege of lighting private houses in the borough with electricity during the term covered by the public lighting contract.

The California Electric Light Company, of San Francisco, has erected at the Cholar Mine the largest electric-power plant in the world. It comprises six 120-horse power brush dynamos, each driven by a Pelton waterwheel with water under a head of 1,630ft. The water is conveyed through two pipes of 8in. and 10in. in diameter respectively. The station is situated in the shaft of the mine, and the exhaust water is carried off by a tunnel to the Caron River. The current is led to the mill, where it drives six brush motors of 125-horse power each.

Belloni's Pile.—The peculiarity of the new galvanic battery constructed by Professor Belloni consists in the fact that both the electrodes are of iron, the same piece serving as positive electrode in one cell and negative in the next. It is based upon the phenomenon of the passivity of iron when plunged into concentrated nitric acid, or into a mixture, according to certain proportions, of nitric and sulphuric acids. The surface of the iron not attacked by the acid plays the part of a positive electrode like platinum or carbon. The other surface, which is attacked, acts as negative electrode for the adjoining cell.

An Improvement in Alloys.—This alloy is intended to be used in the place of steel in the manufacture of the various parts of watches, such as the balance wheel and hair spring, so as to obviate the disadvantages which follow on their magnetisation or oxidation. The composition of the alloy is as follows: Gold 30 to 40 parts, palladium 30 to 40 parts, rhodium $\frac{1}{16}$ to 5 parts, copper 10 to 20 parts, manganese $\frac{1}{16}$ to 5 parts, silver $\frac{1}{16}$ to 5 parts, and platinum $\frac{1}{16}$ to 5 parts. The copper and manganese are first of all to be melted, and the other metals afterwards added, or the whole of the constituents may be placed in the crucible at once, with the manganese at the bottom.

A New Invention in Gunpowder.—A new gunpowder, the invention of Mr. Hengot, has been tested, and the results point to it as a promising substitute for black powder for military and sporting purposes. The new powder is prepared from straw, which is pulverised, chemically treated, and finished in granular form for use. It is claimed for this powder that it is smokeless, flameless, practically non-fouling and non-heating, and that the recoil and the report are less than those of black, with superior penetrative power. From the powerful character of this explosive, which, weight for weight, is stated to be 150 per cent stronger than gunpowder, and is not explodable by concussion, it is probable that in a compressed form it will be found to be applicable for blasting purposes.

Electricity on Railways.—If the scheme which M. Delfieu has just submitted to the Académie des Sciences be as efficient in practice as it appears to be upon paper, there can be no doubt about the benefit that it would confer. He calls it a "system of electric communication." He claims that it will make possible communication with a train on the move; that it will permit acting at a distance on the continuous compressed air brake; that it will render impossible the collision of two trains coming from opposite directions on the same line; and, finally, that it will give to a train, on its leaving a station, the means of announcing itself at the next station. A greater promise of railway security, and all automatically, there has surely never been.

A Sheffield Stand at the Paris Exhibition.—In the Machinery Hall the firm of Messrs. William Jessop and Sons, Limited, Sheffield, will display a varied selection of manufactured steel from their extensive works at Brightside. The converting and melting furnaces, forges, rolling-mills, wire-mills, steel foundry, gasworks, engineering shops, and the adjacent land cover an area of thirty acres, which is intersected by lines of railway three miles in length; and in addition to six water-wheels on the river Don, which flows through and divides the site, twenty-eight steam boilers are required to drive numerous engines, hammers, and machines. It is here that the finest qualities of steel for all purposes are produced, from the heaviest forging to the smallest bar, and from the stoutest plate to the thinnest sheet. At Paris the exhibitors will have on view circular plates of steel specially rolled and of various diameters, for making into circular saws; and in contrast to these there will be steel sheets for making into pens. Bars of cast steel, in diverse shapes and sizes, supply the material for the tools of the engineer and the smith, or for the delicate instruments of the surgeon. Cast steel, in bars, moreover, is utilised for files and cutlery, including scissors. One curious item will be found in a collection of fractures, which are considered very fine, to illustrate the variations that are obligatory in the temper of steel, to suit the many purposes to which the metal is applied. Blister steel and double shear steel in bars will rank side by side with castings of toothed wheels, cross-heads, spanners, &c.; while in another branch one may note the 6in. Palisser steel shells, such as the Government demand in their contracts.

Suez Canal and the Electric Light.—Our consul at Port Said, in his yearly report, just issued, has given some interesting details. He shows that the number of ships with the electric light which navigated the Suez Canal by night rose from 395 for 1887 to 1,611 for last year. This is more than a third of the whole number. This change and the improvements in the Canal itself shorten the average passage considerably. It has been reduced from 36 hours to a fraction more than 31 hours; and whilst this is the average time, the time taken by the vessels with the electric light is much less. It is under 23 hours.

Plating with Aluminium.—A process which it is said will constitute a new trade in Paris consists of a deposit of a coat of aluminium upon a metallic surface by the direct contact of a volatised salt of aluminium with the surface. The sheets of iron or other metal are first of all cleansed from all impurities by an acid bath, and they are afterwards plunged into a solution of borate of soda, hydrated alumina, and some easily fusible flux, so that the surfaces shall be treated in a state of perfect cleanliness. The articles which are treated in this manner are placed within a close muffle, and the walls of the muffle are raised to a very high temperature by a surrounding furnace. In this operation of plating it has been found by the inventor that the metallic sheets are not only covered with a coating of aluminium, but that they become impregnated with it to such an extent that they are practically an alloy of the two metals.

Kirwan's Station Indicator.—An instrument for conspicuously showing in passenger cars the name of the station at which the train will next stop, which is the invention of Dr. G. H. Kirwan, of Wilkesbarre, Pa., has been in use experimentally on a local train of the Lehigh Valley Railway recently for several weeks. The apparatus in each car consists of a roller carrying a wide ribbon or scroll on which the names of the various stations are inscribed. It is inclosed in a neat case with a glass front, and the instruments in the several cars are connected electrically with the baggage car, where, by means of a button, the baggage-master or other trainman immediately after leaving each station sets in operation the mechanism which moves the ribbon and causes a new name to appear. We understand that the indicator has worked with perfect satisfaction during the whole of the trial.

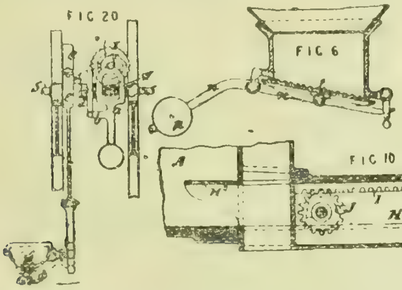
A Great Grecian Railway.—Greece is to be opened out. The long-projected railway from the Piræus to Larissa has now so far advanced that the date for the reception of the tenders for its construction has been fixed. The ancient centre of civilisation has been slow to adopt modern methods of travel. The sea gives the mode of transit for the people and goods of Greece. A little railway some seven miles long, from Athens to the Piræus, was opened in 1868; but for a dozen years it had no competitor. In the present decade, the mileage of line has been greatly increased, and there are over 300 miles in operation. That from the capital to the north would, however, become a great trunk line, bringing a large part of the Hellenic kingdom into communication with the rest of Europe, and very greatly affecting the future of that ancient country. The track of the navvy through Greece is certainly a subject that suggests much thought of the past and present.

The Institution of Civil Engineers.—At the ordinary meeting on Tuesday, the 2nd of April, Sir George B. Bruce (President) in the chair, it was announced that the following associates had been transferred to the class of members: Arthur Lyon Alexander, Henry Charles Baggallay, John Barker, William Henry Burr, Charles Farquhar Findlay, M.A., and Frederick Jopling. At the same meeting it was reported that the following candidates had been admitted as students of the institution: Charles William John Bearblock, Gerald Macleay Browne, John Kempe Brydges, A.K.C., Leslie Clarke, Alexander Sharp Douglas, William Drayner, Edmond Alderson Sandford Fawcett, Robert Stuart Hanckel, Alfred Edwin Hardaker, Edwin Hulme, Horace James Jordon Hummel, Hugh Haughton Latimer, William Orr Leitch, jun., Alfred Percival Livesey, Ernest Leslie Mirus, William George Nash, jun., John William Pole, Colin John Ross, Frederick Murray Royle, Arthur Grove Selwyn, John Roxburgh Sharman, Alfred Leonard Stocken, James Scargill Wade, Bertram Braund Waller, John Huth Walters, Harold Warren, and William Christopher Young. The monthly ballot resulted in the election of four members, viz.: Maurice King, P.W.D., India; Thomas Mudd, Hartlepool; Charles Lewis Strobel, Chicago; and Joseph Helen Thornhill, M.E., P.W.D., India; of twenty associate members, viz.: Charles Adcock, Liverpool; James Bower Bennett, Edinburgh; John William Townsend Boys, Emu Bay, Tasmania; John Browne, Bilbao, Spain; Alexander Brundrett, Rhymney, Mon.; William John Carpenter, Gasworks, Great Yarmouth; Tom Charles Ekin, Westminster; James Thomas Ford, New York; Herbert Goodyear, borough engineer, Colchester; Robert Green, Stud.Inst.C.E., Birmingham; Geo. Francis Horbury, Bombay; Charles Arthur Hutchings, Buenos Ayres; Charles Erskine May, P.W.D., Perth, Western Australia; Frederic Thomas Maltby, borough engineer, Dorchester; Charles Henry Rogers, Holbeach; Louis Charles do Rozario, A.K.C., Stud.Inst.C.E., Manila; Arthur Salmon, Egremont; Roger Thomas Smith, B.Sc., Stud.Inst.C.E. Leeds; Arthur Timmins, Runcorn; and Arthur Prangley Wilson, South Kensington; and of William James Carruthers Wain, Thornton Heath, as an associate.

ILLUSTRATED PATENTS.

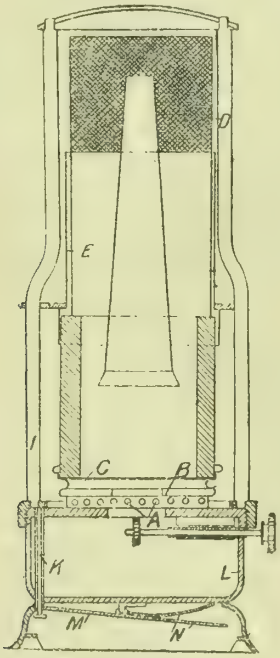
16,582. **Mechanical Retorts**, J. Dempster, Manchester.

Relates to apparatus for mechanically charging and discharging gas and other retorts. The retorts A, B, C, &c., which may be arranged in two vertical rows, are all fed from a hopper L either through a bifurcated shoot, or a main shoot with branch to each retort. The hopper L is covered in by a sliding door M operated by a rack and pinion, or by a rotating door operated by a handle. In another form it has a sliding bottom. The coal on falling into the mouth of the retort is pushed forward by a piston or ram H (fig. 10), formed with a projecting plate H^2 to prevent the coal banking up in the retort mouth, and reciprocated intermittently by a rack and pinion I, J, or other device, operated from a shaft S by suitable mechanism. In one form this consists of an eccentric *e* (fig. 20) riding loosely upon the shaft S and carrying one part of a clutch with which the other part *d*, rotating with the shaft, is intermittently put in and out of gear by a link C having at one end a bowl running in a cam groove Z formed on a worm wheel X driven by the worm W, and pivoted at the other to the arm *b* of a weighted bracket *a* hanging from the stud Y. The reciprocating mechanism may be modified by employing, instead of an eccentric, a crank or crank disc intermittently thrown in and out of gear by a tumbling lever; or a cam, mangle motion, or elliptical wheels may be employed. The rams may be actuated from the front instead of from above, and the intermittent mechanism may be dispensed with. Instead of a reciprocating ram a screw blade or series of blades set spirally on a shaft may be used. The coke is discharged at the other end from the several retorts into a common trunk *i* with sight doors *j* and closed at the bottom by a door *l* (fig. 6) carried by a counterweighted pivoted lever *n*. The counterweight *p* may be made to roll upon the lever *n* so that when the door opens the weight runs towards the pivot and allows the whole of the contents of the trunk to fall out, running back again as the door closes. A sliding instead of a pivoted door may be employed.—December 2, 1887. [1s. 4d.]



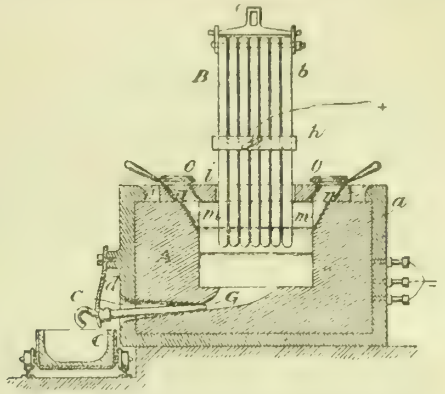
16,904. **Miner's Safety Lamp**, L. A. Groth, London.—(J. Lotineaux, 15, Impasse Ménilmontaut, Paris.)

The air supply entering the perforations A, A ascends through the gauze B and perforated disc C to the flame. The lower part of the gauze cylinder D is protected by an annular shield E. The ring H, receiving the lower ends of the standards I, I has recesses, into one of which enters a pin K passing vertically through the reservoir L. This pin is normally held in the position shown by the pivoted lever M and spring N; and the reservoir can only be detached by operating the lever and releasing the pin K. When in use the miner is prevented from gaining access to this locking device by a cylindrical box containing spring bolts, which project through the sides of the box and lodge upon the annular rim O; the bolts can only be drawn inwards to allow of the removal of the box by the use of a special key. The miner may extinguish the flame in the presence of fire damp by lowering the wick.—December 8, 1887. [6½d.]



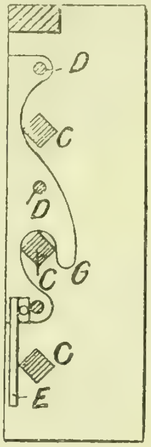
16,853. **Producing Aluminium and other Metals and their Alloys**, W. L. Wise, London.—(The Schweizerische Metallurgische Gesellschaft, Lauffen, Switzerland.)

Apparatus for carrying out the process described in Specificiation No. 7426, A.D. 1887, in which the materials are fused and electrolysed by the heat of the electric current. The drawing shows the arrangement. A crucible A is formed of carbon blocks supported by a frame *a*, preferably of iron cast on to give intimate contact. A tap-hole is formed at G and is closed by a plug *c* held in position by a spring *d*. The positive electrode B is formed of a block, or a number of blocks *b* of carbon, the intervening spaces being filled with soft carbon or metal. It is suspended by a chain hooked in the eye *e*, and passes into the crucible through an opening *i* in the cover. The cover is of refractory material and provided with apertures *n*, fitted with movable covers *o*, through which materials may be charged into the crucible. The positive electrode may be adjusted automatically, and for this purpose is connected with a motor regulated by an ampère-meter placed in the circuit. For the manufacture of aluminium alloys, a metal, say copper, in a pulverised condition is placed in the crucible, which forms the negative electrode; the positive electrode is then brought in contact with the copper and the current switched on; when the copper is melted the charge (alumina or clay) is added. Aluminium is reduced and alloys with the copper. A silico compound may be obtained by adding a silicate to the charge. Other metals or alloys, as manganese add wolfrom, may be obtained in a similar manner.—December 7, 1887. [8½d.]



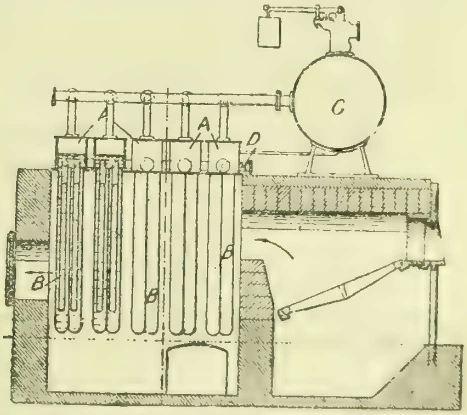
16,876. **Fuel Economiser**, W. Greenwood, York.

A fuel economiser for hanging on to the front of a fireplace, consisting of two end plates F formed with fingers G for hooking on to a firebar, and connected together by two or more bars D which come between the firebars C. The bearin fingers E can be bent to suit the various forms of bottom bars. For fireplaces with a hinged top bar, the upper bar and side plates of the economiser are slightl modified in form.—December 8, 1887. [6½d.]



16,903. **Steam Generator**. R. Panhard and E. Levassor, both of Paris.

The boiler consists of a series of transverse box-shaped elements A, from which are suspended the cylindrical chambers B containing inner circulating tubes similar to those of the "Field" type. The steam generated may be led to a steam drum C or taken direct to a motor. Feed may be supplied to each element through branches of the main pipe D.—December 8, 1887. [6½d.]



16,918. **Heading Cartridge Cases**, G. Greenwood, Leeds.

A side elevation of the machine is shown in fig. 1, and a longitudinal section on a larger scale of the carriage, heading die, and apparatus for resisting the pressure of the heading plungers is shown in fig. 6. The machine has two heavy cross-heads A, A¹ united by four steel tie bolts A², A³, A⁴, A⁵. A table B is bolted to the foot of the cross-head A, and receives a slide B¹ carrying a plunger B². This slide B¹ is connected to a short-throw crank shaft B³, mounted in bearings on the inner face of the cross-head A. A cartridge case is shown in fig. 6 on the mandrel c¹ which is supported by the bolt c. The carriage D receives an intermittent rotary motion on the shaft D¹ to bring its five holes 1, 2, 3, 4, 5 successively into line with the plunger B². The holes 1, 2, 3, 4, 5 carry plungers d¹, d², d³, d⁴, d⁵ of different lengths, so that when a cartridge case has been fed into the machine the plungers d¹, d², d³, d⁴, d⁵ advance it in stages on to the mandrel c¹. An extractor is provided to withdraw the case after the final compressing operation has been performed.—December 8, 1887. [8½d.]

FIG. 1.

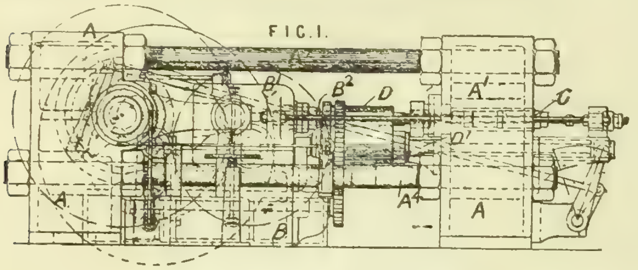
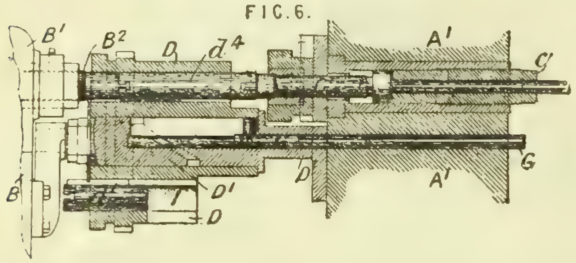
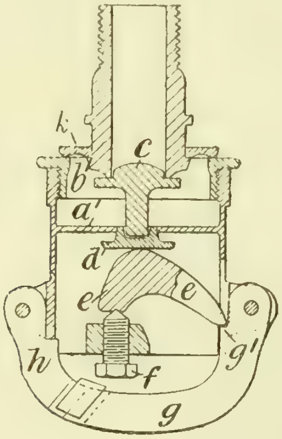


FIG. 6.



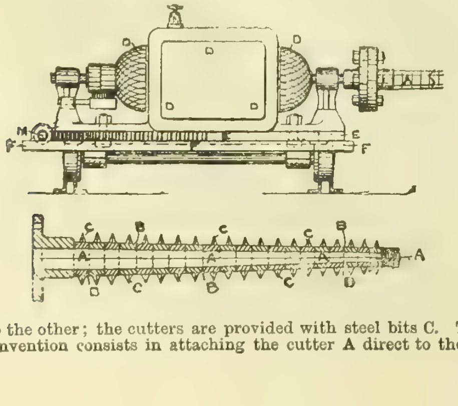
16,947. Fire-extinguishing Sprinklers, T. Witter, Bolton.

The objects aimed at are to obtain a water-tight joint with the least possible strain on the sensitive solder, a high degree of sensitiveness to the action of heat, as well as a good and even distribution of water when the sprinkler opens. The starting apparatus consists of an arrangement of levers with a soldered joint, as shown in the illustration. The valve c is supported on a washer d, which is in turn supported on an elbow of the lever e. The fulcrum of the lever e is a screw f by which the valve may be tightened on its seat; the other end of the lever being supported on a ledge g¹ on another lever g of which the end is soldered to a bracket h. When the valve c is open the water flows into a chamber above the disc a¹, and is projected upwards through the openings b¹, over which a spreader consisting of a serrated ring k rests, and is lifted by the action of the water. Modified forms are described.—December 9, 1887. [8½d.]



16,955. Coal-cutting Machinery, T. and R. W. Bowler and J. Blackburn, Woodlesford, Yorkshire.

The cutter bar A is tapered and the cutters B are reduced in size from one end of the bar to the other; the cutters are provided with steel bits C. The second part of the invention consists in attaching the cutter A direct to the shaft of a suitable electric motor D. The motor is carried on a turntable E actuated by worm gearing M and supported on a carriage F.—December 9, 1887. [6½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

April 15th.

6391 Separating Solids from Liquids, W. Hicks, London.*
6392 Governor, F. Wright, London.
6394 Metal Roofing, G. Ewart, F. J. D. Hüllinghorst, and R. Heywood, London.
6396 Grinding Mills, H. Courteen, Great Ponton, Lincolnshire.
6397 Atomised Solid Fuel, B. H. Thwaite, Liverpool.
6399 Explosives, C. O. Lundholm and J. Sayers, Glasgow.
6400 Motor Engine, G. Pinnington, Chester.
6401 Ventilated Dress Belts, I. Evans, Birmingham.
6403 Blending Flour, W. Jago, Brighton.
6406 Pump Valves, D. B. Morison, Hartlepool.
6409 Lock Nuts, A. E. Rogers, London.
6410 Galvanic Cells, R. A. Burnell, London. (T. Wilms, Hamburg.)
6412 Grippers, Ernest de Pass, London. (The Melbourne Tramway an Omnibus Company, Limited, Victoria.)*
6421 Sand Pumps, A. Brown, London.
6423 Electrical Motors, A. J. Jarman, Moorfield.*
6427 Explosives, W. R. Hodgkinson, London.
6432 Gas Retorts, F. Sanders, London.
6448 Steering Ships, E. A. Wood, London.
6453 Brakes, A. J. Boult, Middlesex. (G. Giussani, Italy.)
6454 Flanging Machines, W. Mullan, Liverpool.
6456 Healds, R. Briggs-Bury, Manchester.*

April 16th.

6468 Relief Valves, H. Kent, Royton, Lancashire.
6471 Recording the Vibrations of Locomotives, J. Milne, Manchester.*
6478 Looms, H. B. Broadhurst, Manchester.
6482 Lubricators, A. Dobson, Belfast.
6487 Throttle Valves, A. Ballantine and G. Cruickshank, Glasgow.
6489 Filters, E. A. R. S. Harvey, Glasgow.
6492 Aerating Machines, H. W. Payne, Birmingham.*
6493 Lock Nut, A. Green, Birmingham.
6496 Roller Mills, H. J. Allison, London. (H. A. Barnard, United States.)*
6497 Lifts, J. Corp, London.
6502 Split Pulleys, J. M. Pollard, P. G. Russell, and H. Orth, London.*
6505 Hydrostatic Levelling Instrument, C. T. Straus, London.*
6510 Valves, R. Miller, Coatbridge, Lanarkshire.
6515 Tyre-rolling Machines, J. Monton, London.*
6518 Steam Generators, W. Chambers, London.
6519 Rotary Shuttles, W. P. Thompson, Liverpool. (T. H. Mahr, Germany.)
6525 Compound Rail, A. E. Scott, London.
6526 Water Motors, F. W. Tuerk, jun. and W. H. Boles, London.*
6535 Steam Boilers, W. J. Jobling, London.
6545 Duplex Engines, H. E. Newton, Middlesex. (C. C. Worthington, United States.)*

April 17th.

6550 Automatic Coupling, G. W. Moon, Westminster.
6553 Meter, Sir W. Thompson, Glasgow.
6560 Portable Drill, J. Clark, Heanor, Derbyshire.
6563 Fire-extinguishing Apparatus, J. Haslam, London.
6567 Gas Producer, W. Deighton, Leeds.
6580 Cutting Washers, F. Shaw, London.
6583 Nut-lock and Fish-plate, G. Cooke, London.*
6593 Type-writing Machines, W. P. Thompson, Liverpool. (A. T. Brown, United States.)

April 18th.

6626 Looms, J. Smithies, Middleton.
6635 Split Pin, R. W. Fieldwick, London.
6638 Motor Engines, H. Williams, Manchester.
6639 Warping Machines, E. Rothwell and W. A. Rothwell, Manchester.
6640 Lock and Weir, A. F. Fowler, London.
6641 Consuming Smoke, T. Walls and J. Walls, London.
6643 Screw Dies, D. Muckley and A. E. Pritchard, Birmingham.*
6645 Safety Valves, J. L. Thomas, Liverpool.
6653 Wood-carving Machine, E. T. C. Köster, London.*
6657 Fire-grates, W. Bruce, Edinburgh.
6659 Water Gas, Joseph von Langer and L. Cooper, Leeds.
6662 Sprinklers, R. D. Bailey, London.
6679 Bush or Bearing, L. W. Thomas, London.
6680 Piston-rod Slides, E. Pinto de Soveral, London.
6684 Furnaces, H. Aitken, London.
6690 Governors, R. Wigram, R. H. Shaw, and W. G. Buck, London.
6692 Steam Engines, W. P. W. Boulton, London.
6693 Pipe Flanges, E. Edwards, London. (R. Weyher, Thuringia.)

April 20th.

6694 Surface Condenser, A. G. Brookes, London. (G. A. Greeven, Germany.)
6697 Water-wheels, W. E. Gedge, London. (A. P. Brayton, jun., United States.)*
6701 Carding Engines, F. Wilkinson, Manchester.
6708 Aluminium, G. A. Jarvis and W. P. Thompson, Liverpool.
6712 Gas Valve, F. S. Lees, Manchester.
6716 Steering Gear, J. H. Amour, Glasgow.
6719 Separators, J. S. Stubbs and S. H. Stubbs, Manchester.
6720 Travelling Bands, J. Moseley and B. Blundstone, Manchester.
6726 Retorts, N. McFarlane Henderson, Glasgow.
6727 Lubricator, W. Cunningham, Glasgow.
6737 Gas Lamps, H. M. H. Delamarre, London.
6742 Air Locomotion, R. Bird, Brampton Brian, Herefordshire.
6746 Rotary Engines, C. T. Colebrook and J. Gamgee, London.
6748 Rotary Engines, F. Cordenons, London.
6751 Wire-rope Grip, J. Williams, Walsall.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER,

MAY 10TH, 1889.

MARINE ENGINE TRIALS.

THE general meeting of the Institution of Mechanical Engineers was held on the 1st, 2nd, and 3rd inst., and the programme was a short but interesting one, consisting of the President's (Mr. Charles Cochrane) address and two papers; one a report by Professor A. B. W. Kennedy, the chairman of the Research Committee, on "Marine Engine Trials," and a paper on "Description of an Apparatus for Drying in a Vacuum."

The accurate testing of marine engines on a large scale is an exceedingly difficult problem. It is sufficiently troublesome and laborious to obtain accurate results in testing even small and stationary engines, but the difficulty is much increased when large marine engines have to be dealt with, while the great expense of occupying the whole time and crew of a large vessel in conducting a test for the purpose of obtaining steam engine data further complicates matters. The tests made upon trial trips are, as a rule, of insufficient duration, and are conducted under circumstances which cannot be considered most favourable to the attainment of satisfactory accuracy. Accordingly we possess but few really accurate tests of the performances of large marine engines under the ordinary conditions of actual work, and are mainly indebted for our knowledge of the subject to Mr. Isherwood's exhaustive experiments upon the engines of the United States Navy vessels, Rush, Bache, and Gallatin. As these were completed fifteen years ago, the engines are somewhat obsolete now, and the conclusions cannot apply to our modern types, except in a very qualified way.

Although inland steam users and engineers are necessarily more interested in the performances of stationary engines, yet much valuable knowledge is gained by a study of the marine engine even for mill purposes, and we therefore propose to briefly discuss the report of Professor Kennedy. The Research Committee included Professor Alexander B. W. Kennedy, F.R.S., chairman; Wm. Anderson, Walter Brock, Horace Darwin, Bryan Donkin, jun., John Dunlop, Frederic Edwards, A. C. Kirk, LL.D., Michael Longridge, J. G. Mair, Wm. Parker, A. E. Seaton, Richard Sennett, Arch. Thompson, Professor W. C. Unwin, F.R.S., and W. H. White, F.R.S., a list of names so well known as to inspire very complete confidence in the results published.

The steamship Meteor of the London and Edinburgh Shipping Company was placed at the disposal of the committee by the kindness of Mr. Thos. Aitken, manager of the company. It is a vessel of a gross tonnage of 1,223, and on the day of trial the mean draft was 15ft. 1¾in., and the displacement was 2,090 tons. The engines are of the triple-expansion type, by Messrs. J. and G. Thomson, Glasgow; high-pressure cylinder 29⅜in. diameter, intermediate 44in., and low-pressure 70in.; stroke of all three cylinders 4ft.; they work on three cranks, spaced equally apart in order—high, intermediate, and low. The three cylinders were steam jacketed, and live steam was admitted to each by independent reducing valves; they have piston valves, one to the high-pressure cylinder, and two to each of the others; valve gear was the ordinary link motion. The high-pressure valve was linked up as much as possible, and gave a nominal cut-off of 26in.; the intermediate and low-pressure motions were not linked up, and the valve gear was left untouched during the whole of the trial. There were two boilers, each double-ended, with—in all—twelve furnaces, which were of steel, and had Fox's corrugated flues. Total grate surface 208 square feet, and tube surface 5,760ft.; total heating surface 6,648 square feet. The object of the trial was to measure the coal, water, and indicated horse power as accurately as possible, and over as long a period as possible without disturbing the ordinary work of the vessel on her usual run from Leith to London, and arrangements had to be made to obtain accurate measurements under somewhat trying circumstances. The arrangements were very complete, and the trial commenced at 1-30 a.m., shortly after leaving Leith, and terminated at about 6-30 p.m., when the vessel reached Cromer, thus extending over about 17 hours. The fuel used during the whole of this period, together with the feed water, were accurately weighed and measured, and the fires were not cleaned during the whole run, in order that the complete ash and clinker might be weighed after the trial. Numerous and periodical indicator diagrams were taken, as well as measurements of temperature of feed water escaping chimney gases, pressures in boilers and steam jackets.

The results are in brief as follow: Total coal burned, 68,693lb., or 4,005lb. per hour, from which there was ash 1,671lb., and clinker 2,806lb., or, ash and clinker together, 6·51 per cent of the total fuel.

The feed water from the hot well and other sources was measured in two tanks, and was in all 512,150lb, or 29,860lb. per hour.

The total indicated power during the run, an average of thirty-four sets of diagrams, was 1,994 H.P., the average speed of the engines being 71·78 revolutions per minute; this gives a consumption of 2·01lb. of coal per indicated horse power per hour, and corresponds to a consumption of 1·76lb. of carbon value per indicated horse power per hour. The water used by the engines was only 14·98lb., or within the limits of error of measurement 15·0lb. per indicated horse power per hour, and the evaporation of the boilers was 7·46lb. of water per pound of fuel put on the fire, including clinker. Calculating this to carbon value and evaporation at 212 deg. F., it amounts to 9·62lb. per pound of carbon value in the fuel, or 62 per cent of the whole heating value of the coal. This percentage therefore represents the efficiency of the boiler.

Analysis of the furnace gases showed, with measurements of their temperature in the funnel, that 22 per cent of the whole heat of the fuel escaped up the chimney with the waste gases as actual heat, while 3·6 per cent was lost due to the formation of carbonic oxide, which accounts for 87·6 per cent of the whole heat, and the remainder was lost by radiation and clinker.

These determinations are exceedingly interesting. The efficiency of the boilers was less considerably than that obtained from a good Lancashire land boiler with economisers, and much less also than the results obtained with the Davey-Paxman boiler at the recent Society of Arts trials, where 82 per cent of the total heat of combustion was applied to its purpose, that of evaporating water, and only 12 per cent was wasted in all other ways. On the other hand, the triple-expansion engine was much more economical than the compound, and, using only 15lb. of feed water per indicated horse power per hour, it converted 16·1 per cent of the total heat which it received into work, or 54·6 per cent of what it could have done had it been an ideally perfect heat engine working between the temperature limits used in it. Curiously enough, however, the united efficiency of engine and boiler was nearly identical with that obtained in the Society of Arts trials by the small compound engine—namely, 10 per cent, so that the more economical engine just balanced the loss occasioned by the less economical boiler. Had the boiler been as economical as that referred to, the united efficiency would have been 13 per cent, a splendid result for the steam engine. We are somewhat surprised, however, at the very low efficiency of the boiler. It is surely possible to get much better results with many marine boilers at present in use.

A comparison between the diagrams and the weight of feed water used gives an insight into the amount of cylinder condensation. The steam accounted for by the diagrams varied in the three cylinders from 75·3 to 80·2 per cent; that is, while the weight of steam calculated from the diagram showed respectively 75·3 to 80·2, the water proved to be in the cylinder by the amount of feed water passed into the boilers was 100. Part of this difference was due, however, to the steam used in the jackets, which could not be measured. The boiler pressure was 145lb. per square inch, and the maximum pressure in the H.P. cylinder was 134·4lb., showing a loss of about 10lb. The condensation in the H.P. cylinder amounted to 23 per cent, including jacket condensation, at a point after cut-off when the pressure had fallen to 110lb. per square inch, and it seemed to remain very constant in all three. It diminished by re-evaporation in the intermediate cylinder to 20 per cent, which, however, increased again in the low-pressure cylinder to 25 per cent. It will be seen that even in very economical engines there is still considerable loss by cylinder condensation.

So far as we can see, the greater part of the loss of 23 per cent in the H.P. cylinder occurred during admission, as the difference between the maximum pressure and the pressure at the moment of measurement was not sufficiently great to cause condensation from work performed. It is, of course, impossible, and indeed undesirable, to prevent the condensation of expanding steam while doing work upon the piston, as that would involve the addition of heat from the sides of the cylinder to the steam during the whole stroke, and would result in considerable loss of efficiency. The object of expanding is, to some extent, reduction of the maximum temperature of the steam in the boiler to the temperature of the condenser, and any heat received from the cylinder during expansion by increasing the amount of heat discharged into the condenser diminishes the economy of the engine. What should be attempted, therefore, is to reduce condensation in an engine, but without increasing re-evaporation. Like all conditions occurring in practice, this requirement is to some extent self-contradictory, and cannot be entirely realised.

By far the greater loss occurring in these engines lies in the construction of the boilers; 62 per cent is an exceedingly poor result from a modern steam boiler, and properly arranged economiser methods would pay the owners handsomely in diminished fuel consumption. Of course there are great difficulties with the limited spaces available on board ship; still it is obvious that something could be done to improve construction in this direction. We are much interested in the work of the committee, which is of vital importance to engineers. At the present time accurate measurement of the disposition of all applied energy is absolutely indispensable in order to understand clearly where improvement is possible, and the amount of gain to be expected from any given change. We shall publish the complete report, with its accompanying diagrams, in an early issue, as it is well worth the most careful study by steam engineers, both land and marine.

THE PARIS EXHIBITION.

Notwithstanding the extreme backwardness of the exhibition, it was opened to the public on Monday, 6th May, with an imposing ceremonial and an enormous attendance of people. As yet it is too early to describe the exhibits themselves, for, except in the British Section, they are still greatly hidden in cases. It is very creditable to those having control of the British Section that it should be so far in advance of the others, and, though there is still a considerable amount of work to be done, it is certainly comparatively complete.

We observe with interest that Messrs. Davey, Paxman, and Co., of Colchester, supply a considerable portion of the motive power of the exhibition, nine 100 H.P. steel boilers and four steam engines, the largest of which is 350 H.P. It is intended to drive two 150 H.P. Gramme dynamos, connected in series, to supply current to four huge arc lamps lighting up the great Machinery Hall. This hall is a wonderful achievement, and in many respects is not second even to the Eiffel Tower itself, and its dimensions far exceed anything that has yet been attempted. It covers an area of 900,000 square feet, and is really one great nave of 375ft. clear span, and about 1,400ft. long. The greatest span of the kind previously existing is that of St. Pancras Station, London, which is 239ft. 6in., and its feet are connected by tie rods.

A syndicate of twenty-four companies has been organised to supply the electricity required for lighting the various departments, exclusive of the Trocadéro, and divide among them the sections, pavilions, domes, illuminated fountains, and colonies of many nationalities. The experience of the Messrs. Galloway has been utilised in carrying out the illuminated fountains, and the effects are intended to far surpass anything achieved by that well-known firm at London, Manchester, or Glasgow in volume of water or lighting effects.

Although fifteen millions of visitors are expected between 6th May and October 31st, yet the expense that has been incurred is so enormous that a heavy loss will be sustained; but the French Government and people care little for a disbursement of thirty or forty million francs in honour of the Republic.

HYDRAULIC DOCK MACHINERY.*

THIS subject is at once so large and so diverse that it is impossible in the space at our disposal to adequately describe in detail the many useful and ingenious hydraulic machines and engines which are to be met with at all well-appointed docks and harbours. As a matter of fact, a paper might well be devoted to any one of the following among other developments of the hydraulic system, viz.: Pressure pumps, accumulators, and pressure intensifiers; machinery for actuating lock gates and sluices; the hydraulic capstan (the most useful of hauling machines); hydraulic gear for swing, lift, and draw bridges; hydraulic cranes; coal-shipping machinery; grain-warehousing machinery; hydraulic motors, and hydraulic lifts. Therefore we must be content with but just briefly glancing at the growth of the system of distribution of power by means of water at a comparatively high pressure.

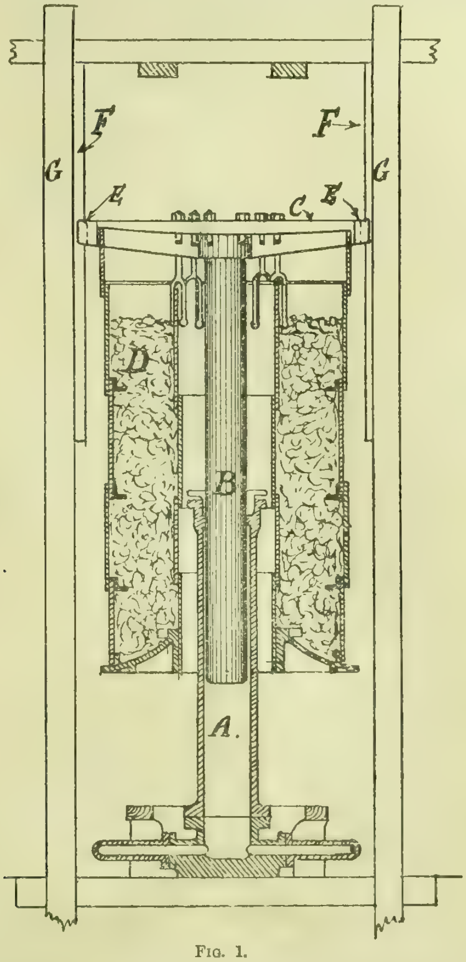

FIG. 1.

That hydraulic power is without a rival in the various operations which must be performed in docking, discharging, and reloading a vessel is fully shown by the almost universal adoption of the system since its first use some forty years ago by Lord Armstrong, in Grimsby, where the celebrated water tower (which the writer believes is the earliest artificial accumulator erected for the purpose of developing power) stands as a fitting monument not only to one of our greatest engineers, but also to the new mode of transmission of power which it practically inaugurated.

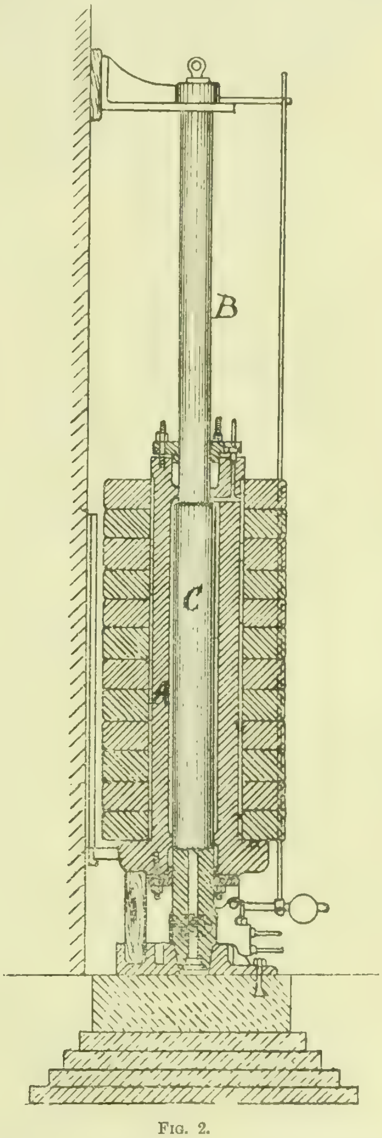

FIG. 2.

Without in any way making this an historical sketch, it is interesting to note that in 1812 Joseph Bramah, who invented the hydraulic or hydrostatic press in 1796, patented a plan for laying water mains in cities, the water to be used for extinguishing fires and for operating hydraulic machines, in factories, warehouses, &c., and for elevating heavy weights, goods, &c., and this is actually done to-day by the General Hydraulic Power Company, Limited, in London and other large cities.

Among the many reasons which go to account for the popularity of hydraulic power are the following: The ready manner in which it may be stored by means of accumulators, thereby enabling the use of pumps of exceeding small size, compared to the large intermittent powers required to keep up the supply, thus requiring a prime mover of but small power, whether steam, gas, or any other form of motor be employed. Absolute certainty in its action, irrespective of distance from the central station. Ten years' experience at the Victoria Docks, London, demonstrated that there was nothing to fear from corrosion in the ten miles of pipes, and the loss from friction did not exceed 2 per cent per mile. The heaviest work may be performed at the greatest speed which may be allowable, there being no shock; a 1in. pipe will transmit about 6½ H.P. at a very moderate speed of water, and a 2in. pipe will transmit 25 H.P., both being under a pressure of 1,500lb. per square inch, while a 10in. pipe will transmit 300 H.P. at a pressure of 700lb. per square inch. The freedom from noise and smell in the several machines is also a characteristic feature of hydraulic power, and if the pipes be laid 2ft. below the level of the ground and boarded over, there is no danger from frost in this country. Above all, there is positively no risk of fire, and in case a fire should take place near a hydraulic system, by the use of a suitable ejector nozzle it forms the best possible fire engine, a small volume of the high-pressure water raising a large volume of low-pressure water from the ordinary mains, and throwing it on the flames at a pressure best suited to cope with fire.

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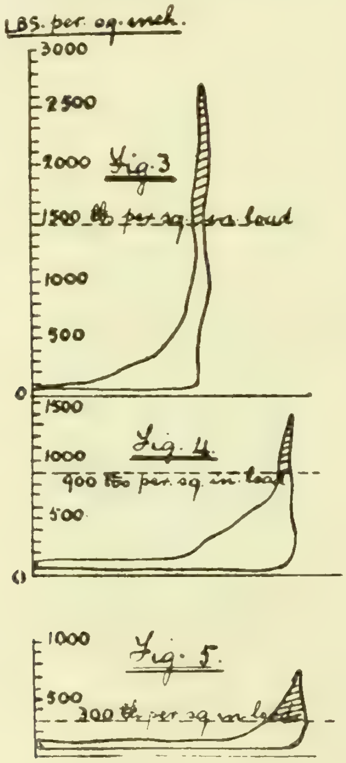
*Paper read by Mr. J. A. Tempest, before the Leeds Association of Engineers and Draughtsmen.

HYDRAULIC MACHINERY.—The pressure pumps and the accumulators are the foundations of the system. The prime mover will necessarily depend on circumstances. Where there is a plentiful supply of water with a few feet fall, this will naturally be utilised by the interposition of a turbine, waterwheel, or possibly a hydraulic engine, to actuate the pumps. Should water not be available, then gas or steam is commonly used, a gas engine working on to a three-throw pump shaft being probably the most economical where gas is reasonably cheap, the more so as the gas engine is well adapted to the intermittent working which is inseparable from the hydraulic system; but the writer thinks there is still much room for improvement in the details of the gas engine. In all cases where gas engines are used that have come under his notice he has heard complaints of their frequently being out of order. The other motor, and that the most frequently adopted, is the steam engine or steam pump. For a large installation, doubtless, it is desirable to use the steam expansively, while for smaller plant, unless there is some other source of power at hand, a direct-acting steam pressure pump such as those of the Worthington Co's., Tangyes', or Fielding and Platt's are probably most suitable.



FIGS. 3, 4, 5.

The accumulator (see fig. 1) consists of a large cylinder A having a ram B with a long stroke, the ram being weighted until it requires a pressure per square inch on the ram to raise it, corresponding with the pressure which it is intended to adopt as the standard for the installation. This is done by suspending from the top casting or crosshead C a wrought or cast iron weight box D, this weight box being filled with scrap iron, sand, gravel, or other ballast, as the case may be, or the weight or ballast box may be done away with and solid weights suspended from the crosshead. This may especially be done in the immediate neighbourhood of a foundry, any sort of metal, ash, clinker, &c. being melted up to form the weights. By this means the mass of weight is denser, and consequently a smaller diameter over all is attained, and the ground area required is very much reduced. At the extremities of the crosshead are guide brackets E which engage with the guide rails F, carried on wood or iron supports G, or bolted direct to a wall. The centre of gravity in the accumulator being very low, it is not necessary to guide the lower portion of the accumulator, though in many cases it is desirable, although the friction of the guides is increased thereby. Fig. 1 is Armstrong's accumulator, familiar to all. Fig. 2 is a representation of the accumulator used by Tweddle for his riveting machines. This has two fixed rams, B and C, of different diameters, the cylinder A sliding up and down on the rams, and carrying the weights necessary to give the pressure required, the rams forming the guides for the accumulator. The capacity of this form of accumulator is only very small, being the difference in the areas of the two rams by the length of stroke. This limited capacity is a desirable feature in hydraulic riveting, as when a demand is made on the accumulator, owing to the small difference in the areas, it falls rapidly, and when the resistance rises to its maximum the descent is hurriedly checked, and a ram action caused, the effect of which may be seen by the diagrams (figs. 3, 4, 5), the accumulator being variably loaded as indicated. In

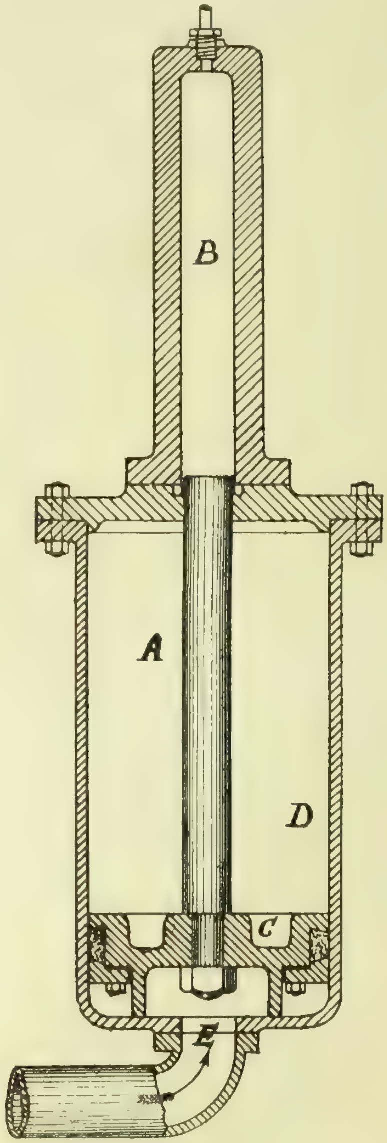


FIG. 6.

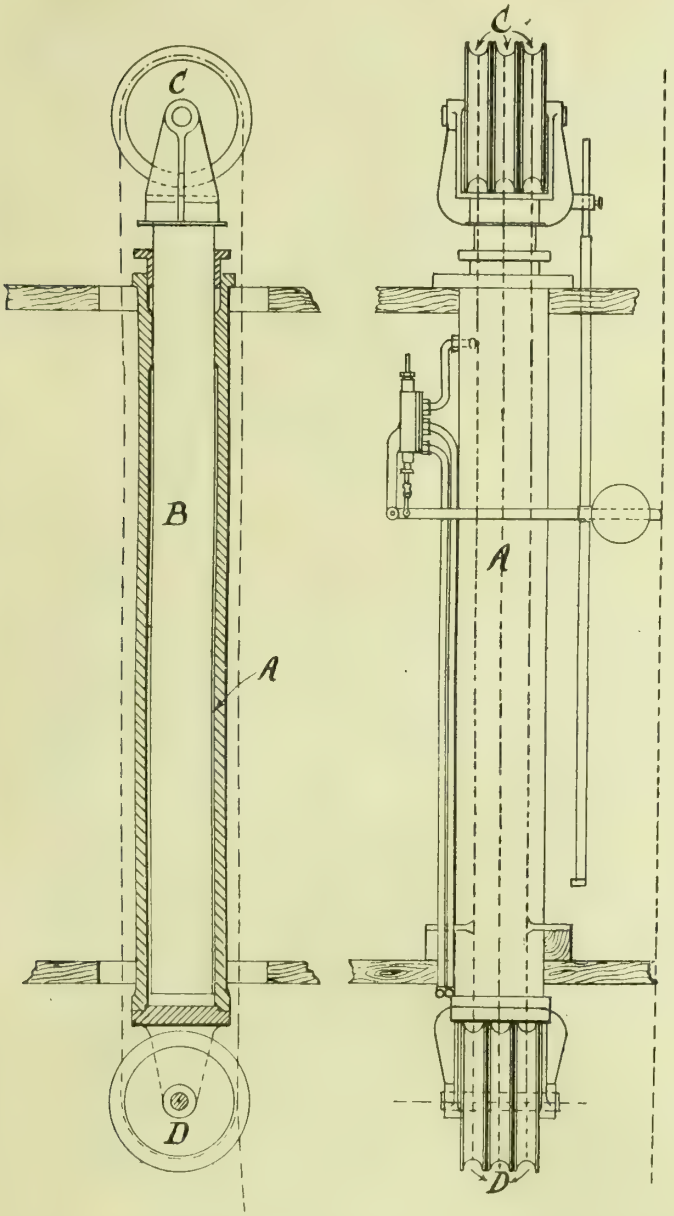


Fig. 7.

ordinary hydraulic machinery this ram action is very objectionable, and to avoid it relief valves or air vessels are customarily used on the machines and mains ; but in cases where the diameter of the accumulator ram is greater than the ram of the machine—*i.e.*, where the rate of travel of the accumulator is slower than that of the machine—this effect is scarcely discernible, and if the valves are actuated by fine thread screws, or by levers having considerable movement, so that the opening or closing of the valve is comparatively slow, no unpleasant shock is noticeable. When the accumulator is at the top of its stroke the pumps are automatically thrown out of gear either by shutting off steam at the stop or throttle valves or actuating the expansion gear, so slowing down or stopping the engine, or by relieving the safety valves or lifting the suction valves of the pumps, or by operating on separate relief valves, the whole of the pressure being relieved. The stopping of the engines is the best method, the engine being slowed down gradually as the accumulator nears the top of its stroke. Engines ordinarily working at 100 strokes per minute may be seen making two or three strokes per minute as the accumulator reaches its highest point. Another form of accumulator, practically that shown in fig. 6, is really a direct-acting steam pump. In this A is the ram of the accumulator working in the cylinder B ; C is a steam piston working in the steam cylinder D, the weight being applied by admitting live steam at E into the cylinder D, the cylinder B containing water, the comparative areas of the piston and ram being such as to attain the requisite water pressure in B, with the available steam pressure in the cylinder D. This is a very useful form of accumulator for use on shipboard, and it is fully described by Mr. A. B. Brown, in his paper read before the Institute of Mechanical Engineers at Birmingham, in 1874. Fig. 6 is actually a hydraulic pressure intensifier, the available pressure in the accumulator being admitted at E into the cylinder D, to give very high pressures in the cylinder B. Say the relative areas are as 10 to 1, then a pressure of 700lb. per square inch in D will give a pressure of 7,000lb., or about 3 tons per square inch in B.

All hydraulic machines are practically presses, and they are for the most part reciprocal in their action, although, of course, any of the various methods in use for converting reciprocal motion into rotary may be adopted. In all reciprocating hydraulic presses the pressure is applied either direct or through a series of pulley sheaves, and each pair of pulleys very materially affects the efficiency of the press. According to Mr. Percy G. B. Westmacott, the coefficients of effect obtained by hydraulic machinery with ordinary hemp packing, without special precautions to reduce friction, are as follows :—

Powers.	Coefficients.	
Direct action	93	per cent.
2 to 1	80	„
4 to 1	76	„
6 to 1	72	„
8 to 1	67	„
10 to 1	63	„
12 to 1	59	„
14 to 1	54	„
16 to 1	50	„

These coefficients will, of course, be higher where great care is taken to reduce the friction to a minimum, but may be taken as a fair average. Dock gates are opened and closed by hydraulic presses having some four or six pulleys, as in fig. 7, A being the hydraulic cylinder, B the ram, on the head of which are carried the three pulleys C, and at the tail end of the cylinder are similar pulleys D, every foot movement of the ram B representing a movement of 6ft. at the end of the chain E. For the dock gates duplicate cylinders are placed alongside in a pit at each side of the lock (see fig. 8), the chains from one press at each side leading across to close the doors on the opposite side of lock to the press, and the chains from the other presses open the locks on the same side as the presses. Messrs. Tannett and Walker, of Leeds, have applied direct acting cylinders to dock gates at Goole and at the Barry Docks, Cardiff, thereby obtaining increased efficiency. Hydraulic capstans and winches are also used for opening and closing dock gates.

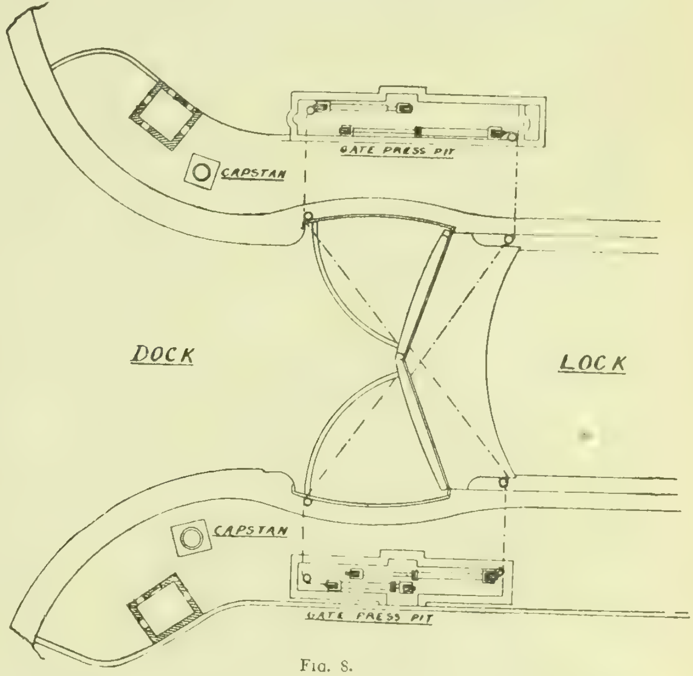


Fig. 8.

Sluices are usually actuated by direct-acting hydraulic presses placed directly over the opening to the culvert, all the operations of opening and closing the various sluices and dock gates being quickly and noiselessly performed, one man easily actuating the various valves, which are placed in a convenient position so that he may command the dock.

(To be continued.)

THE STEEL AGE.

Civilised nations, during their progress from barbarism (says the *Scotsman*), have passed successively through several periods, which, in order to indicate the advance made in the use of the raw materials provided by nature, have received such names as the Stone, the Bronze, and the Iron Age. The time in which we live may be appropriately known, if we follow the nomenclature of ancient history, as "The Age of Steel." The peculiar modification of iron which we know as steel is now everywhere rapidly supplanting iron itself as a constructive material. Thirty years ago its use was confined to the manufacture of what are technically known as "steel toys," meaning such small tools and instruments as are required to be of exceptional hardness, as metal-cutting tools, knives, razors, &c. Nowadays it is used, though hardly in the same form, for the largest structures. Ships and boilers, for instance, are now almost universally built of steel. Before we can understand the importance of this change, and the nature of the discoveries and inventions which have led to it, we must inquire a little into the composition and properties of the material itself. Of the almost innumerable substances which come under the general designations of iron and steel, the only one which at all approaches purity, as applied to the state of an elementary substance, is malleable or wrought iron. This is essentially pure iron, and the elimination of all other elements is the object of great care in its manufacture. Cast iron, on the other hand, consists of pure iron along with a proportion of carbon varying from 2 to 5 per cent, and smaller proportions of other elements, both metallic and non-metallic. Either the whole or part of the carbon, according to the treatment to which the mixture is subjected, is chemically associated with the iron, the remainder being crystallised separately in the form of graphite. The difference in physical properties between cast and wrought iron is very considerable, and of great importance in the arts. Wrought iron is only fusible by very intense heat, while cast iron may be melted without difficulty, this being its most valuable characteristic. Wrought iron, however, becomes soft or pasty at a heat below that required to melt cast iron, and pieces of it may then be welded together, and form a solid mass. The structure of cast iron is crystalline, that of wrought iron fibrous, and this explains the great difference between them as regards toughness and strength. Cast iron, it is well known, is very brittle and cannot be bent, while, although its power of resisting compression or a crushing strain exceeds that of malleable iron, its tensile strength or resistance to a tearing force is only one-sixth as great. There are more varieties of steel than there are of either cast or wrought iron, but one distinguishing characteristic runs through them all, namely, a superiority over both of these, alike in hardness, toughness, or strength. It essentially consists, like cast iron, of iron and carbon, but whether combined chemically, or merely mixed mechanically, science has hardly yet been able to determine, though the balance of evidence appears in favour of the latter theory. Steel only contains from one-sixth to 1½ per cent of carbon, along with a small proportion of manganese, and is, or ought to be, comparatively free from an admixture of any other elements, as its strength and trustworthiness are very injuriously affected by impurities. It will at once be seen that steel may be produced in two ways, either by taking carbon from cast iron or by adding it to wrought iron. The latter is, of course, the more expensive process, as wrought iron is itself first produced from cast iron; but it was the only one used before the great invention of Sir Henry Bessemer, and it is still used for the production of the very finest quality of cast steel for cutting-tools, &c. The methods now chiefly employed are four--the cementation, the Bessemer, the Siemens-Martin, and the puddling processes. The cementation process is the one to which we have just referred, and consists in imbedding bars of pure iron in finely ground charcoal, and exposing it to a high temperature for several days, when it is found that the carbon has been uniformly distributed throughout the whole mass, which has thus been converted into "blister steel" (so-called from its external appearance). When this has been remelted two or three times it becomes what is known as "crucible cast steel," the purest and strongest form in which the material can be obtained, which is very expensive. In the Bessemer process, patented in 1856, melted pig iron is introduced into a large vessel called a converter, through which a powerful blast of air is passed for about half an hour. The air burns the carbon and other impurities out of the iron, almost reducing it to the metallic state, and thus forming a sort of impure malleable iron. To transform this into steel, a carefully measured quantity of a very fine variety of cast iron called "spiegeleisen" is then incorporated with it, and it is poured out and cast into ingots. The Siemens-Martin method proceeds on almost the same lines, but instead of using a converter, the operation is conducted in a large furnace, heated by gas to an intense violet heat. The puddling process is hardly used now in this country, but is the way in which the famous Krupp, of Essen, in Prussia, manufactures the metal for which he has achieved a world-wide reputation. It is simply the same process as that used for the production of malleable iron, in which the melted pig iron is exposed to a draught of air in a puddling furnace, and stirred about to oxidise the carbon and other impurities. This is either stopped before all the carbon is removed, or, preferably, continued till malleable iron is formed; when a little spiegeleisen is added, as in the Bessemer process. Steel combines the malleability of wrought iron with the fusibility of cast iron. In whichever way it is produced, it is always cast into ingots, which are then hammered, rolled, and forged into the various required forms. Cementation steel, owing to its cost, is used only for small articles, the great centre for the manufacture of which is Sheffield. Bessemer steel is used to a very large extent for rails, while Siemens-Martin steel is used for ship, boiler, and bridge work, and is manufactured (especially in Scotland) in much larger quantity than any of the other kinds. Steel possesses the very important and peculiar property of becoming intensely hard and brittle when heated to a bright red heat and suddenly cooled, while any intermediate degree of hardness may be obtained by "tempering." The number of different degrees of temper employed for various tools, &c., is very great, the proper temper for each being determined by the shade of colour which the polished metal acquires, these shades being beautifully graduated from blue to yellow, and each invariably corresponding to one particular temperature. Steel is a remarkably sensitive material, and requires the exercise of great care during its subsequent manipulation to prevent its deterioration in strength. The holes in steel boiler plates are invariably drilled instead of being punched, while ship plates, where the vast number of rivet holes precludes the former method on the ground of expense, are subsequently annealed by heating to redness and cooling slowly, which is found to counteract the bad effects of punching. Steel castings are now used in many cases where iron was formerly employed, such as the framework of marine engines. Unfortunately they are hardly yet so trustworthy as iron castings, being very apt to contain cavities filled with air or "blowholes," which are not discovered till a breakdown occurs. The late Sir Joseph Whitworth, of Manchester, however, invented a system of casting under hydraulic pressure, by which this danger is avoided and a very sound material results (Whitworth's fluid-compressed steel). The great advantage of steel over iron lies in its superior strength. This varies very considerably, but its lowest limit may be taken as one and a half times the strength of malleable iron, both for crushing and tearing. The highest limit of strength is reached in steel wire, a piece of which, one-tenth of an inch in diameter, will support a weight of 1,750lb. With such an increase of strength, of course, very much less weight of material is required, and this compensates for the higher price of the steel, while a considerable saving is effected in the labour of erection. Besides this, there are many cases, such as shipbuilding, where weight is of the first importance, every ton saved in the weight of the vessel itself meaning so much more cargo space, and consequently so much more freight-earning capacity. It is hardly surprising, therefore, to learn that six-sevenths of the ships now built are entirely of steel, and it appears, from the rate at which this material is being adopted, that within a year from now hardly another iron vessel will leave the ways. The effect of this enormous change on the great iron industry of this country has hitherto been, on the whole, rather unfavourable. Unfortunately for us, steel, to be worth using, requires to be very pure, and hence nothing but the very best hematite ore has been used until lately for its production. The greater part of this has been imported from Spain, the ore predominating in this country being the clay ironstone. The objection to this is that it contains a good deal of phosphorus, and phosphorus is more injurious to steel than almost anything else. However, a process (the "basic" steel process) has lately been perfected, by which the phosphorus is extracted, and steel produced equal in quality to that made from hematite.

The use of this steel for shipbuilding has now been sanctioned by the Board of Trade and Lloyd's Committee, so that there is every prospect of our being able to make all our material from native ores. Such, in brief, are the main facts concerning the present position of steel as a constructive material. Its future appears to be a very promising one. The improvements in its manufacture made within the last thirty years are probably but an indication of the vast strides which the steel-making industry will take during the next century. No prospective rival has yet appeared in the field, with perhaps the single exception of aluminium, and that has not yet proved a commercial success. There is, therefore, very little doubt that steel will not only maintain its present high position, but also, as its advantages and trustworthiness become more widely recognised, gradually displace more and more those materials which just now share with it the field of usefulness, until the 20th century may be called, with even greater justice than the present, the Steel Age.

METALLIC PACKING.

The advantages of metallic packing rings for the pistons of engines have long been recognised, and no engineer would now think of constructing a steam engine in which he used the old hemp or fibrous packing for the piston. So great an amount of ingenuity has been applied to the design and invention of perfect forms of piston packing that practically the problem has been long solved, and we can choose from a great variety of perfectly good types the construction of packing most suitable for any given purpose or pressure. Pistons now work admirably, smoothly, and quite steam-tight under high pressures for very lengthened periods without necessity for adjustment or interfering with the piston packing in any way. Accordingly it now seems anomalous that we should still continue the use of the old fibrous packing for piston rods, valve stems, and similar details. It seems as if we should be able to apply metallic packing as readily in the one instance as in the other; that, however, is not the case. The difficulties in the way of efficient and generally applicable metallic packing for piston rods are much greater and more serious than a cursory examination would lead even an engineer to suspect, and this becomes very evident from an attentive examination of the patent list in this country and America; the number of attempts and failures in such contrivances is astonishing. The separate patents devoted entirely to the purpose number not hundreds but thousands. We have tested several forms of piston-rod packing, but without entirely satisfactory results; the conditions seem to be considerably different from those common to pistons. In the first place, if rings are used, they require to spring in instead of out, and it is difficult to allow for vibration, or even want of strict accuracy in alignment, which is more common with piston rods than it should be.

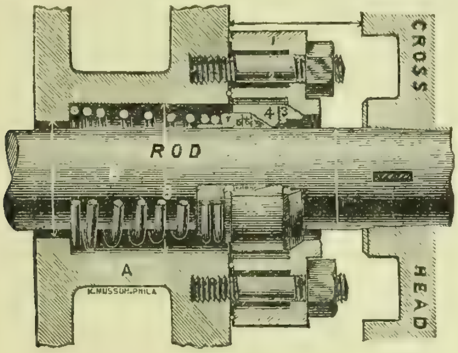


Fig. 1.

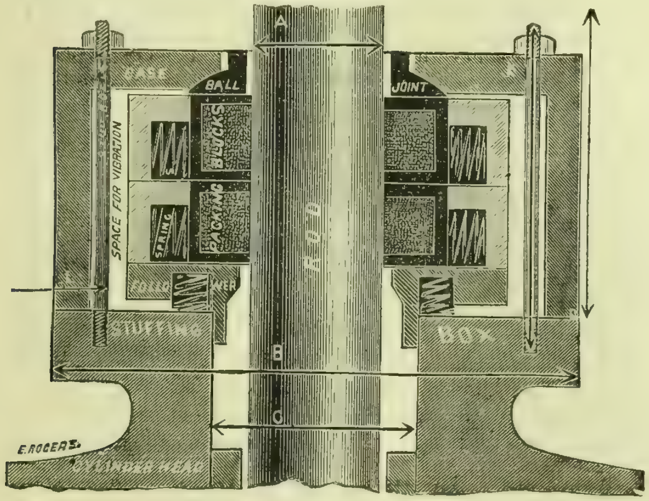


Fig. 2.

We have lately examined a system of metallic packing for piston rods and similar purposes, which is exceedingly ingenious, and overcomes the difficulties in a very complete manner. It is the construction and design of the United States Metallic Packing Co., of Philadelphia, and it is most extensively used both in this country and in America. Two types are manufactured, which we illustrate on this page. Fig. 1 is a section of that suitable for application to the piston rods of locomotives, and for valve stems, pump rods, and throttle spindles, when the diameter does not exceed 3½in. The ordinary stuffing box A (fig. 1) in which the piston or other rod B works is fitted with the cap or case 1, instead of the usual stuffing gland bolted firmly by the studs 2. A ball, or spherical-faced ring 3, fits a corresponding socket or seat in the case 1, and it is bored out to leave considerable clearance for the piston rod. A cup or ring 4 is faced against one side of the spherical-faced ring 3, and is made with a conical interior, as shown, fitting to a similarly shaped or conical Babbit metal ring. Two square Babbit metal rings 6, 6 follow it up, and are kept up by the ring 7, thrust up by the spring 8. The conical Babbit ring 5 is forced inwards by the cone on 4, due to the pressure of the spring, and also the steam pressure, which enters freely round. All three rings 5, 6, 6 are cut like ordinary piston rings. With this construction the piston rod may vibrate as much as ¼in., and yet, by the movement of the vibrating cup or ring 4 along the face of the ball and socket ring 3, together with its movement on its ball socket, the rings 5, 6, 6 always cling closely to the rod, and it moves steam-tight, and with very little friction. The great freedom for play in this type, and the comparatively

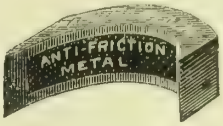


Fig. 3.

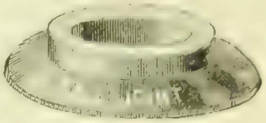


Fig. 4.

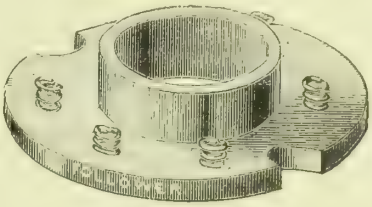


Fig. 5.

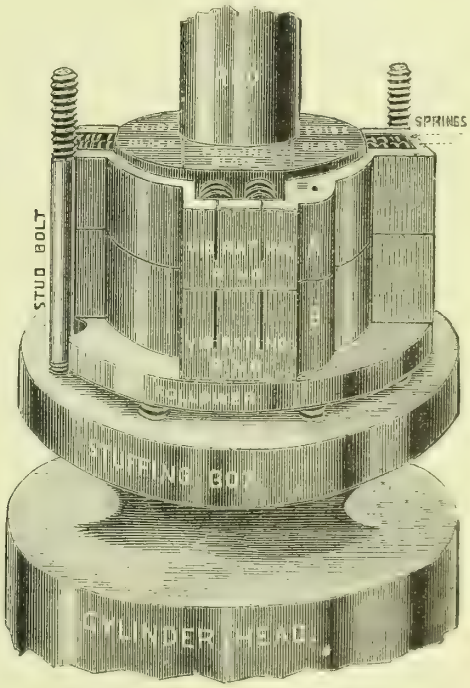


Fig. 6.

soft Babbit metal, make it most suitable for locomotives, where the vibration is necessarily considerable, and for valve stems, which may move about a little, as well as vary their stroke under the action of the link or governor.

Fig. 2 illustrates the type most suitable for large marine and stationary engines, and it consists of eight blocks, of a special metal composition, which are held in a strong ring, and pressed against the rod by springs. They ride gently against the rod, with very little friction, and no risk of binding, as is the case with all packing set up by screwing down nuts. A ball joint, as in the first case, is next the exterior of the case, and a following ring, kept up by springs, is on the inner side. Vibration is allowed for, as in the first type.

Figs. 3, 4, and 5 show details of the packing blocks, the ball joint ring, and the spring following ring. Fig. 6 shows the packing in position on the rod, with the external case removed. This type is applicable to rods up to any necessary diameter.

The packing seems to us very well designed, and completely wrought out in a thoroughly practical way. The continued care necessary with ordinary packing is a grave objection; if not screwed up tightly enough there is loss by leakage, and if too tightly screwed up the loss by friction is far greater than is commonly surmised. A packing which, once put in, can be left to itself without interference or adjustment, as with this one, until worn out, is of great service to engineers, and we expect its use will largely extend. We are informed that in this country there are over two hundred packings in use on the London and South-Western Railway, and that it is used by the Lancashire and Yorkshire, the Caledonian, and the North British Railways; while for marine engines, the Inman, International, the City Line, Clyde, Red Star, and many others have adopted it.

Many well-known engineers now use it, including Messrs. Laird, Messrs. Beyer, Peacock, and Co., Musgraves, and many others. Over 10,000 packings are now in use on the Pennsylvania Railroad in America.

The packing has been introduced into this country by the United States Metallic Packing Company, Exchange Chambers, Liverpool.

INSTITUTION OF NAVAL ARCHITECTS.

The annual session of this institution was continued on Thursday and concluded on Friday, the 12th inst., in the theatre of the Society of Arts, Adelphi, London, Lord Ravensworth presiding. There was a large attendance on Thursday, when Sir N. Barnaby, late Director of Naval Construction, read a paper on "The Protection of Buoyancy and Stability in Ships," which, he explained, had been prepared before he knew that Mr. White's paper of the previous day on the new first-class battleships was to be read. He had read with pleasure the article in the *Times* of that day and the summary of the discussion on Mr. White's paper. In the course of his paper Sir N. Barnaby explained the design of a small ship of 3,200 tons prepared by the Naval Construction and Armaments Company under his advice. The ship would have the same speed as the larger Admiralty design, with powerful guns and armour protection, and would cost only one-fifth of the money, and be capable of perforating more than 99 per cent of the area of the sides of all armoured foreign ships. She had no armoured belt at the water line, but it was proposed to protect the buoyancy and stability, for the first time, by a solid raft. The material to be used for this purpose had been prepared by the Woodite Company, and its qualities and proposed mode of application were explained at length. Proceeding to consider the question of protection to buoyancy and stability, he pointed out the very large proportion of ships in the French navy and in our own which had no such efficient protection by means of side armour. No one gave a thought to the men in these ships, when the perils of insufficient armour in some heavily-armoured monster were descanted upon. Taken altogether, he continued, there is not fighting accommodation in the whole of the British fighting ships of 1,000 tons displacement and upwards, protected and unprotected, built and building, for 50,000 men. Fifty thousand men only, while in our last naval war we had 146,000 seamen and marines borne upon ships' books! We may be sure that the very first effort, in a serious war, would be to find ships and guns for another 50,000. (Cheers.) But what ships and what guns? Confining our attention to the ships, we see at once what they must be. They must be ships without any armour. And yet we are to strain every nerve to increase the already monstrous armour protection for four ships' companies of 500 men each. The critics of the ships find it easy enough to point out and dilate upon shortcomings in any ship which has been limited in size with a view to reduce the cost. Each one of its powers stops short of what would be attainable were the others sacrificed to it. We have seen how the improved armour defence, mainly for buoyancy and stability, has raised the cost of the Admiral class by one-third, and has yet failed to secure the approval of those who choose to concentrate all their attention upon this one secondary quality. I say it is secondary, because if it were of primary importance we should have no seagoing ships sent into action without such defence. We are told, on the highest naval authority, that the heavy-armoured ships will be accompanied on all occasions by a considerable number of unarmoured ships, for the purpose of flanking and supporting the heavy ships against attacks which would be perilous to them. This means that the unarmoured ships will have to give and receive blows, and I presume that there will be no rule that an armoured ship must not strike one that is not armoured; and I cannot conceive that the battleship which is to be so exceptionally treated in armour defences is to be the only class of fighting ship which the enemy will endeavour to destroy by artillery fire. I contend that the distinction in respect of protection which is set up between battleships and other ships is a novel one, and a most dangerous one. Before the days of armour-plating every ship was treated, so far as her defensive power was concerned, in the same manner. They all ran equal chances. They differed only in the power of attack. And it is the more necessary to adhere to this principle, seeing that, according to our most distinguished sailors, large and small ships will be associated in action more closely than ever. But our practice is that the larger proportion of these ships are to be protected by an office classification, and are supposed to need no thick side armour or deck armour either, for the defence of the buoyancy and stability against the gun; while a smaller number, classified in a different manner, are to have so much defence that we can put only a mere handful of men and guns afloat, because the money has to be spent upon this exceptional and monstrous protection for a few ships. In concluding his remarks on this subject, the lecturer pointed out that, with from a million to a million and a quarter of money to spend, in order to put from 500 to 600 men afloat in fighting condition, we might have either one large ship or five smaller ones of the same speed, and he dwelt on the many advantages which, he contended, the five smaller ships possessed over the single large one.

A discussion followed, in which Admiral Sir John Hay, Sir E. J. Reed, Admiral Boys, and Mr. W. H. White spoke. Sir N. Barnaby replied, and was corroborated by Admiral Sir H. Stewart in stating that naval officers had always been consulted by the Admiralty in respect to new ship designs.

The next paper was by Captain Penrose Fitzgerald, R.N., "On the Protection of Merchant Steamers in time of War." He said that at present we did not possess a sufficient number of war cruisers to afford anything like adequate protection to our merchant ships in case of war with a maritime power, and there was thus the possibility of having our enormous trade destroyed and the British merchant flag swept off the sea, with the transference of trade to neutral bottoms. Shipowners must contemplate some timely steps whereby they might render their ships to a large extent self-protecting against everything but the most powerfully armed cruisers of the enemy. He passed by the 40 or 50 first-class steamers already on the Admiralty list, and went on to deal with a proposal applicable to second and third class steamers. This in effect was that ocean-going steamers should have a thwart-ship coal bunker abaft the engines, of about 15ft. to 20ft. wide and 10ft. thick, the top of it 2ft. above the top of the cylinders, and the bottom of it on a level with the screw shaft. Such a bulwark would form a very effective protection for the engines against the bow chasers of most cruisers. Then the vessel should have mountings and fittings for two light guns, say 4in., right aft, one on each quarter. The tactics would be very simple—keep the stern to the enemy, and run away, head to the wind if possible; and he thought that by so running and using the guns the chances generally would be in favour of the merchant vessel.

A discussion followed.

The cruiser Piemonte, built for the Italian Government at Elswick, was next described by Mr. P. Watts, of Elswick, her designer, and a short discussion followed, in which Sir Edward Reed and Mr. White took part.

Subsequently Mr. J. I. Thornycroft read a paper on "Water-tube Boilers for Warships," a specialty of his firm.

In the evening technical papers were read by Mr. John Scott, C.B., Mr. J. Macfarlane Gray, and Mr. V. B. Lewes.

The first paper read on Friday, the 12th inst., was by Mr. Beauchamp Tower, describing an apparatus for providing a steady platform for quick-firing or machine guns, or a telescope, or a search light, on board ships at sea. The apparatus, which could only be fully understood by pictorial illustration, had been successfully applied in the inventor's yacht, and was acknowledged to be a very ingenious device to obtain the results aimed at. The discussion, as well as the paper, was of a technical character, and in the course of it Admiral Sir John Hay expressed a doubt whether men-of-war required any such means for working guns, inasmuch as it was necessary for a gunner to be thoroughly trained in all the varying circumstances of a ship rolling, and to take his aim and to fire after calculations as to the allowances to be made for the arc the muzzle of the gun would traverse, as well as for wind and deflection. The platform might be useful for the search light and telescope. Mr. Brunel and Mr. Froude spoke of the value of the apparatus for the prevention of sickness; and Mr. White referred to the value of the machine as a means of measuring the rolling of vessels. The great ingenuity of the invention received general commendation.

The second paper was by Professor V. B. Lewes (Royal Naval College) on the fouling of steel and iron ships. He said that metallic coatings had proved a failure, and that, so far as it was possible to judge, there was but small likliehood of their ever being made to succeed. He examined the value of all the compositions and coatings, and maintained that tar and tar products and waxes were among the best protectives; but care must be taken to eliminate acid and ammonia salts from these, and the protectives should be applied hot, and then the question of inside protection might be considered to be practically solved. As to the outside, after dealing with the question of fouling by sea animals, he recommended bituminous composition, or varnish with substances to give them body, as a means of protecting the metal. To overcome the long-felt evil of destruction of iron ships through galvanic action in sea water, he insisted that all copper-coating compounds (many of which were in the market) must be carefully rejected. There was considerable discussion, and Admiral Colomb suggested that, with the purpose of destroying the fouling on the bottoms of men-of-war, if they could not visit a river in order that the fresh water might destroy the marine life, there might be means adopted of poisoning the water in which the ship floated. The question was an important one for warships, as the fouling lessened the dearly-bought speed. Mr. Martell (of Lloyd's) spoke of the importance of special care being taken in the protection of iron and steel, and urged with Mr. Lewes that attention should be given to protective compositions in preference to so-called "anti-fouling compositions."

Two papers by Mr. R. E. Froude followed, one on the part played in the operations of propulsion by differences in fluid pressure, and the other on Professor Greenhill's theory of the screw propeller.

Technical papers were likewise read by Mr. W. W. Rundell and Mr. A. F. Hill.

At the close thanks were given to the president for his services during the session.

THE COLUMN PRINTING TELEGRAPH.

TYPE-PRINTING telegraphs (says the *Times*) are no novelty, but down to the present time, so far as we are aware, these ingenious and useful instruments, whether designed for long or short distances, have produced a record on a band of tape only. The House and Hughes machines of the past were marvels of ingenuity, and astonished all by the beauty and accuracy of their work. In the early days of the Atlantic cable, and before Sir Wm. Thompson had perfected, or at least thoroughly tested, his speaking mirror, the Hughes instrument was believed to fulfil all the requirements necessary to successful transmission through long cables. The telegraph companies, both in England and America, at one time employed the House and Hughes systems extensively, but we believe they have now become obsolete. This has arisen, not from lack of speed or accuracy of transmission, both of which were excellent, but on account of their form of delivery. Neither speed nor Roman type could compensate for the inconvenience involved in handling thousands of yards of tape. This objection still exists, although the use of these machines has been transferred to another field, viz., the club and the stockbroker's office. With the view of overcoming this objection, Messrs. Moore and Wright have devised and perfected a machine by means of which a printed column, similar in appearance to that produced by an ordinary type-writing machine, is received by wire in a form suitable either for the hands of the printer, for exhibition on a board, or for delivery to the public. In this machine only one wire is employed, and, while in construction it is free from complication, in action it is, it is said, certain and satisfactory. It contains two clockwork trains, one of which revolves the type-wheel, while the other feeds the paper upwards at the finish of each line and at the same time returns the type-wheel to its normal position for beginning the next line. The clockwork which feeds the paper and returns the type-wheel is released by the action of an auxiliary magnet, to the armature of which are attached two releasing fingers which act upon a pin attached to a pinion at the last position in the train. On this magnet being sufficiently charged to attract its armature, the fingers are merely moved into proper position, the paper not being fed until the current ceases and the armature is withdrawn by means of a spring. This appears to be a perfectly novel arrangement, as is also that for feeding the type-wheel laterally, which is effected by means of two racks, one of which is movable, while the other is stationary. The great practical advantage of this machine lies in the fact of its producing news of every kind, including quotations of the prices of shares and stocks, in column form, agreeable to the eye and easy of reference.

DEVELOPMENT OF HEAT ENGINES.

AT a recent combined meeting of the Polytechnic and the Literary and Philosophical Societies, Liverpool, Professor Hele Shaw read a paper upon the "Development of the Heat Engine," the subject being illustrated by models and by limelight pictures. The professor said the earliest heat engine was described by Hero, of Alexandria, about 200 B.C. For many hundreds of years no other heat engine appeared upon the scene, and the first authentic account of the revival of attempts to use steam occurred about the year 1600, when they found attempts made to utilise the impulsive action of a jet of steam for the purposes of turnspits and small motive engines. It was reserved for a modern engineer, of high scientific attainments—the Hon. Charles Parsons—to show five years ago the possibility of using steam in this way most economically. The true secret of its use was to obtain high speed. This engineer's steam turbine, running at no less than 10,000 revolutions a minute, gave an efficiency which compared favourably with the best modern steam engines. About the year 1600 attempts began to be made to utilise the direct pressure of steam, but for a long time this was only applied in order to force water. The lecturer then traced the history of the steam engine to the time of James Watt, who first separated the hot and cold parts of the engine. Air engines were next treated of, the gas engines following, from its first form to the present silent engines. Professor Hele Shaw then illustrated by diagrams the result of elaborate trials made by the Society of Arts, showing that the Atkinson gas engine gave the best results of any. The gas engine was much more promising of improvement than the steam engine, and the regenerators now used produced a vast saving in the heat which was formerly lost by escapement. The most successful engine utilising the regenerator was that of Mr. James Hargreaves, of Liverpool, and this engine promised to be the most useful of any heat engine yet produced. Mr. Hargreaves had gone further in the solution of the great problem of storing and re-utilising the heat than had any other scientist. A vote of thanks to Professor Hele Shaw closed the business of the meeting.

A NOVEL RAM.

A FORMIDABLE submarine ram has been invented by Mr. W. R. Cavett, foreman of the Porter Machine Company, Pittsburgh. The boat will be flush with the water line, and will have a turtle-shaped deck, protected by heavy steel plates. In the forward part of the vessel will be a heavy cylinder, similar to those used in engines. The cylinder will be about 15ft. long, and will contain a piston rod 12in. in diameter. This piston will extend through the bow of the boat, and will form the ram proper. It will be propelled by a force of steam equal to from 50 to 150 tons, sufficient to pierce the side of the heaviest ironclad at one blow. The forward end of the ram will be made cup-shaped, so that the sharp edges will take hold anywhere they happen to strike. Mr. Cavett promises a speed of from 20 to 22 knots an hour. He says that he has computed the striking force of the piston, and estimates that, with a 60-ton force, it will knock a plate from the heaviest ironclad afloat. Only six men will be needed on board the vessel, and the only vulnerable place on the craft will be a small glass-covered aperture about a foot square for the steersman. The vessel will be so small and compact that it can be carried on board a man-of-war, and can be used in encounters at sea as well as for harbour defence.

A NEW PETROLEUM ENGINE.

FIG. 5.

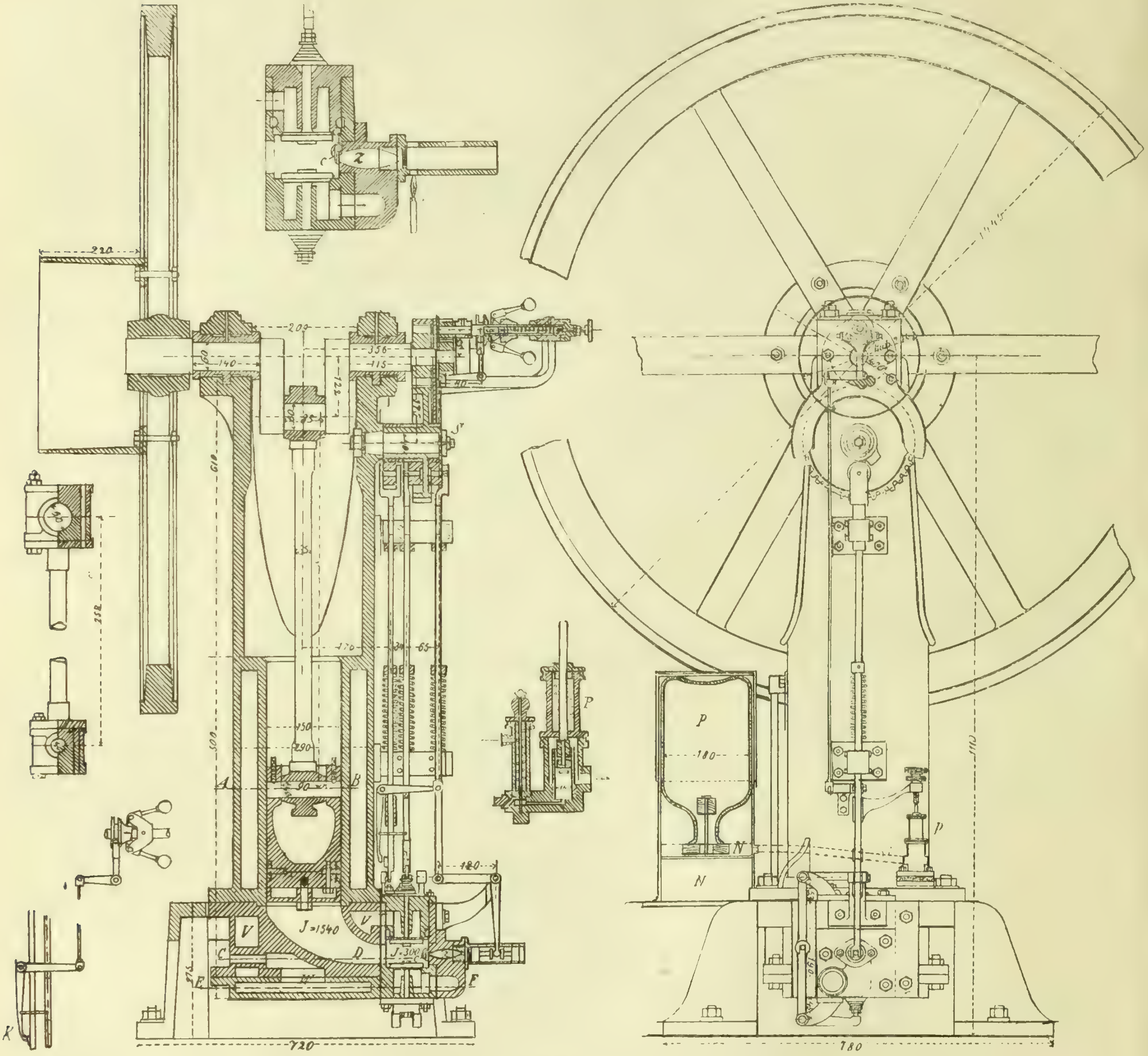


FIG. 3. FIG. 1. FIG. 4. FIG. 2.

MANY attempts are at present being made to apply petroleum as the actuating power for explosive engines, but as yet with incomplete success. It is not very difficult to construct an explosive engine using light petroleum, or benzoline, with a low flashing point and easily vaporisable, but this is somewhat dangerous, as the oil is too inflammable to be safe for ordinary handling. It is very desirable that an engine using petroleum in this way should be able to consume ordinary heavy oil, such as is used in mineral oil lamps, and which is perfectly safe with anything like common care. The Priestman petroleum engine is the only one now used in this country which complies with this condition, but it is at a distinct disadvantage in firing the charge by the electric spark.

We illustrate here an engine designed by Dr. M. V. Schiltz, of Cologne, which has recently been exhibited at Munich, and is said to give very favourable results in economy and efficient action. It is constructed, like most petroleum and gas engines, on the basis of the well-known Otto cycle, or, as some prefer to call it, the Beau de Rochas cycle, in which four single strokes or two double strokes are made for every impulse. In this case during the first out-stroke the piston takes in a charge of air and petroleum vapour, compresses it into a space at the end of the cylinder during the next in-stroke, and the ignition takes place and the impulse is given in the following out-stroke, while the return stroke discharges the products of combustion into the exhaust pipe, and completes the cycle of working operations by which the engine gives power.

So far the process is precisely similar to that in the well-known Otto engine, but the combustion space at the end of the cylinder, instead of being water-jacketed, is allowed to heat up, and by ribs and plates the heat is applied to vaporise ordinary paraffin or petroleum oil. The air supply to the engine is drawn through this hot chamber and the oil is pumped on the surface by means of a small force pump; sufficient heating and mixing surface is obtained by filling the chamber with copper wire or shreds, the mixture of air and petroleum vapour takes place, and the whole charge is sufficiently hot to prevent condensation again when it reaches the cylinder. To start the engine when cold it is necessary to use oil of low specific gravity, so that a supply of vapour may be obtained at once, and after the engine has been at work from twenty to thirty minutes the heavier and safe oil is substituted.

Referring to our illustrations, fig. 1 is a section through the crank shaft axis, showing the engine details. Fig 2 is a section at right angles to the shaft axis. Fig. 3 shows the governing arrangement, which varies from that common in gas engines. The lever K, when moved by the governor link, engages the catch or plate shown, and prevents the return of the rod connected with it. This causes the inlet air valve from the vaporising chamber V to remain closed, and it stops the petroleum pump as well as opens the exhaust valve. The motor piston then moves to and fro, and displaces the exhaust gases in the exhaust pipe, alternately drawing them into the cylinder and discharging from it with but little resistance. The ignitions at once cease when the lever K engages as we have described. When it is lifted out again by the engine slowing down, the charge is taken into the cylinder, compressed, and ignited as usual.

The igniting arrangement is shown at fig. 5, and it consists of a small outer chamber Z communicating with the explosion space by a light lift valve C, and a small perforation from the chamber runs to the outer air, controlled by a slide. When the mixture within the cylinder becomes compressed, a portion flows through the small hole and is ignited at an external flame B. At the proper time a valve is closed outside the flame, and, as it can no longer escape, it ignites back into the chamber, and by its pressure lifts the flap valve, and so explodes the mixture within the explosion space. This arrangement is said to act well and to give no trouble, and it is very fairly simple.

The explosion chamber is arranged so that the exhaust gases carry away any excess of oil which may be condensed by the sides of the cylinder, and the vaporising chamber is arranged to carry off any oil not vaporised by the flow of air in a state of spray.

The engine is arranged to be easily cleaned, and so that the valves and details may be readily accessible for adjustment or repair. The pump details are shown at fig. 4.

An undoubted disadvantage in starting the engine is the use of light inflammable oil to heat up sufficiently; but the absence of the electrical ignition is a distinct gain.

We are indebted to our contemporary, *Dingler's Polytechnic Journal*, for our illustration; and we should like to hear the results of a test with this engine, so far as power and consumption of oil are concerned, and also with regard to durability of the vaporising chamber, which, we think, would be very apt to choke up from deposit unless very frequently cleaned.

ELECTRIC WELDING.

The welding of metals by means of the electric current is perhaps one of the most important of the more recent applications of electricity to the arts.

Fig. 2.

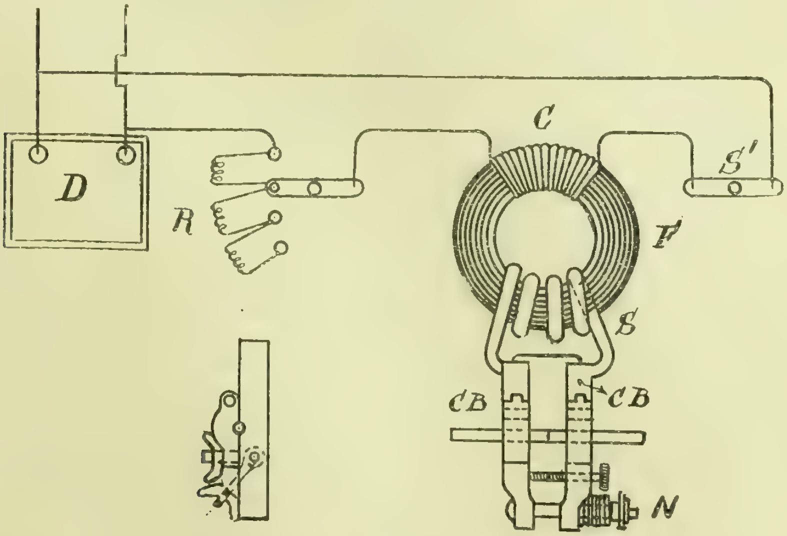


Fig. 1.

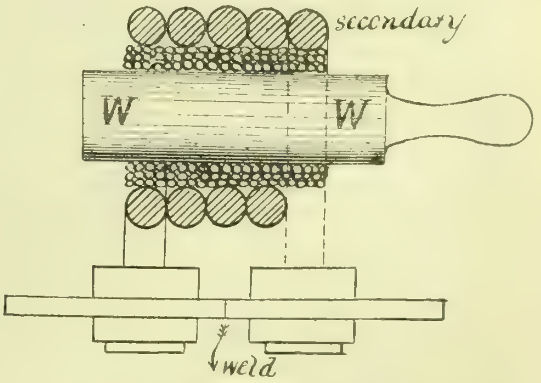


Fig. 3.

By the ordinary processes now in use it is difficult if not impossible to weld together different metals such as iron, steel, zinc, tin, and brass. By means of electricity they may be easily united, and iron, steel, and platinum, which have been the metals most easily welded, are by the new process still more readily united.

The method of electric welding we shall first describe will be that of pressing together two pieces while passing a large current. Here the resistance caused by the discontinuity of section, or "break" between the two pieces, causes an increase of temperature at that point; the resistance and temperature together increase in intensity until the metal under pressure is at a sufficient heat to unite. This process is generally known as the "Thomson" process, after the inventor Professor Elihu Thomson. There are two methods of obtaining sufficiently large currents, and the one most generally adopted is that using alternate current dynamo machines connected with transformers. The other is that using storage batteries charged by continuous current machines, but the welding mechanism is the same in both cases. The first arrangement we illustrate diagrammatically in fig. 1, where the primary circuit of the alternating current dynamo D is coiled at C round one side of a wrought-iron ring F, and a secondary coil S, consisting of four or five turns of heavy copper cable is wound upon the same core. This ring, with the two coils C and S, constitute the transformer, by means of which the dynamo currents of high potential and small quantity are transformed into currents of low potential and large quantity. The transformer may be looked upon as an ordinary induction coil reversed, which can only be used with an intermittent current. A variable resistance R is placed in the outside circuit to provide means for changing the intensity of the current, and a switch S^1 permits of breaking the circuit when desired. The ends of the secondary coil S are attached each to one of a pair of copper blocks C B, which carry clamps for holding the wires to be welded in position. For rapid manipulation they are hinged, as shown in fig. 2. A nut N and a compressed spring permit the arms to be drawn together to bring the wires together by gentle pressure. The current being then allowed to pass, the ends of the wire fuse and unite to form a perfectly welded joint. There are two important variations in the transformers used in this process, one of which is shown in fig. 3, as composed of five turns of large copper cable wound in parallel around the primary, and the ends are bolted to copper plates upon which clamps are placed, as in fig. 1. The iron core W W, upon which the primary circuit T T is wound direct, may be pulled in and out to vary the power of the currents induced in the secondary coil, and adapt it to any sized forging. Here resistance of the secondary coil is 0·00015 ohm. To prevent overheating the secondary coil, resistance may be connected to the primary circuit, or the strength of the field magnets varied.

In the transformer or induction coil, illustrated in fig. 4, the primary coil *h* is a coil 12in. in diameter, 2½in. wide, and ¾in. thick, of many turns of insulated copper wire, the ends EE of which are connected with the alternating dynamo generating the currents. The secondary coil h^2h^2 is a single heavy bar of copper, bent to make one turn outside of the primary coil, and bent at aa^1 out to a parallel position, and connected to strong screw clamps *p*, which are manipulated in a similar manner to those shown in fig. 1. At h^4 it is cut away to allow of spring and shunt wires i^1 to carry the current. When this heavy copper bar has four square inches sectional area bars of iron 1in. in diameter may be welded, and tubes of much larger size. The primary and secondary coils are wound round with an endless coil of iron wire O O, which does not touch the primary or secondary coils, but is wound on a sheet-iron casing, and leaves the secondary coil thereby free. The resistance of the secondary coil is ·00003 ohm, and under the influence of a good primary current gives an electromotive force of two volts. Less, however, is used in most cases. There is a small loss, due to transformation, as a current of 20 ampères and 600 volts in the primary circuit gives in the secondary nearly one volt and 12,000 ampères. The current was generated by an alternate current dynamo, weighing 500lb., absorbing 25 horse power, at 1,800 revolutions per minute. There were 10lb. of copper wire on the armature and 40lb. on the field magnets. The large output from so small a machine, without destruction, is possible only from the fact that the machine is required to give current but for small intervals.

The ends of the pieces to be welded are brightened, and are allowed to project a little beyond the clamp when in position, and a flux of some kind is usually put on the joints. For metals with a high melting point powdered borax is used; for metals with a low melting point, such as lead and zinc, tallow, resin, and chloride of zinc. The flux is generally applied before the current is turned on; after which the rod becomes first red, and the flux spreads over the surfaces, then the screw or spring is caused to press the two surfaces more forcibly together. They now rapidly become white-hot, and weld at the point of fusion. The pressure applied causes the joint to become somewhat thickened or upset, and when the current is switched off the bar may be removed red-hot and hammered down to its proper size.

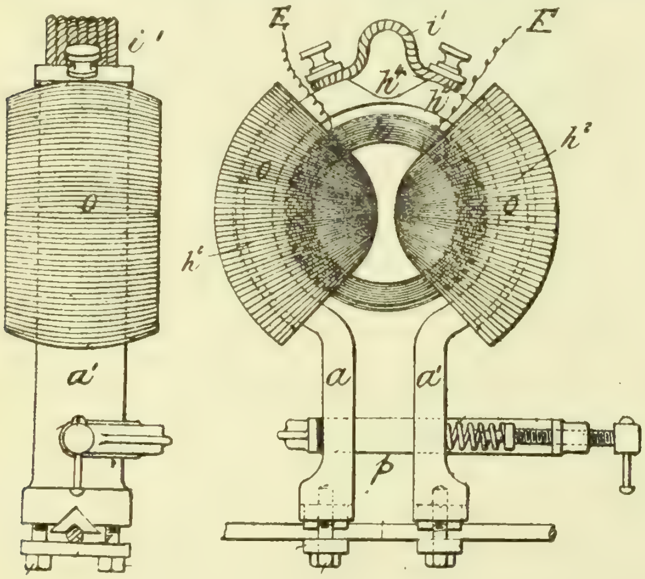


FIG. 4.

In welding a large piece to a small piece the end of the larger is first tapered down to the size of the smaller (figs. 5 and 6), and a blowpipe used to assist in bringing the larger piece of metal to the same temperature as the smaller; or the larger piece is heated before being placed in the clamps.

In the welding of unlike metals a difficulty presents itself owing to the difference in their specific electrical and heat conducting capacities, and a gas jet or blowpipe (fig. 7) is used to assist the better conductor to heat up as fast as the one which is offering more resistance to the passage of the current. In the factory of the Thomson-Houston Company, all joints in copper and iron wire are made electrically; even wires as small as the one-fiftieth of an inch in diameter have been welded by this process.

One circumstance tends to produce uniform heating of the bars, *i.e.*, if one part of the surface is in closer contact than the other parts, then the larger portion of the current will flow through the parts in closest contact, being the path of least resistance. This part becomes hot first, and its resistance to the passage of the current increases in consequence, and the current is to a large degree diverted to the colder portions of the joint until the whole of the abutting surfaces are equally heated. Generally, in electric welding the less the conductivity of the metals the greater the resistance to the flow of the current, and the less current is required to bring them to a given temperature. Thus, a copper rod a little less than ½in. diameter requires about 20,000 ampères, an amount which will weld 1in. diameter iron.

It is interesting to compare the quantity and pressure of the current used in this process with other usages. In arc lighting circuits a current of 10 ampères, with an electromotive force of 2,500 volts is not infrequently used, and in incandescent lighting a current of 250 ampères at an electrical pressure of 100 volts would represent the same amount of energy. In welding wire enormous currents are employed, but 50,000 ampères at an electrical pressure of ½ volt would represent exactly the same amount of electrical energy. This amount of current would probably weld steel bars 1½in. in diameter in less than two minutes. For this purpose currents of 100,000 ampères and even more can be used, as electric lights demand a continuous application of power, while the welding, for instance, of a 1½in. piece of steel would require 35 H.P. for only one minute, and the same power would be required continuously to operate 40 to 45 arc lights.

Numerous and varied articles have been welded, and butted metal tubes of iron, steel, copper and lead have been successfully made. Penknife blades were welded to stumps projecting from a tortoiseshell handle without removal of the tortoiseshell. In one knife, a new blade, which was welded on by this process, was purposely broken, but it did not go at the weld. Many uses suggest themselves, such as the joining of endless saws, long lengths of pipes or coils of pipes, tyres, barrel hoops, chain links, tools, and the like. A shaft with two collars was formed without any welding at all, by simply pressing it endwise by the clamps with the current put on. A bar was put through a hole in a flat piece of wood, and burrs raised on the bar at both sides of the wood, so that the wood is held between the two expansions in the bar, and almost pinched between them. The operation was so quickly done that the heat had not time to char the wood and enlarge the hole. A piece of lead pipe has been welded without obstruction to its interior, and even without expansion outside. A finished axe has had the steel edge welded on by electrical means, and cast iron has been welded to cast iron, cast iron to steel, also steel, brass, and copper, all in one piece. Brazing can be done successfully by putting brass on a hot joint while current is passing. A carpenters' auger was lengthened by this process, and could only be broken after being twisted two turns, even then the weld still remained sound. The application of electrical welding is especially suitable for jewellers, as the process is one of great cleanliness as compared with the present methods. Another point which recommends itself to workers in the precious metals is that the joint or weld can be made more local than by any other method, and there is a great saving of time and labour.

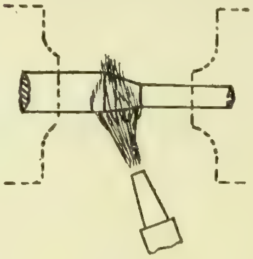


FIG. 5.

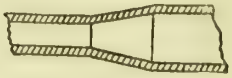


FIG. 6.

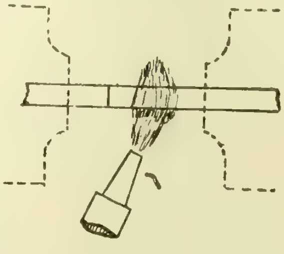


FIG. 7.

Prof. A. E. Dolbear, writing to the American *Engineering Record*, says, "I have had made nearly a hundred tests of the tensile strength of electrically welded bars of iron, steel, and other metals. The results were of such a character that I can state positively that with Thomson's welding process it is possible to weld both wrought iron and steel so that the weld is as strong as the same cross section in another part of the bar; that the appearance of the fracture is fibrous for iron, and generally granular for steel, the strength of this granular steel being on some samples as high as 125,000lb. per square inch; that the process is such that the welding is homogeneous from necessity." He says, "I had a number of bars welded by an expert blacksmith, and a number of similar bars by the electrical process for comparison, with the result that the electrically welded bars were much stronger than those welded by the ordinary process. The bars were of various sizes, up to $1\frac{1}{2}$in. for iron and $\frac{3}{4}$in. for octagon steel."

(*To be continued.*)

MAINTENANCE OF STREETS AND ROADS.*

In commencing the paper the author pointed out that McAdam was not the original inventor of what are termed "macadamised" roads, but that this process had been used extensively in Sweden and Switzerland long before his time; and even the old Roman road, called the Appian Way, constructed in the year 312 B.C., was made in this manner. Macadam roads were first made in England under the direction of Mr. McAdam, in 1796, his idea being that there was no need for preparatory foundations in any way whatever, but that the stone, uniting by its own angles, would form a hard and solid surface, and would remain, even on bad and yielding foundation, without breaking up.

The curvature of roads was then mentioned, and the author thought that too much curvature, or crown, was objectionable, as this tended to keep the greater part of the traffic in the middle, which concentration of traffic of course formed ruts. These retained water, and hastened the wearing out of the roads. The only object in giving curvature to a road was to get rid of the rain.

With regard to road foundations, he thought that McAdam's idea was a thing of the past, and a good foundation was now the first thing considered. Undoubtedly the best foundation was made by a good solid bed of concrete, but the expense necessarily debars the use of this material for macadamised roads. For heavy traffic, after the foundation had been prepared, all soft places dug out and replaced with unyielding material, and the whole surface had been well rolled and made thoroughly hard and uniform, a pitched foundation, carefully laid by hand and well rammed, was necessary. This pitching should be seven inches deep; every stone was set with its broad edge downwards, and, as far as possible, all the interstices should be filled before the broken stone was put on. On this foundation a 5in. layer of broken road metal was spread and then rolled.

For lighter traffic a good and cheap road could be made as follows: A foundation was prepared as above, and to the proper curvature in cross section, and on this was spread a 3in. layer of good clinkers or gas cinders. This should be well rolled, and a 3in. layer of limestone, broken to a 2in. gauge, spread on it, and then rolled. On this should be spread the third and final layer of road metal, broken to a $1\frac{3}{4}$in. gauge, and laid 4in. thick.

The materials for road making were fully described, and with regard to the rolling the author said that a 10 ton steam roller would consolidate about 600 yards of macadam per day.

Speaking of the wear of macadam roads, he said that this should be comparatively small, but in cases where there had been a bad foundation a great amount of binding and cross-breaking took place, through which the rain found its way and ruined the road. Too great care could not be bestowed on the foundations.

Other methods of road-making were described, and wood-paving and stone-paving were also touched upon.

CENTRIFUGAL BLOWER.

In July, 1888, Mr. James J. Barry, of the Corps of United States Naval Engineers, made an extensive set of experiments on a Sturtevant centrifugal blower, delivering air into the atmosphere at large, the results of which are published in the Journal of the Franklin Institute. The blower was situate in the machine shop of the New York Navy Yard, and was driven by an independent oscillating non-condensing engine, connected directly to it. It received its air from the still atmosphere of a very large room, into which it also delivered. The experiments were made with the blower driven at velocities varying from 1,250 to 1,950 revolutions per minute. The oscillating steam cylinder driving the blower exhausted into the atmosphere, and its piston made one double stroke to each revolution of the blower. The diameter of the cylinder was $2\frac{1}{8}$in., and the stroke $1\frac{1}{4}$in. The centrifugal blower consisted of six radial flat fans, or blades, equispaced about their axis, and revolving in a cast-iron case, with a clearance of about $\frac{3}{32}$ of an inch wide. The outside diameter of the fan was $12\frac{1}{2}$in., and the inside diameter 7in. The radial depth of the fan was therefore

$$\frac{12\cdot5 - 7}{2} = 2\cdot75\text{in.}$$

Each fan was a regular trapezoid, its breadth and its outer edge was $3\frac{3}{16}$in., and its inner edge $3\frac{5}{8}$in., making its area

$$\left(\frac{3\frac{3}{16} + 3\frac{5}{8}}{2} \times 2\cdot75\right) = 9\cdot34 \text{ square inches.}$$

The aggregate area of the six fans was 56·2 square inches, the circumference of the surface of the fans was 2·54ft., and the area of the air delivery was 30·07 square inches, or 0·2088 square feet.

Nine sets of experiments were made with different rotary speeds of blower. The increase in the number of revolutions made per minute by the blower for each succeeding set of experiments was made by as nearly equal increments as possible. Each set consisted of twelve observations of each quantity, taken at five minutes interval, so that each set of experiments occupied an hour.

The velocity of the air in feet per minute leaving the blower was obtained from a very sensitive helicoidal anemometer, and the number of revolutions per minute was obtained by means of a counter.

It was found that the velocity in feet per minute of the discharged air was in the direct ratio of the rotary speed of the blower, showing that the quantity of air delivered per revolution of the blower was the same at all rotary speeds within the experimental limits. The quotient of the division of the velocity of the discharged air in feet per minute by the number of revolutions made by the blower in the same time was a constant number.

The velocity with which the air should be discharged into the atmosphere under the pressure of 0·036 pounds per square inch above the atmosphere (the impact pressure) was calculated as as follows: Assuming the air employed in these experiments to have been three-fourths saturated with aqueous vapour, to have had the temperature of 75 deg. F. and atmospheric pressure 14·7lb., would weigh 0·07360785lb. per cubic foot, and the result for the velocity of such air into vacuum—

$$\left(\sqrt{\frac{1468757 \times 144}{0\cdot07360785} \times 64\cdot346078}\right) = 1359\cdot74\text{ft. per second.}$$

The square root of the pressure, 14·7lb. per square inch, was 3·8324, and the square root of the impact pressure per square inch above atmosphere was 0·19; .·. the velocity of the discharging air should have been (3·8324 : 0·19 : : 1359·74), or 67·41ft. per second. Experimentally the velocity was—

$$\left(\frac{4092}{60}\right) = 68\cdot7\text{ft. per second.}$$

This was a remarkably close correspondence, proving the accuracy of the experiments, and the correctness of the assumptions of which the calculation was made.

The number of cubic feet of air delivered into the atmosphere by the blower per minute under the above conditions, allowing 0·82 for the coefficient of discharge through the cylindrical air delivery, was—

$$\left(\frac{30\cdot069 \times 4092 \times 0\cdot82}{144}\right) = 700\cdot658,$$

or

$$\left(\frac{700\cdot658}{1585}\right) = 0\cdot44205552$$

cubic feet per revolution of the blower. These figures were equivalent to (700·658 × 0·07360785), or 51·57lb. of air delivered by the blower per minute, or to

$$\left(\frac{51\cdot57}{1585}\right) = 0\cdot032538\text{lb.}$$

delivered per revolution of the blower.

As each cubic foot of air of the above temperature contained 0·01686lb. of oxygen, the blower delivered 11·8lb. of oxygen per minute; and as the aggregate fan surface of 56·2 square inches acted against the air pressure of 0·036lb. per square inch above the atmospheric pressure, the work done was 8141·5 foot-pounds, or 0·2467 H.P. It was estimated that about one-fifth should be added for the engine frictions, making the I.H.P. not less than about 0·3.

The experimental knowledge possessed on the subject of centrifugal air-blowers is so little, and so important is such knowledge when their extensive use in the industrial arts is considered, that the experiments of Mr. James J. Barry, made with the very limited means at his command, have great value.

The experiments in question, made with an apparatus of the kind and dimensions, and in the manner and within the limits described, allow the following generalisations to be drawn.

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* Paper read before the Students' Section, Inst.C.E., Birmingham, by W. B. Pursen, Stud.Inst.C.E.

1. The quantity of the same air, volume and weight, delivered by the blower per revolution, is constant, let the number of revolutions made in a given time be what it may.

2. The velocity of the air delivered is in the direct ratio of the number of revolutions made by the blower in a given time.

3. The velocity of the centre of the surface of the fans is the same as the velocity with which the air is delivered.

4. For any number of revolutions of the blower in a given time, the air pressure above the pressure of the atmosphere, reacting against the surface of the fans, and existing in the annular space between the periphery of the fans and the circular side of the blower case, and causing the velocity with which the air is delivered, is equal.

5. The velocity with which the air is delivered at the outer end of the delivering cylinder is the velocity due to the excess of the air pressure at the inner end of the delivering cylinder above the atmospheric pressure. This excess of pressure being known, the velocity can be calculated, and *vice versa*, the velocity being known, this excess of pressure can be calculated.

6. The velocity with which the air is delivered at the outer end of the delivering cylinder is in the ratio of the square root of the above excess of pressure. Inversely, the above excess of pressure is in the ratio of the square of the number of revolutions made by the blower in a given time.

7. When the velocity of the air is suddenly extinguished, the same excess of pressure above the atmosphere is reproduced that caused the velocity.

8. The work done by the fans upon the inflowing air is measured by the above excess of pressure per square inch, multiplied by the aggregate area of the fans in square inches, and by the velocity of the centre of surface of the fans in feet per minute. This, however, is by no means the work done by a motor driving the blower, as such work must include, additionally, the difference between the quiescent atmospheric pressure and the pressure of the inflowing air against the back of the fans, and the friction of the motor.

9. The work done by the outflowing air is measured by the above excess of pressure per square inch, multiplied by the cross area of the delivering cylinder in square inches, and by the velocity of the outflowing air in feet per minute.

10. As the velocity of the centre of surface of the fans is the same as the velocity of the outflowing air, and as the pressure above the atmospheric pressure produced by the fans upon the air is the same as the pressure producing the velocity of the outflowing air, the work done by the fans on the air, and the work done by the outflowing air, are in the direct ratio of the aggregate area of the fans to the cross area of the delivering cylinder.

11. The number of cubic feet of air delivered per minute is measured by the cross area of the delivering cylinder in square feet, multiplied by the velocity of the air issuing from that cylinder in feet per minute, and by 0·82 for the coefficient of discharge.

12. Of the entire quantity of air entering the blower and put in motion by the fans, one-third is first brought to rest within the blower-case, after which it is again set in motion by the fans with its original velocity.

13. The theoretical coefficient of the blower as a furnisher of air is two-thirds, including the air leakage; its practical coefficient does not exceed thirty per centum.

14. The resistance of the blower is as the square of the number of revolutions made by it in a given time. The power required to drive the blower, irrespective of the motor, is as the cube of the number of revolutions made by it in a given time.

A RELIABLE ALARM SIGNAL.—A Paris correspondent says that the Southern Railway Company of France are now applying to their passenger carriages a very novel alarm signal, which works by means of the compressed air of the brakes. This contrivance is intended to supplant the electric system now in use. The principal feature in the system is the pneumatic communication, which consists in a valve placed over an opening made in a branch of the main air-brake tube, which communicates with the open air. By pulling the handle in any compartment the pent-up air in the tube is at once set free, and the train is stopped. Two signals then appear over the compartment from which the signal has been given, and the guards can proceed to the assistance of the passenger as soon as the velocity of the train is arrested. The handle cannot be replaced by the passenger. The advantage offered by the new system is that it is unfailing in its efficacy and rapidity of action. Its abuse might be productive of very serious consequences, but the railway and police regulations are excessively stringent in dealing with any such cases, which, by the way, are of very rare occurrence in France.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

WATER-TUBE BOILERS.

To the Editor of "The Practical Engineer."

SIR,—In my letter, published last week, I notice an item which must be admitted an error, probably due to my imperfect caligraphy: "30ft. by 7ft." should be "30ft. by 7ft. 6in." to do the work easily. In reply to "Lancashire," I may say I have no desire to pose as an authority on this subject, especially before such as himself, who has had the exceptional privilege of witnessing such very complete tests. I would here, however, ask, Were the results of those tests ever made known to the public? If not, he cannot be surprised at my ignorance of any good performance of water-tube boilers; but seeing he claims a special experience, I am sure he could not do better than share it with your readers, and I hope he may find leisure and inclination to tell us more than he has yet done. Referring to boilers of twenty years ago, I again say they are identical in principle to those of to-day, all the alteration being in details, such as covers, &c., and if they are now to be called satisfactory I am glad, but I have not seen it as yet. Referring to external fire-grates, I again say they are more favourable to a complete combustion than internal fire-grates, the excessive wear and tear of the boilers being against their general adoption, and I do not think water tubes are any nearer the fire than the bottoms of externally-fired boilers, while large external fire-places (where properly handled) give less trouble from smoke than others. I have seen nearly all the known systems of firing adopted, but of course cannot say what may yet be introduced, or anticipate its influence. "Lancashire's" experience of wet steam from these boilers certainly differs from every one I have spoken to who have the every-day working of these boilers. A perfect circulation is certainly essentially necessary to the success of any boiler, but there is a wide difference between circulation and a violent ebullition, which has been known to cause the water to rush out at both ends, and, as "Savery" puts it, they "boil dry." With respect to the filtering of feed water we are in unity with each other: it should be done in all cases for all boilers; the same may be said about the ample-sized steam drums. These matters I have admitted in other discussions; but when you have spent a fabulous amount in these adjuncts, will the results give a fair return on the outlay? Have they done it yet, or are they likely to do it, and compare favourably with our present types of cylindrical boilers, Lancashire, &c.?

One of their best features is, they can be taken anywhere with greater ease than a boiler from ten to twenty tons in one piece, and they can often be put in without pulling half the place down, as is the case where a blindfolded or short-sighted architect has been at work, and this fact alone accounts for the use of many of them; consequently those who put them in like to make the best case out in their favour. I again say, when working easily they may work satisfactorily.—Yours, &c.,

CHALKLINE.

THE STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

SIR,—As I note from your Correspondence and Query columns that many of the contributors to *The Practical Engineer* are experts in boiler and engine matters, I should be glad if you would throw your columns open for a little while to the discussion of the large number of perplexing rules and formulæ appertaining to the strength of furnace tubes.

Some time ago you published a communication from Mr. D. K. Clark on "The Strength of Furnace Tubes" (see your issue October 5, 1888, p. 471), in which Mr. Clark maintains that though the longitudinal resistance to collapse of plain or unstrengthened flue tubes may be important for short lengths of from 3ft. to 6ft., or even as much as 9ft., it is insignificant for greater lengths, and he gives some instances of collapsed flues of Cornish and Lancashire boilers collected from the reports of the Manchester Steam Users' Association. From these data he deduces a formula for the collapsing pressure of plain iron flue tubes of Cornish and Lancashire boilers, which, as subsequently modified or corrected by Mr. Clark in *The Practical Engineer* of October 26, 1888, p. 515, is as follows—

$$p = \frac{200{,}000\, t^2}{d^{1\cdot75}}$$

where p = collapsing pressure in lbs. per square inch,
t = thickness in inches,
d = diameter in inches.

Wishing recently to determine what would be a fair load for a flue tube 2ft. 9in. diameter, 30ft. long, ⅜in. plates, with plain lapped seams, I applied this formula, and I find that by the above rule the collapsing pressure would be only about 62lb. per square inch; and if we take a factor of safety of only 4, we should have as the safe working pressure of a 2ft. 9in. tube, 30ft. long, constructed of ⅜in. plates, only 15½lb. per square inch.

Now, I know there are scores—and I think it very possible there may be hundreds—of tubes in Lancashire boilers of the above dimensions working at 50lb. pressure, and even higher; and if we turn to Fairbairn, we shall find by the well-known rule deduced after his experiments—$806{,}300 \frac{t^2}{LD}$—that the collapsing pressure of such a tube would be as high as 114lb. per square inch.

Again, if we take the formula suggested as a "safe guide" by Mr. Michael Longridge (*The Engineer*, September 21st, 1888)—

$$\text{Safe working pressure} = \frac{50\,t^2}{\sqrt{LD}} - \frac{D}{L}$$

where t is taken in thirty-seconds of an inch,
D = diameter in inches,
L = length in feet.

We find such a tube would be adequately strong, according to Mr. Longridge's opinion, for a safe working pressure of 40lb. per square inch, or about 2¼ times the pressure given by Mr. Clark's rule, with a factor of safety of 4.

If, again, we turn to the Board of Trade rule for furnace tubes, and try the safe working pressure by the formula

$$P = \frac{60{,}000 \times t^2}{(L + 1)\,D} =$$

where t = thickness in inches,
L = length in feet,
D = diameter in inches,
P = safe working pressure—

we are even more bewildered, since this would give us a safe working pressure of only just over 8lb. per square inch.

These conflicting results from what should be leading authorities are calculated to confuse any ordinary engineer, and hence you could not render a better service to practical engineers, such as I take it your journal is intended to benefit, than by permitting this subject to be discussed in your columns.

Nowhere can I find any data respecting the strength imparted to a flue tube by cross water or Galloway tubes, but it seems certain that a tube stiffened by say five water tubes must offer a greater resistance to collapse than a long plain tube not so strengthened.

Many of your readers will doubtless be regularly engaged in determining the comparative strengths of boiler tubes, and if some of these would kindly give us some little light on this perplexing subject it would be appreciated, I have little doubt, by many others besides yours, &c.,

INQUIRER.

QUERIES AND REPLIES.

37. STEAM JOINTS.—Which is best for steam joints, such as valve box covers and steam pipes, indiarubber, asbestos, or thin wire gauze? Is there any reason for preferring any one of them in special cases?—SUBSCRIBER.

Answer.—Flat lamp wick, soaked in a mixture of red lead and oil, makes a very good joint for cylinder and casing covers.—ORION.

42. BURNISHING BRASS.—Will some practical reader kindly inform me of the best way of burnishing brass?—SMITH.

Answer.—There are two methods by which brass can be burnished—the wet and dry, the former being employed chiefly for ornamental purposes. The burnisher consists of a perfectly smooth, hardened, steel tool the shape of which depends upon the work in hand. The object to be burnished must also be smooth, and quite free from grease and dirt. If the wet process is adopted, the part under operation must be kept constantly wet, either with sour ale or a weak solution of tartaric acid, and as the burnishing is completed this should be dried off. Although the wet process is a little more laborious, the result is far more satisfactory. In either case the burnishing tools ought not to be used too long at once, for should they get warm they are liable to seize and scratch the work.—ORION.

43. SLACK CRANK PIN.—I have an engine of about 25 horse power nominal, and I find that the crank pin has become slack. What is best to be done? Should I put in a new one; if so, what is my best method of proceeding?—CRANK PIN.

Answer.—The best plan will be to put in a new one. First get out the old one and take the exact size of the hole, then put it back with a thin liner of sheet steel if possible, until you can get another forged; and turned to about a hundredth part of an inch larger than the hole in crank arm, which you can expand by heating with hot irons until the pin will go in. The irons should nearly fill, so as to heat it equally; it must be allowed to cool by itself, or it might burst the arm.—W. H.

Answer.—If the crank pin in question is overhung, and not provided with a taper by which it could be tightened up, it would be advisable to fit a new pin, in either of the following ways: First, re-bore the crank with a taper of one in ten, fit a new pin to suit, and rivet the end well. Second, re-bore the crank (parallel) half an inch larger than the present size for two-thirds the total depth, so forming a collar, just cleaning up the rest of the hole; fit a new pin, and rivet as in previous case. "Crank Pin" must, however, satisfy himself that there is sufficient metal round the pin, and make the working part of the pin to suit present bushes. If there are two webs, then re-bore the holes and shrink in a new pin.—ORION.

16. SETTING CORLISS VALVES.—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—ENGINEER.

23. LIGHT MIXING MILL.—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—EASTERN.

35. LOCOMOTIVE DRIVING WHEELS.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

36. NUT CAST ON IRON SCREW.—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and ⅜in. pitch.—SUBSCRIBER.

38. DUPLEX MINING PUMP.—Which is the best duplex action mining pump for use with compressed air, taking into account compactness and first cost as well as economy?—S.

39. SEPARATE CONDENSER.—Which is the best separate condenser for use with high-pressure engines, and state advantages?—H.

40. BARFFING CAST IRON.—Can any of your readers inform me whether cast iron which has been subjected to the process known as "Barffing" will withstand the action of a boiling solution of weak sulphuric acid? Also, can you give me the name and address of any firm where this process is carried out?—WORKS MANAGER.

41. HOT-WATER PIPES.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft.? What book may I get on arrangement of greenhouse?—WATER-HEATER.

44. RESISTANCE OF PIPING TO WATER.—Will you kindly permit me through the medium of your paper to ask if any of your correspondents will answer the following question, viz.: In a rising main of 3in. per yard, 400 yards long, composed of 200 yards of 4in. and 200 yards of 2½in. pipes, a pump is required to force through those pipes 30 gallons of water per minute. Will the resistance offered to the pump vary, and, if so, how much in each case, if the pipes were laid in the following order—

1.—200 yards 4in. pipes next the pump.
200 ,, 2½in. ,, delivery end.
400

2.—200 yards 2½in. pipes next the pump.
200 ,, 4in. ,, delivery end.
400

3.—100 yards 4in. pipes next the pump.
100 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
100 ,, 2½in. ,, ,,
400

4.—100 yards 2½in. pipes next the pump.
200 ,, 4in. ,, the above.
100 ,, 2½in. ,, ,,
400

5.—100 yards 4in. pipes next the pump.
200 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
400

6.—If the pipes were laid alternately—one 4in. pipe and one 2½in. pipe—throughout the entire range?—MEDIUM.

45. BOILER SOLUTION.—Would some practical reader inform me as to the advantage or disadvantage of using paraffin as a boiler solution? My employer has been recommended to use one pint per week. Size of boiler, 15ft. by 4ft., fired externally; no ventilation except through manhole on top of boiler. Would any explosive gases be left behind after emptying boiler for cleaning, thereby causing danger on entering with an exposed light? I should be glad of someone's opinion of the above.—COVENTRY.

TO CORRESPONDENTS.

T. A. H., Birmingham.—You very accurately state the objections to most of the patent lock nuts, and if your nut can do what you say, it would be exceedingly useful. It does not seem possible to us, however, to make a good nut to lock and unlock with the fingers. Write again; we shall be pleased to advise you on seeing drawing.

H. R, London.—The makers of Parson's patent steam turbine are Messrs. Clark, Parsons, Chapman, and Co., Gateshead-upon-Tyne, and Rigg's revolving engine is made by Mr. Arthur Rigg, 42, Old Broad Street, London. The Tower spherical engine is made by Messrs. Heenan and Froude, Manchester and Birmingham. We are pleased that our article has interested you.

YOUNG ENGINEMAN.—We are pleased that our article has interested you. However, it would take a complete article to answer your queries on energy of flywheel and energy of change from rest to motion. We shall have pleasure in going into the subject shortly in our columns.

D. C., KEIGHLEY.—Rigg's treatise on the steam engine is exceedingly practical, and will suit your friend's purpose. It is published by Messrs. Spon.

R. F., Wakefield.—"The Marine Engine," by R. Sennet, chief engineer, Royal Navy, published by Longmans and Co., London, is an admirable work upon the subject.

BASSO, Bolton.—Prof. Jamieson's work on the steam engine is exceedingly good, and contains much sound information at a low price. Mr. Holmes' work on the steam engine, published by Longmans and Co., is also exceedingly good, and is one of the Science Text Book Series. Unwin's book is also reliable. Slide valves are very fully treated in Rigg's work on the steam engine, published by Spon.

TESTING OF THE SUKKUR BRIDGE.—Previous to opening the Sukkur Bridge permanently to traffic, some experiments were made on the morning of the 20th March, with a view to checking the deflections, oscillations, &c., to which the bridge will be subjected in the ordinary course of traffic. A linked train, consisting of thirty-two wagons and two engines, representing a weight of some 700 tons, passed at various rates of speed backwards and forwards across the vast structure; while various members of the railway staff recorded by means of a seismometer and other delicate instruments the effects caused by the movement of this immense weight. It is said that the experiments were most successful, and that the results attained were in every way satisfactory.

MISCELLANEA.

Electric Lighting in Railway Carriages.—In a few days the Midland Railway Company will have ready for working two trains fitted with the electric light. It is intended that they shall run between London and Liverpool and Manchester. A further experiment will be shortly made with the light between Stockport and Manchester.

The Italian Admiralty have recently caused to be carried out a number of experiments with a view of testing the comparative merits of castor oil and olive oil for lubricating purposes on board ship. From the results obtained they have given orders that henceforth all exposed parts of machinery are to be lubricated exclusively with castor oil, while mineral oils are to be used for cylinder and similar lubrication.

Gas for Trains in the Argentine Republic.—The Board of the Buenos Ayres and Rosario Railway have resolved to substitute gas for the present system of illuminating railway carriages. They have already ordered the necessary plant for that purpose. Within a few days the trains on that line will also be provided with self-acting brakes.

The Westinghouse Air Brake Company is creating a new town in the United States in connection with their works, which are being removed from Pittsburg. An extensive tract of land has been taken, and laid out in streets and parks. Building lots have been staked off, sewers constructed, gas and water pipes laid down, hotels, clubs, and schools provided for. As soon as the new works are completed, and the dwellings for the employés ready for occupation, this model town, which is called Wilmerding, will be taken possession of.

Mr. Fletcher, of Warrington, has recently put in the market a new and very cheap sensitive flame. It consists of a special arrangement of the small Argand bunsen, and differs from other sensitive flames inasmuch as any considerable sound completely extinguishes it. An interesting point in connection with it is that its sensitiveness is not constant, but apparently varies with the atmospheric conditions. The circular issued with the burner particularly states that the transparency of the flame renders it unsuitable for lecture experiments.

The Projected Congo Railway.—Captain Gambire, who has directed the surveys for the projected Congo Railway, declares (a Brussels telegram says) that a capital of £1,000,000 will be sufficient for the construction of the railway, for the acquisition of rolling stock, for general expenses, and for paying the interest on the capital during the four years of construction. The line, starting from Matadi on the Lower Congo, and terminating at Indolo, on Stanley Pool, will have a length of 260 miles, and the whole journey on it will take two days. The cost of working the line is estimated at £300,000 annually.

Another New Material in Steel.—Messrs. Schneider and Co. have recently taken out a patent for manufacturing steel containing a variable proportion of copper, which is to be used in making artillery of large calibre, armour plates, rifle barrels, and projectiles. Ordinary copper is used for the purpose, care being taken to prevent it from oxidising before it is mixed with the steel in the crucible, and the composition contains 2 to 4 per cent of copper, the alloy being capable of far more resisting power and more elastic and malleable than simple steel would be. This new material is supposed to be valuable for making girders for building purposes and ship plates.

Railway Development in Australia.—The steel bridge built over the Hawkesbury River, on the railway between Sydney and Newcastle, which has been under construction for the last two and a half years, was recently opened by the Governor of New South Wales, in the presence of the Minister, the members of both Houses of Parliament, and a large assemblage of the general public. It carries a double line of rails, and is the third largest structure of its kind in the world, and the largest of any in the southern hemisphere, having seven spans of 415ft. each. The headway above high water is 40ft. The new bridge completes the system of railway communication between Brisbane and Adelaide.

The North British Water-gas Syndicate, Limited, have issued a prospectus with a capital of £300,000, in 60,000 shares of £5 each. The object of this syndicate is to secure licenses to work in Scotland the well-known water-gas patents for improvements in the manufacture of gas for illuminating, heating, welding, and all metallurgical purposes. Hitherto all attempts in this country to manufacture and apply water-gas on a commercial scale for heating, smelting, and illuminating purposes by simple and economical means, and without the use of skilled labour, have failed; but, after application and use on a large scale, these inventions have proved beyond all doubt that pure water-gas, when used as an illuminating medium in combination with the Fahnejelm magnesia comb, the Scottish rights of which are secured to this company, gives a light superior to coal-gas, and yet having all its convenience of application, and rivalling in brilliancy the electric light, can be manufactured at under 4d. per 1,000 cubic feet, after allowing for cost of production wages, wear and tear of plant, and all contingencies.

Wood-block Pavements.—Mr. Walter A. Williams has invented a wood-block road pavement which, he claims, gives greater security against slipping than the wood pavement at present in use. In order to effect that object Mr. Williams grooves his blocks in a peculiar way, thus affording, he considers, a safe footing for horses, especially when starting a load uphill. Part of the grooves he proposes, if necessary, to fill with a form of consolidated shell sand, which would gradually wear with the pavement, and at the same time give a foothold. The system would also have the great advantage of carrying off any surface water by the grooves, leaving the face dry, especially after a fall of snow or flushing. If the invention possesses all the advantages which Mr. Williams claims for it, the boon conferred on the owners of horses would far outweigh the extra cost of grooving the blocks, which, however, he says, is very trifling. Mr. Williams is anxious to have a portion of the new pavement laid down in London, so that its utility may be practically tested.

Institute of Civil Engineers.—A meeting of the Association of Birmingham Students of the above institution was recently held at the Colonnade Hotel, Birmingham, Mr. E. Pritchard, M.Inst.C.E., in the chair; when a paper was read by Mr. R. Peirce, A.M.Inst.C.E., on the "Graphic Method of Calculating Strains in Arches." The rapidity, ease, and accuracy of this method (the representation of forces by lines) were clearly shown, and by numerous diagrams the author pointed out how, by means of lines, the strains in any arch, with any form of dead load or live load, could be readily ascertained. At the close of the discussion the hon. secretary, Mr. Robert Green, Assoc.Mem.Inst.C.E., was presented with an illuminated address and timepiece on behalf of the members and friends, in recognition of his services to the association as its originator and hon. secretary since its commencement. The president made the presentation, and Mr. Green expressed great regret at being compelled to give up the position of hon. secretary, owing to his election as an associate member of the institute.

A Locomotive Record Breaker.—A New York paper says that the longest continuous runs ever made by a locomotive drawing a full train of cars have just been accomplished by the engine A. G. Darwin, built by the Strong locomotive works. The runs were made on the Erie Railroad from Jersey City to Buffalo and return, a distance of 423 miles each way, with a rest of less than twelve hours between the runs. The entire distance of 846 miles was made without the slightest mishap. The nature of the achievement will be better understood if it is considered that the average run made by a locomotive is not much more than 100 miles, and that it usually requires four locomotives to do the work done by this one engine in going from Jersey City to Buffalo. The engine, it is claimed, has several advantages over the ordinary locomotive which its inventor, Mr. George S. Strong, thinks will revolutionise the fast express business all over the country. One of the original features of the engine is the introduction of two fire-boxes instead of one, which, it is said, gives greater steam-generating power, and on long runs allows the cleaning of one box while the other is still in use. The valve gear is also different from the old style. Double valves are used instead of single ones. The engine weighs 68 tons exclusive of the tender, which weighs 40 tons when full of coal. Soft coal was burned on the entire trip, but the combustion chamber attached to the fire-boxes did away with the cinders and soot, which are the accompaniments of the ordinary railroad journey when that kind of coal is used. Twenty-two tons were consumed by the engine, which is one-third to one-half less than the total amount burned by the four regular engines used on this run. The locomotive has been built for use on the Atchison, Topeka, and Santa Fé Railroad, where its ability to make long continuous runs will receive full scope.

The Sukkur Bridge.—The following particulars about the Sukkur Bridge, which has just been opened across the Indus, will be of general interest. It is nearly 20 years since such a bridge was seen to be necessary in connection with the Indus Valley State Railway, and not fewer than four different sites have been suggested for it. These were all close together, however, and were known respectively as Campbell's Crossing, the Point Crossing, the Island Crossing, and the Rohri Crossing. At this point the river Indus is broad and flows rapidly between high banks. Fortunately an island, named Bukkur lies in midstream and halfway between the opposite towns of Sukkur and Rohri. Sukkur is on the right bank and Rohri on the left, or Indian. The three first crossings named did not contemplate using Bukkur island, and one after another they were given up. The Rohri Crossing itself, which utilized that island, was finally set aside in favour of an improved crossing known as the Hadji Moti, the difference between the two being that the bridge from Bukkur to Rohri is a little lower down than that from Sukkur to Bukkur. The bridge from Sukkur to Bukkur consists of three spans, the longest of which is 271ft., is composed of ordinary girders, and was completed as long ago as March, 1885. The more remarkable engineering feat is the bridge from Bukkur to Rohri, generally designated as the Sukkur Bridge. This was made on the cantilever principle. The length of this bridge is 790ft. From each side projects a cantilever of 310ft., and the connecting link is supplied by a girder 200ft. in length. The bridge was designed by Sir Alexander Rendel, and was constructed by Messrs. Westwood and Baillie, of Poplar. It was sent out in pieces and fitted on the spot under the direction of Mr. F. E. Robertson, the superintending engineer, within 16 months of their arrival on the Indus.

SHIPBUILDING.

There was successfully launched, on Tuesday, April 30th, from the shipbuilding yard of Messrs. S. P. Austin and Son, Sunderland, a handsomely modelled screw steamer of about 2,130 tons gross register, constructed of Siemens-Martin mild steel, under special survey, to class 100 A1 at Lloyd's, designed to carry a dead-weight cargo of about 3,100 tons on a light draft. She will be fitted with triple-expansion machinery of 1,000 indicated horse power, by Messrs. Blair and Co., Limited, Stockton-on-Tees. She was named St. Thorwold.

On Saturday last, the new steamer Agosto, of Bilbao, built by Messrs. Wm. Pickersgill and Sons, of Sunderland, to the order of Messrs. Compania Bilbaina de Navegacion, was taken on her trial trip at sea. Her engines, which are 21in., 35in., and 57½in. cylinders, and 39in. stroke, have been supplied by Messrs. Black, Hawthorn, and Co., of Gateshead. The vessel attained an average speed of 10½ knots, which was considered highly satisfactory. After the compasses were adjusted, the vessel proceeded on her voyage to Bilbao.

The steamship Pocahontas, built and engined by Messrs. Robert Stephenson and Co., Limited, of Newcastle, was taken on her trial trip on Thursday, the 21st ultimo. Her principal dimensions are: 300ft. between perpendiculars, 39ft. breadth, and 27ft. 6in. depth moulded, with a carrying capacity of 3,750 tons. She has been built for the Mediterranean and New York Steamship Company, for whom Messrs. Phelps Bros., of Liverpool, are managers, and is intended for the Mediterranean and New York trade. She is fitted with triple-expansion engines of the latest type, having cylinders 25in., 39in., and 62in. diameter, with a stroke of 42in., and supplied with steam power from two extra large steel boilers, working at a pressure of 156lb. per square inch. Four runs were made on the measured mile, when a mean speed of 12¼ knots was attained. The engines worked without a hitch, and the owners' representatives on board expressed themselves highly satisfied with the ship's performance throughout.

On April 30th, at the yard of Messrs. John Readhead and Son, South Shields, a steel screw steamer was launched, named Holme Eden, which has been built to the order of Mr. Wm. Wright, of South Shields and London. The dimensions of the vessel are: Length, 290ft.; breadth, 39ft.; depth of hold, 20ft. She is of the improved well-decked type, and classed 100 A1 at Lloyd's, under special survey. Her gross carrying capacity is 3,450 tons. The most modern appliances for the reception and discharge of cargoes have been introduced, and the hold fittings are specially adapted to the requirements of the Grain Cargoes Act. The engines are on the triple-expansion principle, and steam will be supplied from two large steel boilers, working at a pressure of 160lb. to the square inch. The engines have been built under the superintendence of Mr. W. Menzies, and Captain G. W. Freeman has inspected the construction of the hull. The Holme Eden is the fourth steamer built for the same firm by Messrs. Readhead and Son.

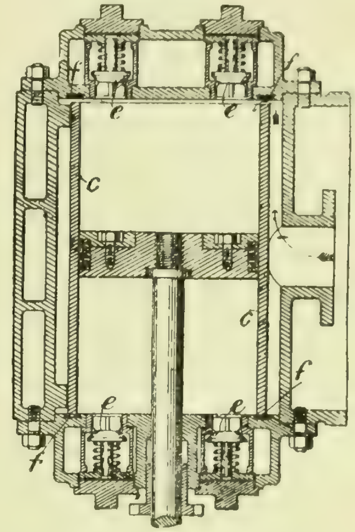
Messrs. W. Doxford and Sons launched from their yard at Pallion' on Wednesday, May 1st, a beautifully modelled steamer, built for the Shaw, Savill, and Albion Co., Limited, of 34, Leadenhall Street, London. The vessel is of steel, with cellular bottom fore and aft, to Lloyd's 100 A1 class, and her dimensions are: Length between perpendiculars, 360ft.; breadth extreme, 42ft.; and depth moulded, 31½ft. The engines are the ordinary triple-expansion crank, by Messrs. Doxford, the cylinders being 27in., 44in., 71in., and 48in. stroke, supplied with high-pressure steam from two exceptionally large boilers, which will give a mean speed of 11 knots loaded. She is fitted for the New Zealand meat trade, with exceptionally large refrigerating machinery, by the Haslam Foundry Co., of Derby, and will have insulated chambers fitted for 40,000 carcases. She is fitted with Macginnis's patent steam-steering gear, Harfield's windlass, Hastie's screw gear aft, and has five 7in. by 10in. steam winches, with gearing by Messrs. Welford Bros., of Pallion. The captain's, officers', and engineers' cabins are tastefully got up, and the crew and firemen are comfortably berthed. The vessel was named Marmari.

Messrs. Short Brothers launched from their shipbuilding yard on Friday, May 3rd, a steel screw steamer, built to the order of the Prince Steam Shipping Company, Newcastle, of the following dimensions: Length, 300ft.; breadth, 39ft.; and depth moulded, 21ft. 2in. The vessel is constructed under special survey to the highest class for steel in Lloyd's Registry, and is built on the cellular double-bottom principle for water ballast all fore and aft, and web frames, dispensing with hold beams. There is a short full poop aft for the accommodation of captain and officers; long raised quarter-deck between poop and bridge, the latter extending before foremast, with accommodation for engineers at the after end and the crew in the fore end; and open shelter forecastle, which is connected with the bridge by a gangway. There are four large hatchways, with a powerful steam winch at each, and donkey boiler fitted on deck. Steam-steering gear is fitted amidships, patent direct steam windlass, and all the latest improvements. The vessel has a handsome cutwater and figurehead, giving her a very graceful appearance. The vessel was named Moorish Prince. The engines, which are to be fitted by Mr. James Dickinson, of Sunderland, are of 200 horse power, on the triple-expansion principle, having two steel boilers of 150lb. working pressure, with all the latest improvements in marine engineering.

ILLUSTRATED PATENTS.

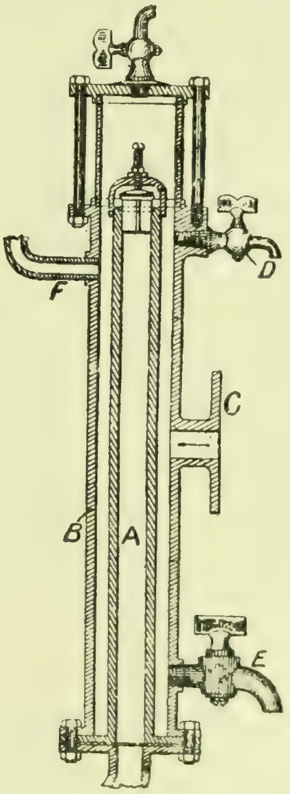
16,986. Reciprocating Pump, E. B. Ellice-Clark and L. Chapman, Westminster.

The cylinder is fitted with a movable liner, each end of which acts in turn as an inlet valve. The outlet valves are stationed in the end covers, as shown at *e*, *e*. C is the liner, which is moved longitudinally at each stroke by the friction of the piston, thus leaving an annular space at the inlet end; *f*, *f* are its seats.—December 9, 1887. [8½d.]



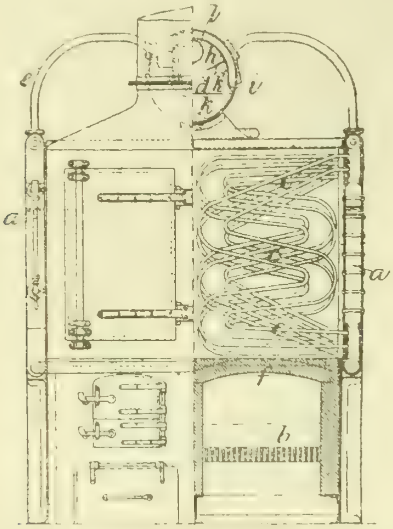
17,158. Purifying Feed-water for Steam Boilers, H. H. Lake, London (N. H. Daniels, Boston, U.S.A.)

The apparatus employed is shown in vertical section. The feed is pumped through the internal pipe A into the cylinder B and escapes at the branch C. The oil remains at the top and can be drawn off through a cock D, while the solid matter falls to the bottom of the annular space, and is removed from time to time by the blow-off cock E. A non-return valve is fitted on the end of the pipe A, and the upper portion of the casing B is of glass so that the level of the liquid inside can be noted; but the casing may be made entirely of metal and fitted with a gauge-glass. F is a pipe by which steam is supplied to blow off the apparatus.—December 13, 1887. [8½d.]



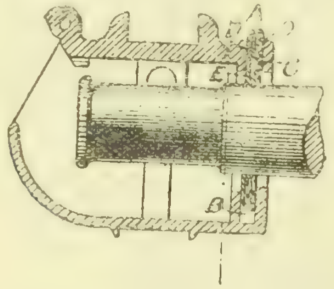
17,026. Sectional Steam Generator, F. Godard, Cherbourg, and C. Petit, Indret, both in France.

A series of sinuous water tubes *c*, *c*, arranged in a heating chamber, connect the upper and lower portions of the rectangular water sides *a*, *a*. The furnace *b* is situated below and separated from the heating chamber by the arched fire-brick partition *f*. The products of combustion pass into the heating chamber from the rear of the furnace. The steam collecting in the upper portions of the water chambers passes to the separator *d* through pipes *e*. The separator is provided with the semicircular plate *h* perforated all along its lower extremities. Transverse partitions *k*, having apertures on their lower edges, and longitudinal baffles k^1 are also provided, while the steam pipe *l* is perforated near its upper sides. The water walls may be constructed of iron, steel, or copper plates, with upper and lower iron, steel, or brass castings, or wholly of castings or plates. In a modification the water walls are each formed of an upper and lower cylindrical drum united by vertical tubes, the upper and lower ends of the sinuous tubes opennig into their corresponding drums. These chambers, as in the preceding case, are situated outside of and separated from the furnace and the heating chamber. When the boiler is used as a locomotive boiler the firebox would be situated within an extension of the tube chamber.—December 10, 1887. [11½d.]



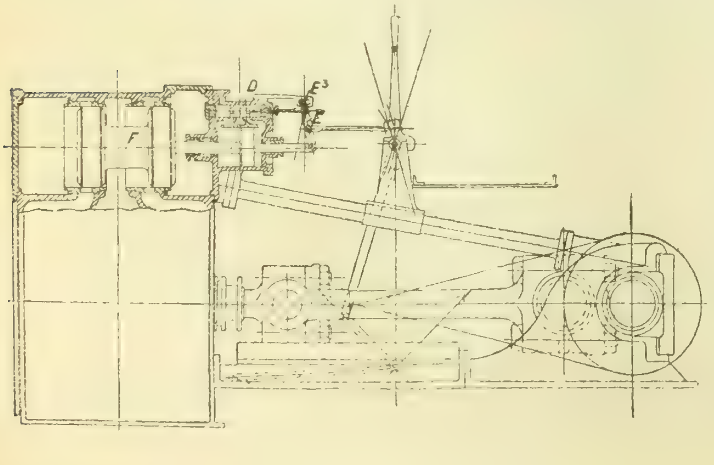
17,042. Axle-Boxes and Bearings, J. W. Cloud, New York, U.S.A.

The object is to provide a dust guard and leak preventer for axle-boxes and bearings generally. The figure is a section of a railway axle-box showing the guard A in position in a channel or groove B with an open top formed in the back of the box. The guard consists of a washer C of felt or other elastic material enclosed between two metal plates D, with flanged overlapping outer edges. A washer E of leather or similar material is riveted to one of the plates, its inner edge being flanged inwards (as shown) to fit the axle. The thickness of the guard is such that when it is inserted in the channel B the felt is compressed and forces the flanged inner edge of the washer E against the axle.—December 10, 1887. [6½d.]



17,168. Valve Gear for Motive-power Engines, D. Joy, Westminster.

Consists in methods of combining a positive or mechanical gear with fluid-pressure actuation of the valve, so that the pressure is in part controlled and assisted by the former. In each case the main valve spindle is prolonged, and carries a piston working in an auxiliary cylinder, wherein the fluid is distributed either by an auxiliary valve or by the piston itself. The auxiliary valve may be employed in three ways. Firstly, the main and auxiliary valve spindles are connected by a lever E, which is so fulcrumed as to give the necessary relative movement of the two valves F and D, and is, in addition to the automatic fluid actuation, in part operated by an ordinary mechanical gear. Lead is given to the auxiliary valve by a small amount of lost motion at the fulcrum E^3 of the lever. Secondly, instead of the auxiliary valve spindle being directly connected with the main valve spindle, both are separately directly operated from the mechanical gear. In this case lead is given to the auxiliary valve by a shifting valve-face worked from the main valve spindle by a reducing lever. Thirdly, the auxiliary valve is fluid actuated by means of puff-ports from the auxiliary cylinder, and the main valve is again connected with the mechanical gear directly. When the fluid is distributed by the piston in the auxiliary cylinder, the admission takes place through ports in the piston, and the exhaust directly through ports in the cylinder. This arrangement is especially suitable for such fast-running engines as those in locomotives and torpedo boats. In cases where an elastic fluid is employed, a cataract cylinder of an incompressible fluid may be added; or an incompressible fluid alone may be used, heated, however, in order not to produce condensation of surrounding steam.—December 13, 1887. [11½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

April 23rd.

6763 Heating Rivets, W. Oxley and J. Gemmell, Newcastle-on-Tyne.
6768 Fluting Metal Rollers, A. S. Chew, Gloucester.
6773 Trip-expansion Gear, J. Cochrane and W. Cameron, Glasgow.*
6774 Lubricator, S. Green, Wolverhampton.*
6776 Gas Lamps, J. Worthington, Blackpool.
6779 Shuttles, E. Haworth, Nelson.
6782 Pumps, M. Blumrich, New York, United States.
6783 Motors, M. Blumrich, New York, United States.
6785 Fountains, W. Gillett, Slough, Buckinghamshire.
6788 Steam Engines, E. Wigzell and J. Pollit, London.*
6790 Screw-cutting Machines, T. B. Smith, Birmingham.
6792 Furnaces, R. H. Radford, Sheffield.
6794 Governor, W. H. Gray and J. D. Gray, London.*
6799 Registering Machines, E. Herring, London.
6803 Reeling Ropes, M. H. Day, London.*
6804 Telephone Transmitters, W. R. Lake, London. (J. Straton, Canada.)*
6811 Grips, T. W. Lemieux, London.
6812 Winding Gear, T. W. Lemieux, London.
6818 Crank Pins, G. H. T. Beamish, London.
6820 Steam Boilers, M. Hutchison, Glasgow.
6822 Metallic Roofing, S. C. Frederick, London.*

April 24th.

6828 Steam Boilers, C. F. Dixon and W. N. Dack, Manchester.
6830 Signalling, W. E. Hickling, Leicester.
6831 Engines, J. H. Knight, Farnham.
6835 Carding Engines, H. Isitt, Manchester.
6843 Furnaces, R. Amstrong, Newport, Monmouthshire.
6849 Pump and Motor, J. C. R. Okes, London. (F. M. Roots, United States.)
6850 Refrigerator, S. Price and C. A. Soderberg, London.
6865 Batteries, G. E. Heyl, London.*
6880 Type-writers, G. A. Wilkins, Middlesex.

April 25th.

6883 Dynamos, L. B. Atkinson, Clapham.
6897 Buffering Railway Vehicles, E. C. Ibbotson, Sheffield.
6900 Submarine and Aerial Vessel, F. W. Pool, Minnesota, United States.
6907 Furnace Bars, W. Redman, Halifax.
6915 Metal Roofing, G. Ewart, F. J. D. Hüllinghorst, and R. Haywood, London.
6916 Drilling Machine, W. Dyer, Birmingham.
6934 Steam Boilers, J. L. White and H. S. White, Middlesex.
6936 Cleaning Grain, C. Frauzel, London.
6937 Artificial Fuel, C. J. Lungley, London.
6939 Printing Machines, L. Gunn and E. Rice, London.

April 26th.

6952 Internal Flues, G. S. Jones, London.
6955 Pumps, G. E. Dorman, Stafford, Staffordshire.
6965 Lubricator, J. Liddle, Glasgow. (H. O'Connell and S. A. Cahill, United States.)
6970 Water-circulating Apparatus, R. Armstrong, Newport, Monmouthshire.
6972 Riveting Machines, J. Crow, Glasgow.
6973 Raising Sunken Ships, H. W. Cook, Essex.
6976 Pumps, T. Eddleston, Halifax.
6983 Couplings, G. W. Moon, Westminster.
6990 Furnace Fire-bars, J. G. Galley, London.
6991 Gas Lamps, A. Kitson, London.*
7005 Galvanic Batteries, A. Schanschieff, London.
7012 Testing Pipes, W. R. Lake, London. (Hollander and Vinken, Holland.)
7013 Aluminium, L. P. Devaucelle, London.

April 27th.

7023 Electric Meters, R. Snowdon, Manchester.
7024 Carding Engines, H. Isitt, Manchester.
7026 Screw Propellers, J. Harper, Liverpool.
7030 Bending Iron, J. Wotherspoon, Glasgow.
7031 Breaking Flax, A. Spiegelberg, Glasgow.
7032 Furnaces, R. F. Craig and A. Neilson, Glasgow.
7033 Bearing, B. Schrader and G. Schmidbauer, Liverpool.
7034 Governors, W. Chadburn, Liverpool.
7035 Furnaces, H. B. Fletcher, Sheffield.
7042 Indicators, D. H. Rivers, Liverpool.
7047 Steel, W. F. Jackson and W. Galbraith, Stoke-on-Trent.
7062 Injectors, T. Sandiford and A. Diggle, Rochdale.
7066 Coating Steel, W. H. Rickard and T. J. Rickard, London.
7069 Engines, A. E. Tavernier and E. Casper, London.

Publishers' Announcements.

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Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE

PRACTICAL ENGINEER,

MAY 17TH, 1889.

STEAM ENGINE EFFICIENCY.

SOME time ago we pointed out the desirability of an agreement among engineers and a thorough understanding of the proper modes of estimating the efficiency of heat engines. We also insisted upon the necessity of comparing engine performances, not with the unattainable perfect heat engine, but with engines perfectly carrying out the operations which, in actual practice, are of necessity carried out imperfectly. This subject is at present one of very considerable interest in view of the recent marine engine trials reported on by Professor Kennedy, and in the discussion upon that report considerable difference of opinion appeared to exist among several of our leading authorities upon the subject. To us the matter appears a perfectly straightforward one, upon which there is little room for difference of opinion.

We do not agree with the remarks of our contemporary, the *Engineer*, in which it is stated "that engineers generally are beginning to understand that the old time-honoured formula $\frac{T-t}{T} = E$ has no more to do with the practical steam engine than it has to do with the manufacture of tin tacks." On the contrary, we are of opinion that engineers generally understand the practical application of the principles of thermo-dynamics to the construction of steam and other heat engines much more completely and fully than at any previous period, and that few of our educated practical engineers are so misguided as to doubt the truth and applicability of Carnot's fundamental equation. They understand, however, very fully the limits of its application, and are consequently in a position to apply it in a proper way. This is very fully evident from the remarks at the meeting of the Institution of Mechanical Engineers by Mr. Willans, Prof. Cotterill, Prof. Unwin, Mr. J. G. Mair, and Mr. Anderson. Carnot's cycle, as we have already pointed out, does not apply directly to practicable heat engines, because the process described is one which it is impossible to carry out in practice in its entirety, but it tells us at once the limits which we cannot hope to exceed in any form of engine using certain temperatures as the range within which the engine works. All practicable heat engines must have cycles which, even if properly carried out, are inferior to this, and, therefore, the true measure of the efficiency of any engine must be estimated by reference to such an ideal standard. On this point we thoroughly agree with Mr. Willans, and consider that the standard steam engine should be one in which say one pound weight of steam is supposed to be taken into the cylinder at the given pressure, without loss of any kind due to clearance, wire drawing, leakage, or condensation, and expanded down to the intended limit, then condensed and returned to the boiler. Such an engine is, of course, impossible, but it is that to which we all strive to approximate as closely as possible, and the more successfully we comply with the necessary conditions the greater economy we obtain.

It is quite obvious, for instance, that we cannot hope to obtain the maximum economy possible in a steam engine from a small motor such as a Davey domestic motor, in which the pressure in the boiler is never allowed to exceed that of the atmosphere, and where the power is entirely obtained by condensation. But here it would be apparently unfair to compare the results obtained with that of an engine using high pressure and expansion. The makers had certain objects in view, and for that reason they had to submit to certain restrictions, the main one being a boiler in which no pressure above atmosphere existed. The measure of the success of the engine, then, is not its consumption of steam compared to that of an engine where different conditions are allowable, but its consumption if there were no losses in the utilisation of steam in the manner intended. In a perfect engine of this kind the cylinder would have no clearances; there would be no loss by throttling; the pressure during the whole admission would not fall below atmosphere; and there would be no resistance in discharging to the condenser; there would also be no condensation due to the cooling of the cylinder walls. The efficiency of the engine is, therefore, measured by its approach to this standard. If, for instance, an ideal engine of this kind would use 25lb. of steam per I.H.P. per hour, and the actual consumption was 50lb., then the efficiency of the actual engine would be 0·5, or 50 per cent, as it received double the amount of heat necessary to give the power if all losses could have been avoided.

The term efficiency has so many different applications in a perfectly legitimate way, that it is necessary to discriminate carefully and qualify the term very clearly in order to avoid misunderstandings. This was rendered very evident during the discussion to which we have referred, and similar difficulty has arisen during previous discussions on engine matters. The term "absolute efficiency" should be used, in our opinion, to express the ratio of the heat equivalent of indicated work done by the engine to the total heat received. Thus in the Meteor marine engine trials the absolute indicated engine efficiency was 16 per cent. Of 100 heat units given to the engine as steam, 16 were converted into available indicated work. In the Society of Arts trials the Davey-Paxman engine gave an absolute efficiency of 12 per cent, and trials by Mr. Willans of his type of engine seem to have given absolute engine efficiency of about 17 per cent. Now, the absolute efficiency of a steam engine is misleading in one way unless misapprehension is carefully guarded against, as the mere fact of comparing the total heat given to the engine as steam and the amount of that heat converted into indicated power favours the assumption that it is possible to convert the whole heat into work, or at least that the difference between 16 per cent and 100 per cent is waste in some form. This is not so; but nevertheless it is necessary to use the absolute standard in comparing engines of different types with each other, be they steam, air, or gas. The real measure of success, from an economical point of view, is undoubtedly the percentage of heat conversion of which each engine is capable, and it is needful therefore to have this absolute standard. The efficiency with reference to Carnot's cycle is another common mode, and it supplies a standard more nearly attainable than the first, but it also could not be realised in any practicable heat engine. It is impossible in any practicable heat engine to comply with the conditions of Carnot's cycle, because the most important are antagonistic to each other, and therefore cannot be combined in a working machine. The proper standard of comparison to estimate the extent and disposition of the various losses is undoubtedly that of an ideal engine with the same operations as the actual engine, but in which it is supposed that all practical losses are suppressed. The performance of such an engine can readily be calculated from the known properties of steam, and when the results obtained in practice are compared, the amounts and sources of loss can be ascertained, with a view to remedy where possible. This might be called the ideal steam efficiency, as it is the ratio of heat converted into indicated power to heat which could be converted if all practical losses were suppressed. Comparing the Meteor's engines in this way with a perfect steam engine, working with the same pressures and expanding the same amount, they have done 64·3 per cent of what they could have done if all practical losses had been avoided; that is, the ideal steam efficiency is 64·3 per cent, and as the loss due to condensation in the high-pressure cylinder was 23 per cent, the total heat accounted for by those two items was 87·3 per cent, leaving 12·7 for losses due to back pressure and throttling. From a practical point of view this is exceedingly satisfactory. We cannot avoid all losses; but when we know where the heat goes, it is the first step to saving some of it.

The initial condensation of 23 per cent is divided between the cylinder and steam jacket, and it is most unfortunate that jacket water drained off could not be measured, as it would have greatly increased the accuracy of our knowledge of the subject. However, Professor Kennedy has promised that in future trials arrangements will be made to measure this carefully. In the Davey-Paxman engine trials the percentage of water in the high-pressure cylinder, shortly after cut-off, was 35, or almost one-half more than in this case, and the steam pressure was very similar, about 150lb. per square inch; but the engine was a very small one, only a little over twenty horse power, so that it is impossible to compare the two results.

The condensation, however, is undoubtedly due to the cooling action of the cylinder walls; at high pressures a comparatively small difference in temperature between the entering steam and the metal causes a much more rapid condensation than occurs with a much larger surface at condenser temperatures and pressures.

We cannot see—as our contemporary the *Engineer* still continues to do—that work done during admission can cause liquefaction; it seems to us a matter upon which difference of opinion can hardly exist—that is, amongst those reasonably well informed upon the subject. We agree, however, in doubting seriously the utility of a steam jacket upon a low-pressure cylinder. Of course, every precaution should be taken to prevent loss of heat by radiation, but heat should not be added to cause re-evaporation.

THE STRIKE OF GERMAN MINERS.

THE conditions of labour on the Continent are, as a rule, much harder upon the worker than in this country; at the same time, the liberty of combination is much more restricted, while the means resorted to by the civil authorities to put down rioting are very severe. When strikes do occur they are much more apt to degenerate into rioting and violence than among ourselves. The Westphalian riots, which broke out near Bochum more than a week ago, are not yet at an end, notwithstanding the number of troops brought upon the spot, who have been permitted to use their weapons freely upon the rioters. Their mode of procedure is vigorously simple; the order to disperse is given, and if disregarded after thrice repeating a warning by drum and trumpet, fire is opened upon the mob. It is pitiful to note that no fewer than ten men have been killed and many wounded in this way; but still the attitude of the strikers grows more menacing, and this week about 100,000 men have left work.

It appears that 15 to 25 per cent addition to wages is demanded, and a reduction of working hours to eight per shift. These demands have been moderated, however, and now the Government has intervened to arrange the difficulty between the men and the employers.

The strike has produced a marked effect upon the price of coal in the North-east of England, and also on freights between the northern ports and Germany, as numbers of ironworks throughout Westphalia and Rhenish Prussia have had to suspend operations, or considerably reduce production. Messrs. Krupp's Bessemer steel-rail and plate-rolling mills are stopped, and many furnaces are being damped out for want of fuel. Arrangements have been made for a supply from England and Upper Silesia for two months to come, in order to keep the works going.

The conditions of life with foreign miners are almost unbearable, and it is very desirable that they should be able to obtain better wages. If they succeed in doing so, it will materially assist this country by diminishing foreign competition and enabling us more easily to maintain our present relatively high standard.

BIRMINGHAM ELECTRICAL EXHIBITION.

The arrangements for the Birmingham Electrical and Industrial Exhibition are progressing satisfactorily, as nearly the whole space has been taken up, although the exhibition does not open till August. It will be held in the well-known Bingley Hall, and should be a very interesting and complete little exhibition. Those who visited the British Association Exhibition of 1886, held there, will remember how unexpectedly attractive the arrangements were at that time, and how it was crowded from day to day. The hall, although small compared to the size demanded by the great exhibitions, such as those of London, Manchester, Glasgow, and Paris, is quite sufficiently large to bring together a great variety of interesting matter—quite as much, indeed, as one is able to appreciate in a visit of several hours' duration. Although the great exhibitions are exceedingly impressive, yet the mere magnitude of their dimensions spoils their effect, and distracts the attention from the more important features, and very often, from an engineering point of view, one learns more from a few novel constructions than from a great mass of exhibits, which have to be carefully examined to discover the most interesting points. The list of exhibitors includes many important companies and firms, among them the Edison - Swan Electric Light Company, the Anglo-American Electric Light Company, Woodhouse and Rawson, Limited; Elwell Parker, Limited; Laing, Wharton, and Day, Limited; Fowler, Lancaster, and Company, Limited. Of steam engineers, we observe Messrs. Robey and Company, Ruston and Procter, Galloway, and Greenwood and Batley. Apart from electrical matters, the exhibition is considerable, and includes the manufacturing processes of ribbon weaving, metal plating, pen making and boot making, and a switch-back telpherage railway on the electrical system of the late Professor Fleeming Jenkin, is to be fitted up to convey passengers through the air round the hall. It will be remembered that Professor Jenkin's system of telpherage consists in the electrical propulsion of goods and passengers, from suspended single lines, by electric locomotives and carriages, suspended under the line. It will form an interesting feature of the exhibition.

HYDRAULIC DOCK MACHINERY.

(Continued from page 323.)

Vessels are readily moved into position, whether through the dock gates or alongside the quay wall, by means of the useful but insignificant looking bell or dome known as a capstan. This is actuated by hydraulic power by placing a small motor, either working direct or through gearing, in a convenient position, varying according to circumstances, but usually on the underside of the foundation plate of the capstan, and so arranged that by tilting over this plate, which is balanced, the whole of the mechanism is exposed to view, the motor having two or more cylinders, preferably three, and these may be single or double acting and either oscillating or fixed, as in figs. 9 to 17. The Brotherhood three-cylinder engine (figs. 13 and 14) specially commends itself to the writer. These are single acting, all working on to one crank, the strains being balanced throughout the revolution. The practical uses of the capstan seem to be unlimited, any requirements of haulage being met by using loose bollards or snatch blocks in conjunction with the line capstan, and with snatch blocks it may be converted into hoisting tackle, and it is very frequently used for opening and closing dock gates.

In the neighbourhood of docks (as we often find to our cost when in a hurry to catch a train) are always a large number of swing, draw, and lift bridges, and those who have waited until two or four men at the hand-turning gear have slowly swung the bridge round, while you stand watch in hand calculating the fewest possible minutes necessary to get to the station when you land the other side, will welcome the enlightened dock boards and others who have now added hydraulic turning gear to their bridges. Swing bridges actuated by hydraulic power are either carried on a central press or water pivot, or on line roller bearings; and in large bridges a combination of the two is adopted, the great weight of the bridge being relieved by the central ram while the bridge rotates on a roller path. When the water pivot is used the bridge is raised from its solid bearings previous to the turning gear being put in motion; this, of course, being done by admitting pressure to the central cylinder. This method is usually adopted when the bridge is swung from one of the banks. In cases where there is a central pier with a span opening on each side it is customary to use the roller bearings, the weight of the bridge in cases being nearly balanced, as previously stated, by a central ram under pressure.

In bridges of this description it is necessary, for the purpose of obtaining a perfectly solid roadway, when the bridge is in position for the traffic, to raise the two ends of the bridge a little, four or six resting blocks or wedges then being inserted and the weight of the bridge allowed to rest on them. When it is proposed to open a bridge the ends are first raised by two hydraulic lifting presses at each end actuating toggle levers. The weight being thus taken off the resting blocks, they are withdrawn, a separate hydraulic press working direct on to each, and the lifting presses make their return stroke. A locking bolt is now disengaged and the turning gear set in motion; this latter consisting either of hydraulic presses with multiplying pulleys (fig. 7), and chains working round a large central drum about the roller path, or hydraulic motors working by gearing on to a circular rack attached to the underside of the bridge. When the bridge is closed the locking bolt shoots into its place, the lifting presses are again set in motion, the ends of the bridge are raised to allow the resting blocks to be pushed home by their presses, the lifting presses make their return stroke, and the ends of the bridge rest firmly on the resting blocks.

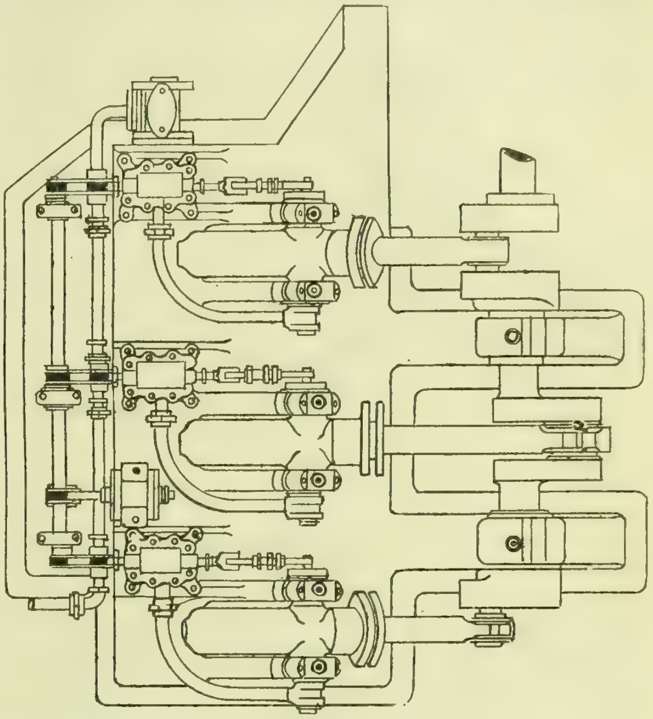

Fig. 9.

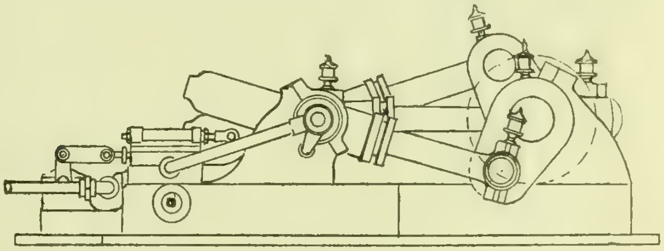

Fig. 10.

The turning gear may be either in the centre of the bridge or on one of the banks. In situations where a hydraulic system is in operation, the power is, of course, obtained from the pressure mains, but in isolated cases the power is generated in the immediate vicinity of the bridge, sometimes in the central pier itself, as in the North-Eastern Railway Company's bridge over the Ouse, near Goole, the engine, pumps, and accumulator, which has a 16½in. ram making a stroke of 17ft., all being in the central pier of the bridge. In a few cases lift bridges are used, and gangways similarly constructed are very useful; a press with multiplying pulleys being placed either vertically or horizontally at the foot of two columns at the shore end of the gangway, the latter being hinged and suspended by chains passing over pulleys at the top of the columns and connected to the hydraulic presses. The application of hydraulic power to cranes has been one of the most useful of all. The sole requirements of a crane being rectilinear motion and sufficient power, the hydraulic press is particularly suited for the purposes, the one drawback being the fact that the same power is consumed in an ordinary hydraulic crane irrespective of the load raised, and even when required for lowering only, the same quantity of pressure water is used to simply take up the chain. This might readily be remedied by using say two pressures, which the writer would strongly recommend, one say of 200lb. per square inch, and one of about 1,000lb. to 1,200lb. per square inch; or a simple balancing cylinder might readily come into operation only when light loads are being lifted or when weights are being lowered. Other methods are used. In one case there are two or more cylinders, one, two, or all three, as the case may be, being actuated by the hydraulic power, the others drawing water from a tank. The easy manipulation of the valves by the crane attendant makes any of the several methods quite under his control. But it is open to question whether it is really desirable to introduce these complications, although the control is so simple, because it must mean greater first cost and add a possible source of error. Mistakes, however, are not of very great consequence, as by the use of properly designed and constructed hydraulic apparatus it is impossible to put on any machine a greater pressure than that in the accumulator, except where it is specially so required, as in riveting, for instance. Except in very short lifts, the press with the multiplying pulleys (fig. 7) is adopted, and this is usually placed either vertically on or inside the crane centre, or horizontally in any convenient position, the chain leading from the press round a pulley up through the centre of the crane post and over the jib. The slewing gear usually consists of two direct-acting hydraulic presses placed horizontally and working on to the crane post, one press slewing the cranes in one direction, the other slewing in the reverse direction. Mr. McConnochie, the engineer of the Cardiff Docks, in conjunction with Sir William (now Lord) Armstrong, introduced hydraulic power to hydraulic cranes, and very fine examples of this class of crane can be seen at the Alexandra Docks, Hull, and other modern docks, the cranes being moved into suitable positions alongside the vessels in dock and coupled up to the mains by a flexible pipe, allowing a small amount of motion, the crane being thus taken to the vessel, and not the vessel to the crane—a distinct advance in dock engineering. The hydraulic press with the multiplying pulleys is of almost universal application for lifting and hauling purposes, chains being led over snatch pulleys to the holds of vessels or any other place where lifting is necessary. The hydraulic winch is also

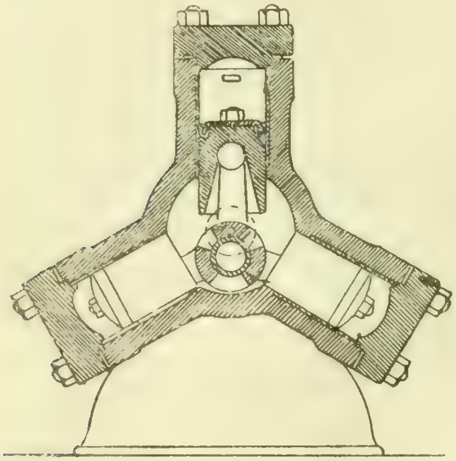

Fig. 11.

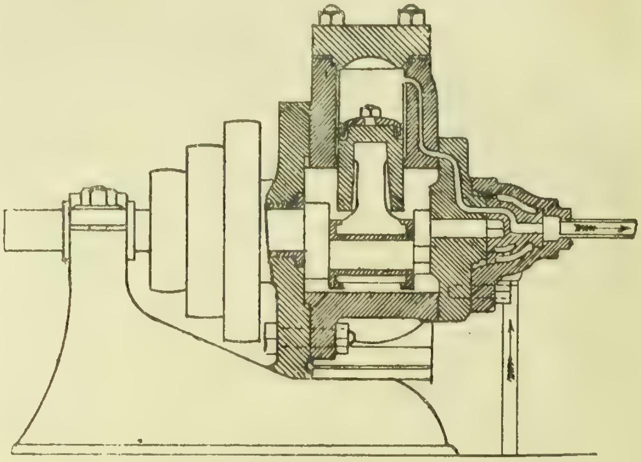

Fig. 12.

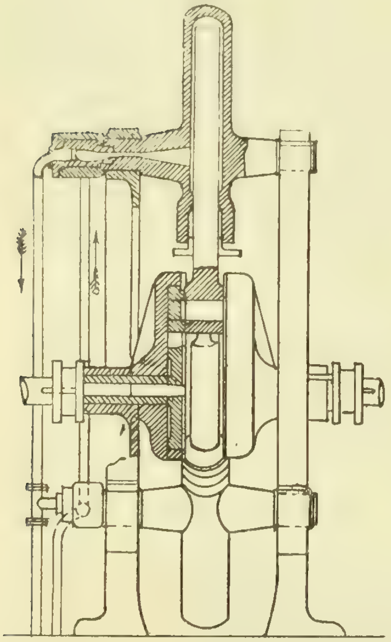

Fig. 13.

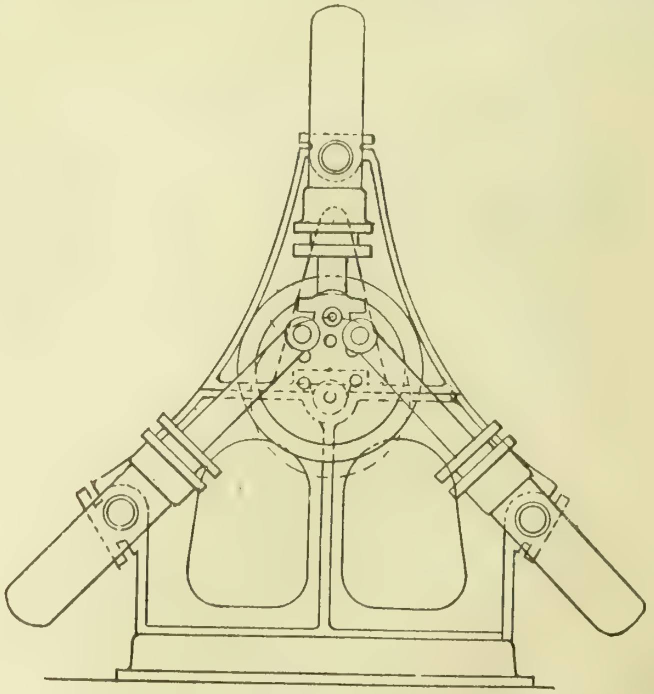

Fig. 14.

much used for lifting on shipboard, but for ordinary purposes the hydraulic press, with the multiplying pulleys, is the most suitable. The hydraulic winch may be driven by any hydraulic motor, a few of which will now be referred to. The Armstrong motor or hydraulic engine (figs. 9 and 10) has three single-acting rams, working on a three-throw crank shaft, the cylinders being of the oscillating type, the slide valve being worked from one of the trunnions, while the pressure is alternately admitted and expelled through the other trunnion. Brown's motor (figs. 11 and 12) also has three oscillating cylinders, but the single-acting rams work on one crank pin, and the trunnion itself forms the valve. The Brotherhood motor (figs. 13 and 14) is of their well-known three single-acting fixed cylinder type, with trunk plungers or rams, the large ends of the connecting rods working on to one crank pin, the valves being actuated by a revolving disc, worked by the out end of the crank pin, the ends of the rams being alternately open to pressure and exhaust. Several methods have been introduced to vary the power of these motors in accordance with the work to be done. In Brown's motor the length of stroke may be varied by putting the pin in one or other of the holes in the crank disc (fig. 11). In the Brotherhood-Hastie motor (figs. 15 and 16)* the ordinary Brotherhood engine is used, but with a longer stroke than usual, and instead of the crank pin being at a fixed distance from the centre, it is on a slide, adjustable by a cam, actuated by mechanism as follows: The crank shaft is hollow, with a central spindle to which the cam plate is fixed; the flywheel is in two parts, one being carried by the central spindle and the other by a strong spiral spring, the arrangement being such that the crank shaft can only communicate power to the flywheel through this spring, thus coiling it more or less according to the power required, and automatically adjusting the throw of the crank to the work to be accomplished. In the Rigg motor (fig. 17) three cylinders are also used, but in this case the cylinders revolve round a movable pin, the outer ends of the rams being attached to a disc. When the pin coincides with the centre of the disc there will be no motion, but two hydraulic rams act upon this pin, moving it right or left, as required; when it is moved to the left the disc will revolve to the right, and *vice versa.* The greater the movement sideways of the pin, the greater the power of the motor. The pressure is admitted and exhausted through the pin, suitable ports being provided. The movement sideways of the pin may be controlled either by hand gear or by governor, thus increasing or decreasing the power as required.

The home production of feeding stuffs not being sufficient for the requirements of the country, great demands have been made on the foreign and colonial grain markets, and special machinery has been designed for taking the grain direct from the vessels and depositing it in silos or bins in the warehouses. Elevators, consisting of endless bands of webbing or chain, travelling at a rate of 200ft. to 300ft. per minute, and having buckets or cans at intervals of 12in. or 18in., are dropped into the holds of the vessels, and these are actuated by a motor at the top of the elevator. The cans dipping into the grain scoop it up, and deliver it over the top pulley on to a broad canvas and indiarubber band or shoot, which delivers it to an automatic weighing machine. From this it runs to another elevator, which takes the grain up to the top of the building, where it is deposited on to another conveyor band, running in either direction at about 500ft. per minute.

Discharging carriages, with other bands, cover the whole of the warehouse, and the grain is thus automatically stored in any building or series of buildings as required, and on any floor. For the purposes of mixing or turning over the grain, and for facilitating its removal from the store, conveyor bands are placed under the floor, and, communicating with the bins or silos, they bring the grain from any portion of the warehouse to an elevator, which may either deliver it on to the top system of bands or into railway or other wagons or barges, or into sacks a sacktackle or hoist depositing the sacks in the barge or wagon. The whole of this machinery is actuated by hydraulic motors similar to those described, only the elevator or band actually required being in motion. These elevators will each lift 30 to 100 tons per hour, independent of the height; the power, of course, depends directly on the height and the quantity raised. A 22in. conveyor band at 500ft. per minute will deliver 100 tons of grain per hour at an expenditure of about 2 H.P. per 100ft. run. Our export coal trade has rendered necessary the construction of special facilities for the rapid shipment of coal, the coal being delivered from the railway wagon or barge into the collier by hydraulic gear. At Cardiff may be seen hydraulic tips in which a railway wagon is raised on a cradle (actuated by a vertical hydraulic ram, 12in. diameter and 20ft. stroke), sliding in guides at the four corners. The frame is pivoted at the front end, and a second hydraulic ram at the back of the frame tips it, with the wagon on it, and so discharges the coal on to a shoot conveniently placed for delivery into the vessel alongside. On each of these tips is placed an anti-breakage crane, with a square bucket holding one ton of coal. As the South Wales coal is brittle, and the value would be impaired by breakage, the coal is discharged from the shoot into the bucket; this being lowered into the hold, the bottom of the bucket is withdrawn and the coal is quietly placed in the vessel. This is continued until a conical heap of coal is formed nearly high enough to reach the hatchway, when the shoot is allowed to deliver the coal freely, and, delivering close down upon the heap, it prevents breakage of the coal by a vertical drop. As much as 200 tons of coal have been shipped in an hour by these tips.

(*To be continued.*)

THE INSTITUTION OF MECHANICAL ENGINEERS.

The spring meeting of this institution, which commenced on May 1st, was opened by the transaction of some formal business, after which the president (Mr. Charles Cochrane) delivered his inaugural address, in which he traversed the latest developments of mechanical engineering. He stated that there is a sad neglect in the use of land engines and boilers in the matter of economising steam, and pointed out that the aid of the mechanical engineer might often be called in to point out possible economies not obvious to the user. In sanitation many of the new drainage systems had left foul evidence of the nuisances which should have been removed. He mentioned many instances of bad drainage, and strongly advocated the establishment of sewage farms. As regarded the heating of houses, Sir William Siemens had shown the necessity of a system for perfect combustion of fuel employed for heating and warming our houses, as a remedy for the existing clumsy method of burning coals extravagantly in an open firegrate. Sir Douglas Galton also had done excellent work in showing how, even with an open firegrate, real warming of fresh air in a room may be effected, so that instead of cold air rushing in to create draughts, a plenum of warm air should greet anyone entering the room. This not only reduced the quantity of coal required, but prevented most of the heat passing up the chimney, and carrying with it smoke and dust to add to the impurities of the atmosphere. In water supply great progress was being made in the removal of contaminations. In blast furnaces, the almost universal adoption of firebrick stoves had resulted in considerable economy, and the substitution of lime instead of limestone as a flux, had materially assisted in this direction. He pointed out that engineers should take into serious consideration, in the use of cast iron, the impossibility of running a small thin casting with the same metal that is proper for a large one. Although made from identically the same materials, the lower numbers of pig iron are weaker than the higher numbers, and it is out of the lower or greyer numbers that small articles must be cast.

Mr. Cochrane also called attention to the larger application of agricultural machinery to the object of converting arable land into pasture, and old pasture into arable. The latter work is easy enough with a plough alone, but it has not been generally recognised that in three or four years the arable can be converted into valuable pasture by the removal of the grass from the old pasture and laying it in strips upon the arable with narrow intervals between, over which the grass spreads by inoculation. At present the cost of removing the turf by hand is a serious impediment; but when once the principle is recognised a new field will be open for the application of machinery in the shape of an improved skim-plough and appliances for rolling up the turf as cut, so as to simplify the whole process.

A paper by Professor Kennedy, upon "Marine Engine Trials," and one by M. Emil Passburg, of Breslau, upon "Apparatus for Drying in a Vacuum," were read, but as we propose to publish them, with illustrations, in an early issue, we shall not refer to them further here.

A Valve for Electricity.—A device which may be of considerable value has been discovered by M. Neyreneuf is an electric valve, by means of which the current can be sent in one direction, but not in the other. With a voltameter constructed of two aluminium electrodes, dilute acid as electrolyte, and an alternating current, he found that pure hydrogen was evolved at both electrodes, but on making up an arrangement with one electrode of aluminium and one of mercury, using distilled water as electrolyte, the current was found to pass in one direction only.

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* Illustrations will be given in next issue.

A TERRIBLE CATASTROPHE.*

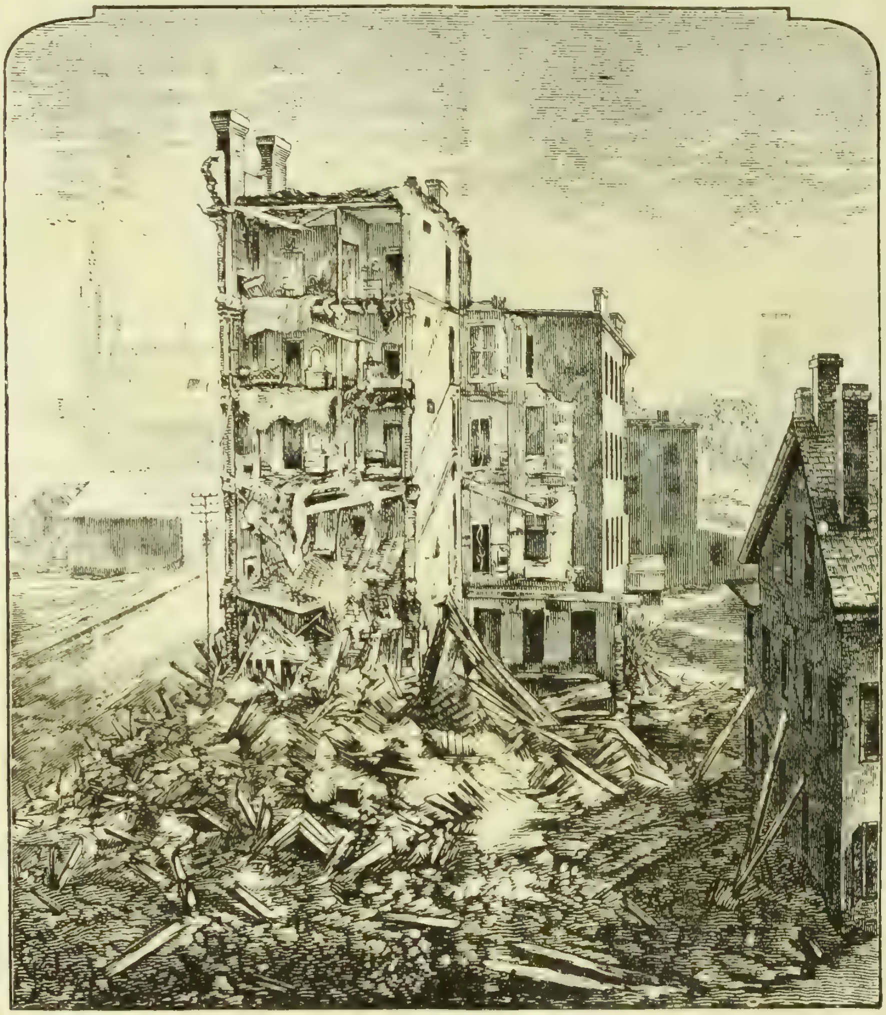

Fig. 1.

At 4-50 a.m., February 18, 1889, a tubular boiler of about sixty nominal horse power exploded in the cellar of the Park Central Hotel, corner of High and Allyn Streets, Hartford, Conn. The building, a fine-looking five-story brick structure, was completely demolished, and the inmates were buried in the ruins. The work of rescue began at once, and ten persons were taken out more or less severely injured, and sent to the hospital ; while twenty-three bodies, many of which were so mutilated as to be scarcely recognisable, were sent home and buried by sympathising friends. In several cases whole families perished. The loss is estimated at 75,000 dols., none of which can be recovered, as the property was covered by fire insurance only, which does not indemnify against loss or damage by explosion. Such was the violence of the catastrophe that the roar and shock of it were heard and felt for miles around the city, and surrounding property suffered a damage of thousands of dollars.

Our illustrations will give the reader a good idea of the appearance and magnitude of the hotel. Fig. 2 shows it as it was before the explosion, and fig. 1 shows what was left standing of the rear portion of the building. This had afterwards to be pulled down, thus making the destruction complete.

The cause of this terrible disaster was an iron boiler of the horizontal tubular type, about four years old, and of the following dimensions : Diameter, 54in ; length, 16ft. 3in. ; shell plates of Bay State refined iron, $\frac{5}{16}$in. thick, double riveted ; heads (iron), $\frac{3}{8}$in. thick ; tubes, 3in. in diameter, 15ft. long, and 58 in number. Two engineers were employed, one of whom has held a marine license ; one of them stood watch by day, the other by night. The boiler was inspected annually by the State Inspector of Steam Boilers, First Congressional District, and was last tested by

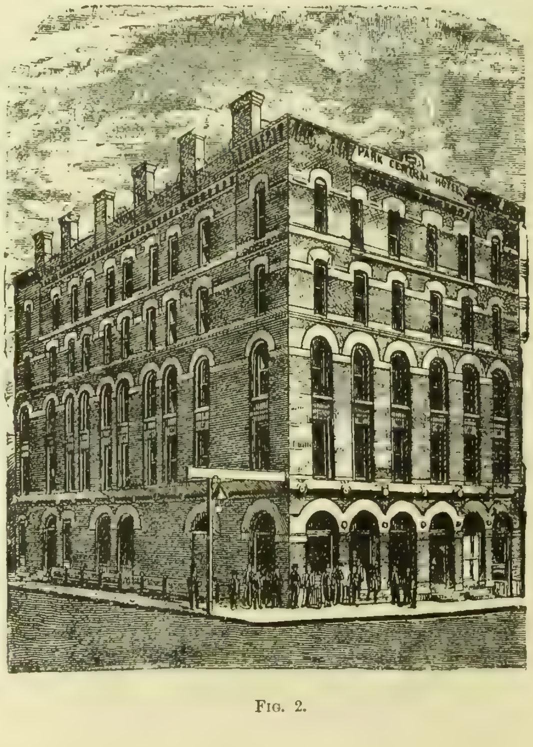

Fig. 2.

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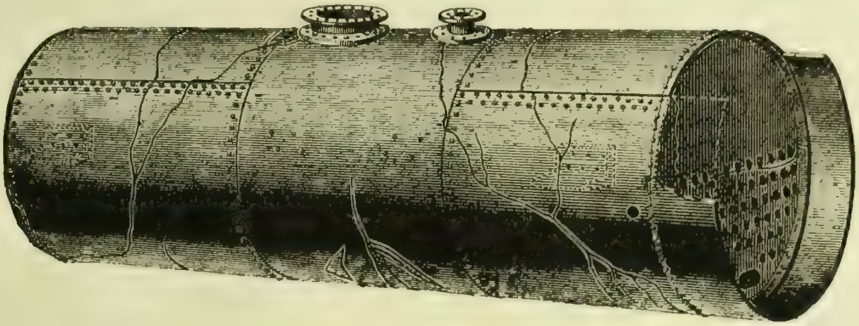
* From *The Locomotive*, Hartford, Conn., U.S.A.

hydrostatic pressure in August, 1888, and a certificate given conformably to law for a steam pressure of 75lb. per square inch. It is not true, as was stated in various papers, that this boiler had been inspected by the Hartford Steam Boiler Inspection and Insurance Company. This company had never inspected the boiler in question, nor had it any knowledge of it.

The work of recovering the fragments of the boiler was undertaken promptly after the explosion, and as fast as they were brought out of the ruins they were carefully measured, and the work of re-assembling them was begun. The result is shown in figs. 3 and 4. It will be readily seen that, although a few small pieces were lost, the five principal pieces into which the boiler separated (see lines of fracture, figs. 3 and 4) were recovered, and their position, condition, &c., carefully noted; and these tell the story of the explosion.



IG. 3.

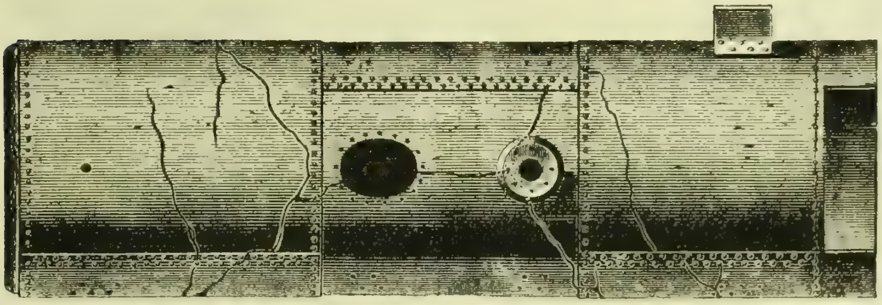


FIG. 4

It was thought at one time, before the wreck was cleared up, that owing to defects and general structural weakness known to have existed in the building, it was possible that the building had fallen first and in its fall wrecked the boiler; but as soon as the pieces of the boiler were exhumed from the ruins that belief was dispelled, and it was apparent that a boiler explosion was the cause of the calamity, and not the effect.

There was some diversity of opinion as to the cause of the explosion, but it was thought from the first, by the representatives of this company, that there was no evidence of low water, nor any appearance of overheating upon the shell plates or heads. This opinion was fully sustained by the subsequent discovery of the back head of the boiler with the fusible safety-plug still unmelted.

The shock of the explosion (which was felt for miles around the city), and the general destruction of the hotel and injury to adjoining property, must of necessity have arisen from the release of a very considerable force, and this force we believe to have been the stored energy in the water contained in the boiler at the time of the explosion, the approximate amount of which we will endeavour to compute from the available data. In view of all the facts that have been brought out by investigation since the explosion, we are of the opinion that it cannot be accounted for upon any other hypothesis than that of a pressure greatly in excess of the seventy-five pounds allowed by the State inspector's certificate; how much greater is a matter of conjecture. The steam gauge, one of the Bourdon patent, was found in the ruins in a dismembered condition (unfortunately it had been so badly shattered as to be of little service in unravelling the mystery), but it was noted that the steam tube, or Bourdon spring, had been straightened out so as to receive a permanent set, and there were no indications that this had resulted from any other cause than a high pressure. As Bay State refined stamps were found upon the plate of the boiler, it will perhaps be fair to assume it to have been of the tensile strength usually accorded to that quality of iron plate—that is, 45,000lb. per square inch of sectional area. This, in a boiler of $\frac{5}{16}$in. thickness, double riveted, and 54in. diameter, would give a safe load of 104lb. (see United States Steamboat Inspector's Manual, p. 76), and a bursting pressure of some 375lb. The steam nozzle and manhole of this boiler were placed upon the same sheet, the openings being 8½in. and 12¼in. by 16½in. respectively. It will be apparent from a study of the illustrations that this portion of the shell would not be as strong as other parts of the shell of like area. Under an excessive pres-

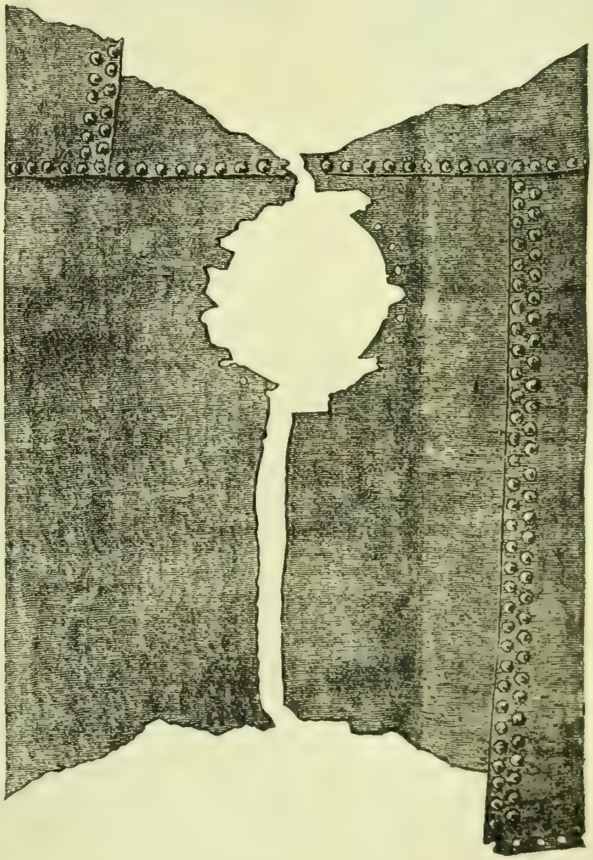


FIG. 5.

sure the longitudinal section of the middle part in the line of the manhole opening would be the weakest, and there would be a distortion, as it flattened down in assuming an oval shape under a gradually increased pressure, from a concentration of the strain at that part. That this was the case seems demonstrated by the drawing down of the plate on that line, for this was the only place so far noticed where there was any perceptible reduction of thickness in the plate along a line of rupture. This strain would have to be withstood by the manhole frame, and when that fractured, the opening being so close to the edge of the sheet, rupture and explosion were inevitable. (See fig. 5.) The manhole frame is thought to have been shattered, but no pieces have as yet been found.

If, as we believe, this middle sheet was weaker than the others, a much lower pressure than 375lb. (the theoretical bursting pressure) would cause rupture. Suppose, then, for the purpose of our computation, that the pressure at the time of rupture was 200lb. per square inch, the corresponding temperature being 388 deg. F. It is true that we cannot tell the height of water in the boiler at the time of the explosion with precision, but the fact that the fusible plug was found intact, and that it readily fused when subsequently heated, establishes beyond dispute that there must have been at least enough water to cover it; and our calculation will assume this to have been the case. On making this assumption we find that the boiler contained 5,552lb. of water and 48lb. of steam. When the explosion occurred a portion of this mass of water was vaporised, the temperature of the remaining water being thereby reduced to 212 deg. The assumed original temperature being 388 deg., the fall in temperature was 388 deg. – 212 deg., or 176 deg.; and this, multiplied by 5,552lb., gives 977,150 British thermal units, which is the amount of heat given off and immediately converted into mechanical energy. The difference between the total heat of a pound of steam at the assumed pressure and at atmospheric pressure is 1200°·2 – 1146°·6, or 53°·6; and this multiplied by 48lb., the weight of steam in the boiler, gives 53°·6 × 48 = 2572· British thermal units. Now, if we add this to 977,150 (the heat given off by the water), we have 979,722 heat units, which is the amount of heat given off in the form of mechanical energy. Since one heat unit is equivalent to 773 foot pounds of energy, the heat given off by the boiler was equivalent to 772 × 979,722 = 756,345,000 foot pounds.

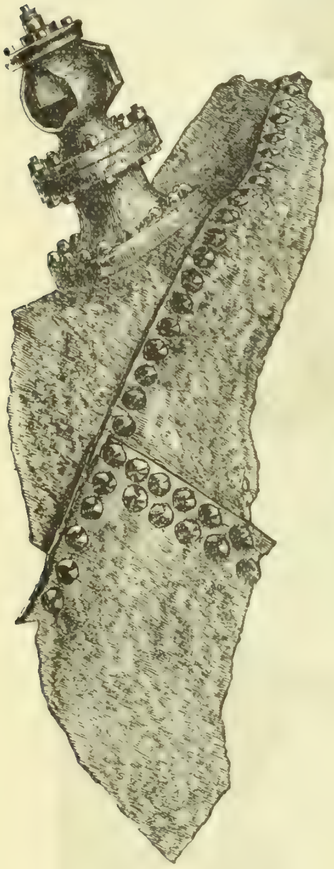


Fig. 6.

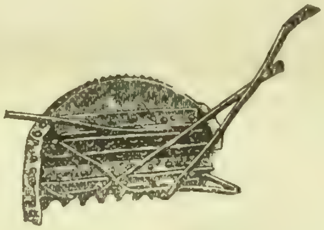


Fig. 7.

We may more fully understand the magnitude of the force confined within the boiler by comparing it with the destructive effect of the wind at the time of a violent hurricane that destroys buildings and uproots large trees. The wind, we are told, has a maximum velocity at such times of 100 miles per hour, and exerts a pressure of 50lb. per square foot, while in the boiler under consideration the pressure is believed to have been 200 × 144 = 28,800lb. per square foot.

Many of the most destructive explosions of which we have any knowledge have been caused by an inoperative safety valve, an accumulated pressure, and a full supply of water in the boiler; indeed the greater the quantity of water at such times, the more disastrous the effect.

There are many stories in circulation as to the want of care and proper management of this boiler. The coroner is now engaged in an investigation, and it is hoped that he may clear up the mystery of the safety valve, and among other things tell us whether it was purposely set fast, or became so in some other way. It was of the common lever variety, with a conical valve 3in. in diameter, and it was amply large, when in working order and intelligently used, to discharge all the steam the boiler was capable of making. Fig. 6 shows the valve as it appeared after the explosion. The observed tendency of a conical valve to stick to its seat, and the ease with which it may be tampered with, have led to the introduction of various improved safety valves. Figs. 7, 8, and 9 represent portions of the heads. There are other details of the boiler that might be discussed with advantage; but it would not be courteous for us to discuss them now while the official investigation is in progress.

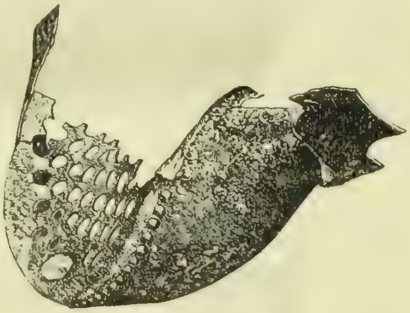


Fig. 8.

The facts that we have outlined seem to justify the following hypotheses: That the fire was not properly banked by the engineer who went off duty at midnight; or that, if it was, one of the two tramps who were allowed to sleep in the fire-room, and lost their lives there, had opened the damper and closed the fire-door after the engineer was gone, probably not realising the danger of the act; that the safety valve was inoperative, and that steam accumulated until the strain on the shell reached the limit of strength of the weakest point, which weakest point is shown by the explosion to have been the manhole frame and middle course sheet; that the explosion wrecked the partition wall in the cellar, against which the boiler was placed; and that it then raised the building, displacing connecting walls, joints, supports, drawing them inwardly, with the exception of the front wall on High Street, which, not being connected, was blown outwardly, and fell into the street. Explosions of boilers similarly placed have not always wrecked the building as completely as this one did, but of course there is the possibility that the other explosions were not so violent. When boilers are placed beneath buildings (and it is impossible to avoid placing them so in some cases) the result is apt to be very serious in the event of an explosion, for such walls as are not blown down at the time are often so badly shattered that they have to be pulled down and rebuilt. In this case, if more of the main walls had remained standing, it is probable that beams and other parts would have lodged against them in such a manner as to save many of the lives that were lost.

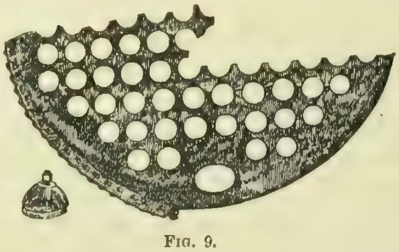


Fig. 9.

THE IRON AND STEEL INSTITUTE.

Mr. Daniel Adamson, of Manchester, was in the chair during the earlier part of the proceedings at the meeting of the Iron and Steel Institute, held in London on Wednesday, the 8th inst. There was a full attendance of members. Among those present were Lord Granville, Sir James Kitson, Sir Henry Bessemer, Sir Isaac Lowthian Bell, Sir Bernhard Samuelson, M.P., and Ex-Mayor Hewitt, of New York. The local members present were Mr. J. W. Williams, Mr. J. W. Hulse, and Mr. W. E. Norbury, of Manchester; Mr. W. H. Bleckly, Warrington; Mr. Hewlett, Wigan; Mr. F. S. Ainslie, Ulverston; Mr. George J. Snelus and Mr. C. F. Valentine, Workington; and Mr. F. Butler and Mr. David Evans, of Barrow.

The Council reported that the Institute has now 1,355 members, an increase of 42 on the year. They have accepted an invitation from the French Society of Civil Engineers to hold the next autumn meeting of the Institute in Paris. The meeting will commence on the 10th of September, and will extend over three days. The Council further reported that they had accepted the invitation of the American Institute of Mining Engineers to hold the autumn meeting of 1890 in America. Mr. Andrew Carnegie, one of the members of the Institute, had been elected chairman of the committee which would receive the Institute in the States, an appointment which the Council thought would secure them a reception worthy of the occasion. As regards finance, the Council reported a balance of £792.

The President, in moving the adoption of the report, congratulated the members on the continued prosperity and usefulness of the Institute, and expressed the hope that they would take into consideration the advisability of working in conjunction with some other learned societies. He also impressed upon the members that there was no duty more important than that of endeavouring to bring to the small iron-founders a closer technical knowledge of their calling.

The report was then adopted.

Sir James Kitson, the new president, then took the chair, and in his inaugural address reviewed the scientific advances made in recent years in the manufacture of iron and steel. He pointed out that notwithstanding the prediction ten years ago of a speedy extinction of the manufacture and use of wrought iron and mild steel, there had been a revival in the demand for wrought iron, the explanation no doubt being that with the enormous expansion of the purposes to which steel was applied there had followed a multiplication of the many special purposes for which iron was needed. He referred to the success attained by the best classes of Yorkshire iron for boilers, crank axles, straight engine axles, as illustrated by the experience of the North-Eastern and the London, Brighton, and South Coast Railway Companies. After referring to the development of blast furnaces, blowing engines, cogging mills, and hydraulic charging machines, the Chairman reminded the meeting that hydraulic pressure had led to numerous labour-saving appliances. The steam hammer, he thought, appeared to have reached its fullest development. He believed that its days were numbered, and that the Titan blows which disturbed and injured a whole district would be supplanted by the silent, slow working, but irresistible press. Electrical welding was a process which now had a practical value, and the perfecting of which would afford further opportunity to the engineer, and lead to new applications of iron and steel. In conclusion, the President quoted a number of interesting statistics with regard to the iron and steel industry. In the year 1888 he stated 169,935,219 tons of coal were produced in the United Kingdom. That quantity exceeded by 6,198,219 tons the largest output of any previous year in the history of the trade. In the same year 7,898,634 tons of pig iron were produced, 2,012,794 tons of Bessemer steel ingots, 1,292,749 open-hearth steel ingots. They had, he reminded the meeting, alert and instructed competitors in every neutral market, while fiscal restrictions interfered with their trade in most continental countries, and any serious advances in the price of materials would endanger the trade. He, therefore, impressed upon the members the importance of developing their appliances and processes with care, prudence, and wisdom, when the progress would be sound and secure.—A vote of thanks was accorded the President for his paper.

Ex-Mayor Hewitt, of New York, on behalf of the American Institute of Mining, invited the Institute to hold its 1890 meeting in America.

The President next presented the Institute's Bessemer medal for the year to Mr. J. D. Ellis, of the Atlas Works, Sheffield. He stated that it was awarded to Mr. Ellis in "recognition of his developments of the Bessemer process and his dogged enterprise as a practical man." Sir Henry Bessemer also referred to Mr. Ellis's services to the steel industry.

Mr. James Riley, of Glasgow, read a paper on "Alloys of nickel and steel." He stated that the alloy could be made in any good open-hearth furnace working at a fairly good heat. No special arrangements were required for casting, the ordinary ladles and moulds being sufficient. If the charge was properly worked, nearly all the nickel would be found in the steel—almost none was lost in the slag, in that respect being widely different from charges of chrome steel. If the steel had been properly made, and was of correct composition, it would hammer and roll well, whether it contained little or much nickel. As regards the use of these metals, Mr. Riley said they were equally important to the shipbuilder and to the civil engineer. That was strongly brought out in considering the immense advantage to be derived from their use in large structures. A long discussion followed the reading of the paper. In reply to a question, Mr. Riley stated that he was not in a position to give any details as to the cost of the production of the metals he had been describing.

EXPLOSIVES.

Mr. C. Napier Hake, F.I.C., has read an important paper on the subject of explosives before the Society of Chemical Industry, Burlington House, London. Professor Dewar, F.R.S., occupied the chair. Having glanced briefly at the past history of the subject, the author pointed out that a new period might be said to have commenced with the discovery of gun cotton some forty years ago. It was eagerly taken up at the time, but was abandoned after twenty years of severe testing, during which period disasters occurred owing to imperfect knowledge of its chemical properties, and to the want of good methods of manufacture. Nitro-glycerine then appeared, and for the same reasons was also in time laid aside. The patient researches of Sir Frederick Abel as regards gun cotton, and of Mr. Alfred Nobel as regards nitro-glycerine, brought these explosives under control. The application of the principle of detonation to these explosives was the finishing touch of a great work. Mr. Hake pointed out that a dynamite cartridge one foot in length occupies only 1-24,000th part of a second in explosion. At this rate a ton of dynamite cartridges about ⅞in. in diameter, placed end to end and measuring one mile in length, would be consumed in a quarter of a second by a detonating cartridge at each end. A similar train of dynamite, if simply ignited, would occupy several minutes in its combustion. The author then referred generally to the theory of the subject, after which he entered upon its practical consideration. He pointed out that although in Major Cundill's "Dictionary of Explosives" over 400 varieties are recorded, very few of these have come into practical use. Referring to the rapid development of the trade in modern high explosives since the Explosives Act of 1875 came into force, Mr. Hake showed with what foresight the Act had been framed. The safety of those engaged in the manufacture of explosives had been distinctly promoted as well as the interests of commerce. The rapid growth of the explosives industry since 1875 was shown by reference to the annual reports compiled by Colonel Majendie, Her Majesty's Chief Inspector of Explosives, and his colleagues at the Home Office. The author concluded by stating that no country in the world could be said to possess an Explosives Act so far-reaching and so efficiently carried out as Great Britain. Nor could any country boast of such a high standard of manufacture as regards the purity, safety, and strength of its explosives.

A NEW COMPOUND STEAM PRESS.

A compound steam forging press has been patented by Messrs. B. and S. Massey, of Openshaw, Manchester. In the machine there are two cylinders placed one above the other, the lower piston having a piston rod working through the upper one; steam is admitted direct from the boiler into the cylinder, and the valves are so arranged that the pistons can be worked either together or separately. Thus, for light work one cylinder can be used without the other, or whilst one piston closes a pair of dies the other piston can drive a punch through the article which is held fast in the dies. They have just completed the first of these steam forging presses for their own use at the works, and with steam at 60lb. to the square inch the press exerts a pressure of 100 tons. The cost of these machines is very moderate as compared with hydraulic presses; there is an entire saving of engines, shafting, pumps, and hydraulic tubing, all that is needed being a pipe direct from the boiler. As only as much steam is used as is needed to move the tools the required distance, the cost of working is very little, and there is neither vibration nor noise in working, and no foundation is required. Several specimens of forging produced by this machine have been sent to the Paris Exhibition. Amongst these are the standards and base plates for a steam hammer entirely in steel and flanged in the most perfect manner, there being no welding, and the whole operation being done in a few seconds. The base plate had also a round hole to receive the anvil block, which had been pressed through as truly cylindrical as if bored out by a machine.

McDOUGALL'S PATENT MECHANICAL STOKER.

CONSTRUCTED BY THE CHADDERTON IRONWORKS COMPANY, LIMITED, CHADDERTON, NEAR MANCHESTER.

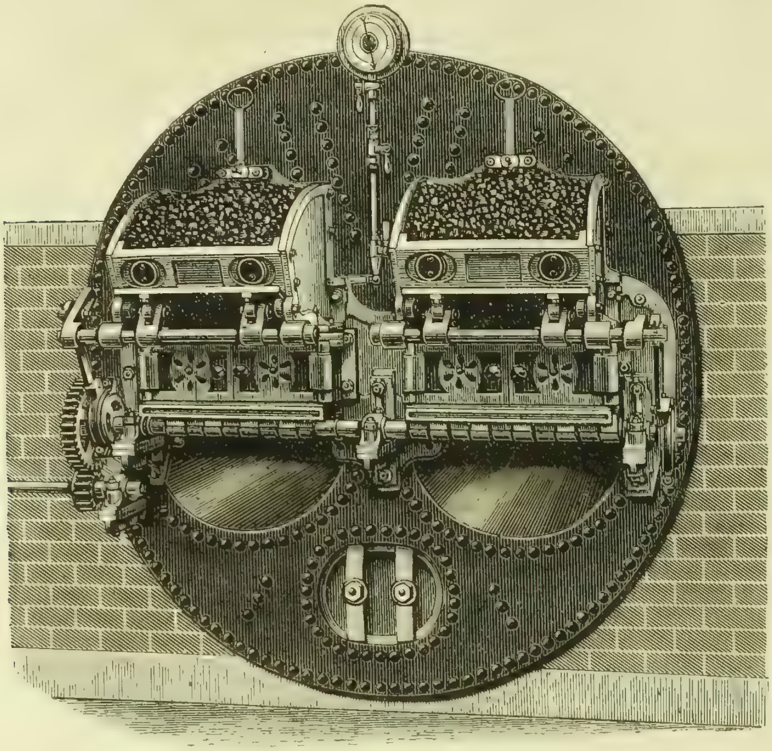


Fig. 1.

We now illustrate the second and third types of mechanical stoker of Mr. McDougall's invention, constructed by the Chadderton Ironworks Company, Limited, and referred to in a recent issue. In some circumstances it is found advantageous to use the arrangement shown in fig. 1, especially where the load upon the engine is fairly constant, and therefore the steam consumption moderately uniform, or when the coal used is of a hard nature and does not form soft or sticky clinker on the surface of the grate. It is cheaper than that described by us recently, but still it answers admirably under these circumstances, both as regards economy of fuel and the prevention of smoke. We are informed that it has been at work for many years, and many users consider it perfectly satisfactory for their special requirements. When soft bituminous coal is used, and where the boiler is called to meet sudden and heavy demands for steam, the more expensive type is desirable.

The coal is not fed on to the grate by a horizontal ram, but is introduced to the coking plate by means of an inclined step, while the firebars, instead of being moved on the level and actuated by cams, are driven from an eccentric shaft, which gives, in addition to a reciprocating motion, a rising and falling one. This causes the clinkers to be prevented from adhering to the bars, and carries the coal steadily forward along the grate to deliver the ashes and clinkers at the bottom of the flue precisely as in the first type.

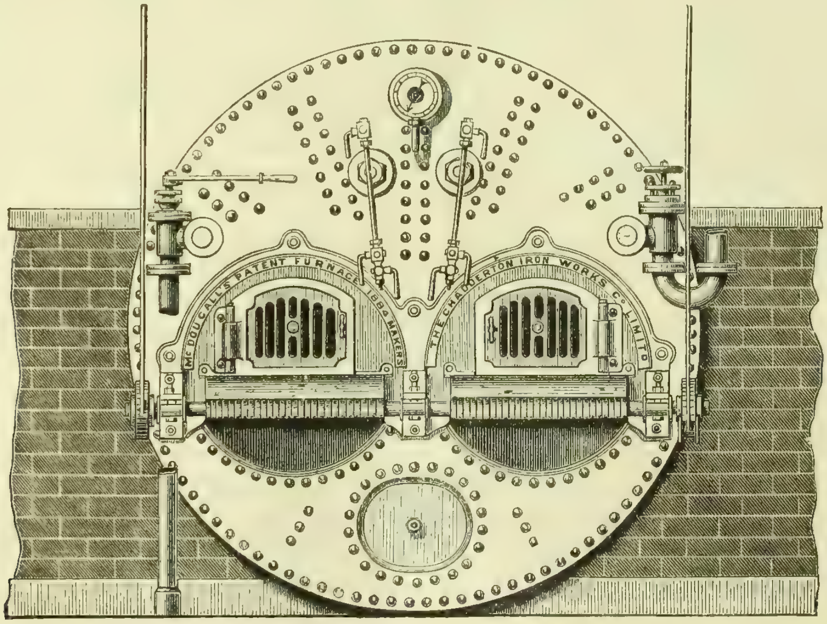

McDOUGALL'S PATENT FURNACE 1884 MAKERS
THE CHADDERTON IRON WORKS Co LIMITED

Fig. 2.

In this case also the arrangements are such that hand firing can be resorted to if necessary.

Figs. 2 and 3 illustrate a very cheap and simple form of hand-

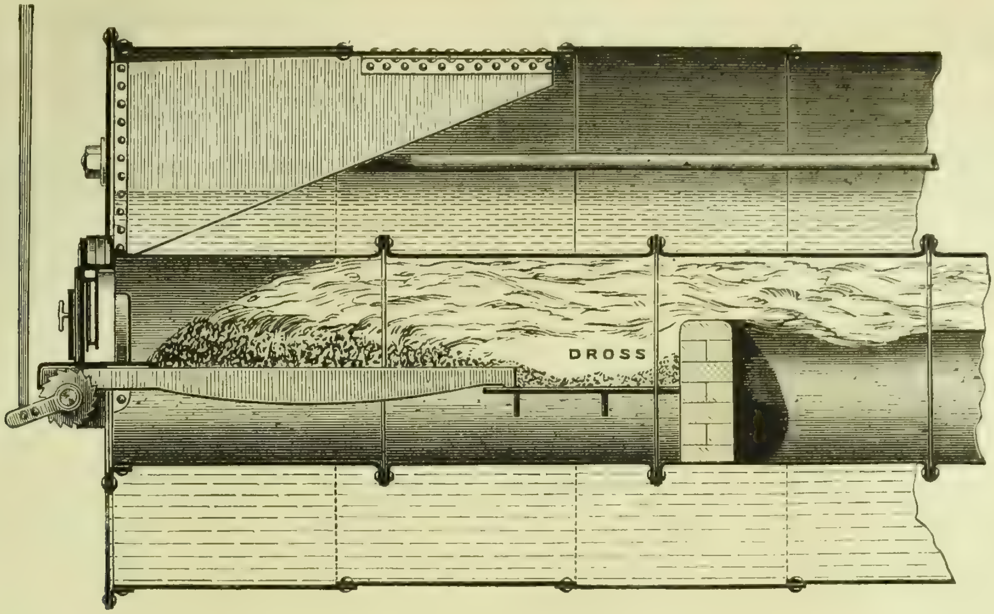


FIG. 3.

firing arrangement with continuous moving bars of simple and efficient construction, which cause a uniform consumption of fuel and secure the absence of smoke. It has been designed specially to meet cases where sudden and heavy demands for steam are made upon the boiler, and where it may be inconvenient to apply a more complete and costly stoker. The motion of the bars is obtained by a series of eccentrics working on a shaft placed beneath the front of the firegrate and moving in jaws provided in the ends of the firebars. By this means, a continuous and even motion is imparted to the bars, while the eccentrics are so arranged that each bar moves in an opposite direction to that immediately adjacent, and prevents adhesion of clinker or burning. The air spaces are thereby kept clear and effective to insure a proper air supply and complete combustion of the fuel. Behind the firegrate and on the same level a combustion chamber is provided, where an excess of incandescent fuel may be placed during work, or when the clinkers are being removed to secure the complete combustion of the gases when in work, and facilitate the restarting of the fires after cleaning. This method is a satisfactory solution of the problem of preventing smoke, and securing the advantages of mechanically moved firebars at but a small cost above the ordinary firebars. We do not doubt but that steam users may now find means to supply any special want in these three mechanical stokers of Mr. McDougall's.

THE PUMPING MACHINERY ON THE CITY OF PARIS.

WHILE the City of Paris embodies in its construction many novel features and some departures from previous marine practice, none has attracted more general attention in England than the fact that she and her sister ship, the City of New York, are both fitted out completely with the well-known Worthington duplex pumps.

In all English practice hitherto the boiler feed pumps have been a part of the main engine, and worked from levers connected directly therewith. Their action has been more or less unsteady, and the strain brought upon the pumps directly, and to some extent upon the engine, has been such as to bring about at times results more or less disastrous.

So long ago as 1884, when the America, constructed by the builders of the Paris and New York, Messrs. Thompson, of Clyde Bank, Glasgow, and the Oregon, built by the well-known firm of John Elder and Co., of Glasgow, both left New York on the same day, much interest was developed in the trial of speed which all initiated knew would follow. The Oregon made Fastnet Light first, beating the time of the America by only five hours; but the America lost twelve hours by the breaking of one of her pumps, which occurred by the racing of the engine. This is liable to occur on any steamer and all steamers where the pumps are a part of the engine.

The City of Paris, as well as the City of New York, and also the City of Berlin, are equipped throughout with Worthington pumps, and the main boiler feed pumps on each of them are independent of the main engines. As each of these ships are furnished with triple-expansion engines, and carry a constant boiler pressure of from 150lb. to 160lb. to the square inch, and in the case of the two former ships develop upwards of 20,000 indicated horse power, the boilers are large, and it becomes a necessity to reheat the feed water to a temperature of from 275 deg. to 320 deg. Fah. This is accomplished by taking the water first from the hot well to a closed heater, in which a live steam jet is introduced directly from the boilers, and the water reheated. Thence it is pumped directly to the boilers. Both pumps are controlled by a device which regulates their speed to the available supply of water in the hot well, which is not at all times constant.

The quiet, uniform motion of the Worthington pumps can be appreciated perhaps better in this service than in almost any other in which they have been placed. The reports of the engineers of the City of Paris are that in the rough weather incident to her first stormy voyage across the Atlantic, when at times it became necessary to slow down the main engines on account of racing, the pumps named kept on the uniform tenour of their way, and required little or no attention at the hands of the engineering staff. This fact was appreciated at the time, and will be appreciated by all engineers who have passed any time in the engine-room of an Atlantic liner.

There are sixteen Worthington pumps on the City of Paris, the same number on the City of New York, and nine on the City of Berlin.

The White Star steamers Teutonic and Majestic are both equipped with Worthington pumps.

HEALTHY DWELLINGS.

A PAPER was read on this subject by Mr. J. S. Pickering, Stud. Inst.C.E., before the meeting of the Birmingham students of the Institution of Civil Engineers.

The principal questions affecting the health of our homes might be summarised as follows: Aspect, site, design, ventilation, drainage, and disposal of refuse matters. The author spoke of damp foundations, and said that these might be avoided at small cost by laying down an impervious bed where damp soils existed. The chief aims in arranging a dwelling should be to secure a sufficiency of open space round the building, ample accommodation according to circumstances so as to avoid overcrowding, direct light, thorough ventilation, and a supply of pure air unaccompanied by draughts.

Referring to artificial ventilation, he said that this received little attention except in superior dwellings, where health and comfort were primary considerations. The nearest approach to efficient ventilation, which was within the reach of every householder, was by the introduction of inlets diffusing pure air at various points in the room, in such positions as to avoid draughts, and an exhaust ventilator from near the ceiling, communicating with the outer air through the chimney flue.

The question of the disposal of refuse was fully gone into, and then the author discussed the subject of drainage, and showed one or two simple experiments by which the efficiency of the drains might be tested.

In conclusion, Mr. Pickering, referring to the sanitary requirements of dwellings, maintained the advisability of having skilled advice in all sanitary matters. The rudiments of sanitary science should be understood by every householder, but the practice of an amateur sanitary engineer was as dangerous as that of an unskilled physician.

ALUMINIUM.

On Friday of last week, Sir Henry Roscoe gave an address on the above subject at the Royal Institution of Great Britain. He pointed out that whereas aluminium was formerly merely a chemical toy, and was bought, half a century ago, at its own weight in gold, recent improvements admitted of its being sold at a price which enabled it to be in daily use. He described the Castner process carried on by the Aluminium Co., Limited, at Oldbury, &c., who were now manufacturing 100,000lb. per year, being ten times the output a few years ago. Its uses were many, and he showed specimens, produced in the form of foil, tubes, wire, rod, and domestic vessels. It bore either a bright or dull surface, and was also used in the manufacture of "silver braid." It did not, like silver, tarnish in the presence of sulphurated hydrogen. Its main use, however, was as an alloy of about 10 per cent combined with copper and iron, in which it had most important effects. In this connection we may mention that Mr. Cochrane, in his presidential address at the Institute of Mechanical Engineers last week, said that the presence of one part of aluminium in 800 parts of steel appears, on the authority of Admiral Kolokoltzoff, the director of the gun factory at St. Petersburgh, to set the steel entirely free from air bubbles, as the simple outcome of lowering its melting point. In the preparation of the celebrated Mitis castings Mr. Nordenfelt appears in like manner, by the employment of 1-200th to 1-700th part of aluminium, to have succeeded in lowering the melting point of nearly pure iron, so as to enable it to be run into moulds.

THE EDISON SEPARATOR FOR MAGNETIC ORES.

Mr. Edison has recently completed his separator for magnetic ores, the motion of which is continuous, and for a description we are indebted to our American contemporary the *Electrical Review*, of New York.

The ore, which is first roughly broken, is carried up by means of a Persian wheel to a platform, on which the crushing machinery is placed. The crushers work continuously and reduce the veinstone and ore to a fine powder; thence it falls into a revolving sieve through which the powder passes; the solid particles are carried down the sieve to the cups of a second Persian wheel, which raises them up to the separator. This consists of a box in the form of a V, of which the bottom can be opened and regulated at will to allow of variation in the outlet. Below, and a little beyond the vertical centre line of the separator, are placed two electro-magnets in positions alterable according to circumstances. These magnets are actuated by means of a small dynamo. The mixture of vein-stone and ore carried through the separator in falling passes the magnets, which attract the magnetic particles to one side, while the other particles fall perpendicularly. A partition placed on the receiving platform separates the two streams of products and allows of their being collected. The second magnet, being placed behind the first, prolongs the attraction, and thus tends to secure complete separation of the veinstone and the ore. Therefore the apparatus works continuously, and the use of Persian wheels makes it automatic. It treats very large quantities of ore at small expense, and furnishes a very pure product for the melting furnaces, or for the mixtures in the puddling furnaces.

The trial trip of the steamer Alford, which has been built and engined by Messrs. Hall, Russell, and Co., Aberdeen, for the Adam Steamship Co., Limited, there, took place on Thursday, May 9th, with 2,760 tons on board. The measured mile was run over four times, and a mean speed of over 10 knots an hour obtained, the machinery working with the greatest smoothness, and steam at 160lb. easily kept up. She left the bar the same day for Alexandria.

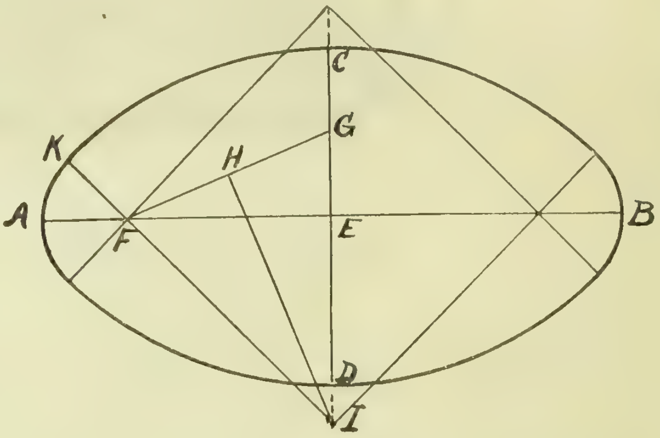
CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

MARKING OFF MANHOLES.

To the Editor of "The Practical Engineer."

Sir,—In your issue of April 19th I observe some useful rules for the construction of ovals. May I remind you of the following method? The major and minor axes being given, to construct thereon an oval consisting of arcs of circles. Let AB, CD be the major and minor axes intersecting in point E.



In AB take a point F so that AF is less than CE. The bluntness or acuteness of the ends of the oval will depend on the greatness or smallness of AF; but if AF = CE, the sides of the oval would become straight lines, and if AF be taken greater than CE, the sides will be concave.

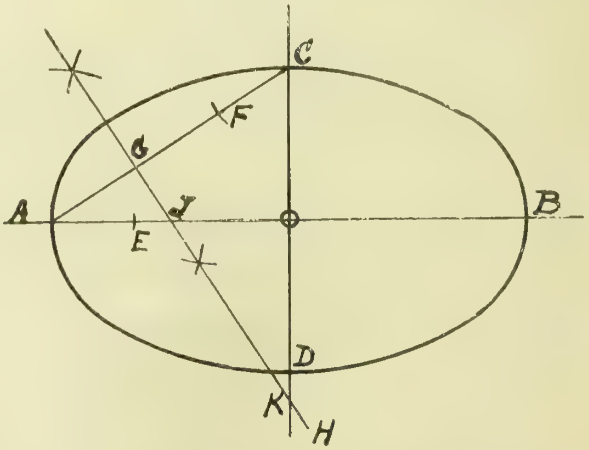
In CE take a point G, so that CG = AF. Join FG. Bisect FG in H. From H draw HI perpendicular to FG, and cutting CD or CD produced in I. Then I will be the centre of the arc to pass through C, and F the centre of arc to pass through A. The centres for the remaining arcs can now be readily found.

To find the points where the arcs meet, draw lines through the major and minor centres, as I, F, K, &c.—Yours,

Portsmouth. Fantôme.

To the Editor of "The Practical Engineer."

Sir,—I think your very interesting article on marking off manholes, &c., was hardly complete, as you did not give any means for constructing an ellipse when the sizes were predetermined. The following, which I have never seen in print, will be found to make a fairly approximate ellipse, and is easily remembered when once drawn down. To construct an approximate ellipse when length and breadth are given, let AB and CD be the major and minor axes, intersecting each other at O. Join AC. Mark off OE = to OC. Mark off CF = AE. Bisect AF at point G. Through point G draw the line GH at right angles to AF, cutting the two axes at the points J and K. These points, J and K, will be the centres for ellipse. Then from centre J, with radius JA, describe part of circle, and with K as centre, with radius KC, describe part of circle. I trust this will be of use to a number of readers.—Yours, &c.



Glasgow. A. M.

STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

SIR,—The very pertinent remarks of "Inquirer" in your last week's issue as to the strength of flue tubes opens up a question which has, I suppose, exercised the minds of mechanical engineers more or less since Cornish and Lancashire boilers first came into use; and although the matter has been much discussed and much written upon, it is still in such an undetermined state that no two formulæ by different authorities can be found that do not give widely divergent results the one from the other, and every engineer has hitherto had to work from comparisons and his own experience. Such a discussion as "Inquirer" suggests will admit of a comparing of notes, and will, no doubt, in this way prove beneficial; but it would appear that no definite rule can possibly be formed without a series of experiments properly conducted.

The only point upon which there appears to be practical unanimity is as to the effect of the thickness of plates, it being pretty generally conceded that the strength of tube varies as the square of the thickness of plate. Most authorities also agree that the strength is inversely as the diameter; but Mr. D. K. Clark, in the paper published by you some time back, asserts that theoretically the resistance to collapse is inversely as the square of the diameter, and, from the cases of actual collapse which he has tabulated, he deduces that the strength varies inversely as the 1·75 power of the diameter. The effect of the length of the tube appears, however, to be the great point of difficulty. Fairbairn assumed that the strength of the tube varied inversely as the length, but in this his rule is evidently incorrect, as it gives for short tubes much higher pressures than have been found safe in actual practice.

The only experiments hitherto made or published are those by Fairbairn and those by the Board of Trade.

The latter were made with short tubes only, and the Board of Trade rule is, I believe, expressly stated to be inapplicable to tubes of greater length than 9ft. or 10ft. From observations of a considerable number of cases, Fairbairn's rule appears to give a fair and safe load for long tubes, say 28ft. to 30ft. long, with 3 for a factor of safety. Assuming this and the Board of Trade rule to be reliable for long and short tubes respectively, and taking these data as a basis, a rule may be devised for the strength of tubes of intermediate lengths. Fairbairn's rule is the best known, and is probably the simplest in form, and can be adapted by using a modifying factor of safety varying for different lengths of tubes. For this purpose a factor $= \sqrt{\frac{300}{L}}$ has been proposed, and appears to meet the case fairly well. Taking as an example the 33in. tube of $\frac{3}{8}$ plates referred to by "Inquirer," by this modified Fairbairn's rule the factor for a tube 30ft. long would be 3·16, and the pressure 42lb.; while for a tube 4ft. long the factor would be 8·66, and the pressure $115\frac{1}{2}$lb., as against $104\frac{1}{2}$lb. by the Board of Trade rule. It may here be remarked that the Board of Trade rule, as might be expected from a rule published and supposed to be applicable to boilers under all circumstances, certainly errs on the side of safety. As regards Mr. D. K. Clark's inference that the length of a tube, if more than 9ft., has little or no effect on the strength, and that by dividing the tube into 3ft. lengths the strength will be increased 50lb. to 60lb. only, this scarcely appears to be borne out by a comparison between his tabulated particulars and the particulars published by you in October last of the experimental collapsing, under Board of Trade supervision, of a steel tube.

This tube was 43in. diameter, of $\frac{17}{32}$in. plates, and 7ft. 9in. long, but divided by flanged seams into four lengths of about 23in. each. To collapse each of these lengths required hydraulic pressure varying from 760lb. to 840lb. per square inch. From the examples given by Mr. Clark, a tube of similar diameter (42in. inside), but of $\frac{3}{8}$in. plates and 28ft. long, and another one $30\frac{1}{4}$ft. long, collapsed while working at 45lb. Taking this 45lb., and calculating therefrom the collapsing pressure of the tube, if made of plate $\frac{17}{32}$in. thick (allowing the strength to be as the square of the thickness), and neglecting the length of the tube, gives a collapsing pressure of 90lb. only. In this case the short tube is immensely stronger than the long one, and the discrepancy can scarcely be explained by the difference between steel and iron, or the fact of one tube being under hydraulic and the other under steam pressure. It is, in fact, probable that the tubes selected by Mr. Clark did not collapse from pressure alone.

Perhaps other of your readers will give their views, and explain what courses they adopt for determining the strength of tubes.—Yours, &c.,

C. T.

CAVITIES IN SIEMENS STEEL INGOTS.

To the Editor of "The Practical Engineer."

SIR,—Allow me to thank you for your insertion of my question as to the cause of the cavities occasionally to be met with in Siemens cast-steel ingots, and also to thank "Orion" for his reply. In my opinion there are two things which account for them. When casting from a Siemens furnace, and immediately before running the metal into the moulds, it is customary to put into the ladle the requisite weight of ferro-manganese to re-carburise the molten iron. This is attended with the evolution of carbonic oxide. Now, ferro-manganese very rapidly oxidises, so that the first group of ingots cast will be harder and more impregnated with gas than those cast last.

Here, then, with "Orion," I think that the air which is carried down the central feeding pipe will combine with the gases in the steel, and thus form the cavities spoken of.

Another cause probably is, if the ingot moulds are not sufficiently warmed before casting, the contraction, which is the cause of the ordinary piping, will be so severe as to cause the piping to spread in a zigzag fashion far into the centre of the ingot.

The subject is one of great importance, and well worthy the attention of our eminent metallurgists.—Yours, &c.,

W. P.

THE SMOKE NUISANCE AND MECHANICAL STOKERS.

To the Editor of "The Practical Engineer."

SIR,—The question of the smoke nuisance is continually coming to the front in our large manufacturing towns, and the question of how to burn it has had the attention of many would-be inventors. Some few weeks ago the National Engineers' Association, No. 1 Lodge, Oldham, received an invitation from Herbert Fletcher, Esq., J.P., of Bolton, to visit his collieries and witness the burning of smoke by the mechanical stoker he has on three boilers. Accordingly a party of engineers and others, including directors and managers of private firms and spinning companies, numbering between 60 and 70 persons, visited the collieries, which are situated at Farnworth Bridge. Mr. Fletcher received us, and we entered the boiler-house, where the machines were at work. No. 1 boiler was stopped, Nos. 2 and 3 were working. They were watched minutely for an hour and a half, as was also the mode of firing, and all this time there was no smoke to be seen. Then we had the fires stirred up, so as to mix the uncoked fuel with the fire, and had one fire cleaned out, but even this only succeeded in making a very small quantity of very light-coloured smoke of about a minute's duration, which we thought was very satisfactory, especially with the quality of coal used—only the waste product from the mine.

The boilers were supplying steam to a pair of non-condensing engines, winding water from the mine up one of the shafts, and lifting three tons at a time, which was emptied in four or five seconds; then off again, repeating the operation continually. They also supplied several small pairs of pumping engines at the bottom of another mine. The chimney for these boilers is only 25 yards high.

On leaving the collieries the party were highly pleased with the performance of these mechanical stokers as smoke consumers. From here we were taken to a mill, some distance from the collieries, to inspect a split bridge in the furnaces of a boiler, for the purpose of burning their smoke, and, although this is an old idea, the performance was good. It is a pity we have not more men who are willing to spend time and money in reducing the smoke nuisance.

If you could see your way to inspect the machine on Mr. Fletcher's boilers, and see a test made for the purpose of giving the results in your valuable paper, you would benefit a great many, not only of your readers, but others. There is no doubt of it being a public question. Capitalists are getting somewhat prejudiced against the mechanical stokers on account of so many failures. What is wanted is a thoroughly reliable test, and one that may be considered impartial.

It may interest you and the readers of *The Practical Engineer* to know that the party represented a total of 1,951,000 spindles, 84 looms, 30,997 indicated horse power, and 1,768 tons of coal burned per week.

We remain yours, THE ENGINEERS.

Oldham, May 7th, 1889.

POWER OF LOCOMOTIVE ENGINES.

To the Editor of "The Practical Engineer."

SIR,—I should esteem it a great favour if Mr. James Bolas or any of your numerous subscribers would kindly explain, in a very simple manner, the following, viz.: What is the nominal H.P. and the probable indicated power of a locomotive engine, cylinders 11in. diameter and 18in. stroke, weight of engine about 18 tons, boiler pressure 120lb. per square inch, dia. of wheels 3ft., and four wheeled coupled, speed of train 18 miles per hour? I can only manage to take up on an incline of 1 in 75 about a mile in length 80 tons, not including engine, at a speed of say five miles an hour, and, when the rails are a little greasy, only just manage to get over.

Having read Mr. James Bolas's paper printed in your valuable journal several times, I find his figures on page 8 of January the 4th too complicated for me, as I am not able to work anything more than a very few simple questions in rule of three; hence the reason in writing.

Thanking you in anticipation, I am, yours, &c.

LOCOMOTIVE ENGINE-DRIVER.

Brazil, South America, 2nd April, 1889.

QUERIES AND REPLIES.

16. **SETTING CORLISS VALVES.**—Would some reader kindly inform me which is the best method of setting Corliss engine valves?—ENGINEER.

Answer.—The setting of Corliss valves is practically the same as with the ordinary slide valve, as both are worked by eccentrics. The advance of the eccentric must be such as to give the required lead to the valves when the engine is on the centres, and the length of valve rods must be adjusted to give an equal opening at each end. If the exhaust and steam valves are worked by the same eccentric, the steam valves should have sufficient cover or lap to admit of the eccentric being put forward, so as to open and close the exhaust a little before the end of the stroke. Where there are two eccentrics, the exhaust valves can, of course, be adjusted independently from the steam valves.—C. T.

23. **Light Mixing Mill.**—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—Eastern.

35. **Locomotive Driving Wheels.**—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

36. **Nut Cast on Iron Screw.**—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and ⅝in. pitch.—Subscriber.

38. **Duplex Mining Pump.**—Which is the best duplex action mining pump for use with compressed air, taking into account compactness and first cost as well as economy?—S.

39. **Separate Condenser.**—Which is the best separate condenser for use with high-pressure engines, and state advantages?—H.

40. **Barffing Cast Iron.**—Can any of your readers inform me whether cast iron which has been subjected to the process known as "Barffing" will withstand the action of a boiling solution of weak sulphuric acid? Also, can you give me the name and address of any firm where this process is carried out?—Works Manager.

41. **Hot-water Pipes.**—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft.? What book may I get on arrangement of greenhouse?—Water-heater.

44. **Resistance of Piping to Water.**—Will you kindly permit me through the medium of your paper to ask if any of your correspondents will answer the following question, viz.: In a rising main of 3in. per yard, 400 yards long, composed of 200 yards of 4in. and 200 yards of 2½in. pipes, a pump is required to force through those pipes 30 gallons of water per minute. Will the resistance offered to the pump vary, and, if so, how much in each case, if the pipes were laid in the following order—

1.—200 yards 4in. pipes next the pump.
200 ,, 2½in. ,, delivery end.
400

2.—200 yards 2½in. pipes next the pump.
200 ,, 4in. ,, delivery end.
400

3.—100 yards 4in. pipes next the pump.
100 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
100 ,, 2½in. ,, ,,
400

4.—100 yards 2½in. pipes next the pump.
200 ,, 4in. ,, the above.
100 ,, 2½in. ,, ,,
400

5.—100 yards 4in. pipes next the pump.
200 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
400

6.—If the pipes were laid alternately—one 4in. pipe and one 2½in. pipe—throughout the entire range?—Medium.

45. **Boiler Solution.**—Would some practical reader inform me as to the advantage or disadvantage of using paraffin as a boiler solution? My employer has been recommended to use one pint per week. Size of boiler, 15ft. by 4ft., fired externally; no ventilation except through manhole on top of boiler. Would any explosive gases be left behind after emptying boiler for cleaning, thereby causing danger on entering with an exposed light? I should be glad of someone's opinion of the above.—Coventry.

46. **Lining Shafting.**—Will some reader inform me the best way to put up some shafting in line with some already up; also some at right angles to it? I want to know how to line it up, and how to get the position of the plummer-blocks; they will be bolted against upright pillars.—R. D.

TO CORRESPONDENTS.

G. W. T., Manchester.—The best alloy to resist the action of strong vitriol is composed of a mixture of lead and antimony. The makers of the pump will doubtless supply a special pump for acid when requested to do so, having the cylinder and plunger lined with resisting alloy. Asbestos packing should be used. You can have the rams and cylinders altered no doubt.

Piston, Chester.—It is too soon to re-insert your letter on compound engines. It is difficult to get experts thoroughly acquainted with the subject, to give the public the entire benefit of their personal experience. Many details have been already published on the matters you mention.

J. T., jun., Norwich.—There is no increase in friction due to reciprocation. In ordinary engines any increase in pressure upon the crank pin at the end of the stroke is balanced by a decrease at the beginning of the stroke. As a matter of fact, apart altogether from mere theory, the friction of most rotary engines, in proportion to their power, is greatly in excess of that common to well-constructed reciprocating engines; and there is no rotary engine in the market, to our knowledge, in which the consumption of steam is not greatly in excess of that of reciprocating engines. You greatly exaggerate the friction in ordinary engines, which, with carefully designed and constructed machines, non-condensing, does not exceed five per cent of the indicated power. The question of loss of power by the crank converting rectilineal into circular motion is not one which is open to discussion. It has been settled long ago beyond dispute that there is no loss of the kind.

Fitter, London.—We are not aware of any works upon New York life which would give you the information you seek. You will find hours longer and work much harder in American engineers' works than it is here.

J. H. F., Beith.—The indicator diagrams you sent us are, we fear, misleading. You have either pressed the indicator pencil too hard upon the paper, or the piston is sticking. Take other diagrams, and see that the indicator piston is working with perfect freedom, and press very lightly on the paper. There seems to be quite sufficient cushioning, but the steam admission is late. We consider that it would be unadvisable for you to dispense with the expansion valve. However, write again, enclosing new set of diagrams.

MISCELLANEA.

There are now 32½ miles of cable tramway in Melbourne. The number of persons carried during the last half of 1888 was over 19,750,000, being an increase of 9,400,000 as compared with the returns for the same period of the previous year.

A New War Vessel.—H.M.S. Daphne, which has been built at Sheerness Dockyard, was passed out of hand on Saturday, May 11th, as completed for foreign service. She is a sloop of 1,140 tons displacement, and is fitted with machinery of 2,000 horse-power, propelling her at the rate of 14·5 knots per hour. Her armament consists of eight 5in. breechloading guns and eight machine guns. The total cost of the ship and her equipment is nearly £68,000. Orders have been received at Sheerness directing the Daphne to sail on May 23rd for service on the Pacific station.

National Association of Draughtsmen.—At a fortnightly meeting of the members of the National Association of Draughtsmen, held on the 7th inst., a paper entitled "Auxiliary Steam Fittings on Steamships" was read by a well-known engineering draughtsman on the Tyne. The reader, after describing the several modes of construction of winch boilers, winches, valves, &c., went on to show what was, in his opinion, the best way of fitting the steam pipes, conveying steam from the boiler to the winches. A discussion took place on the paper, and the meeting terminated after a hearty vote of thanks had been accorded the lecturer. The subject of the next paper to be read will be "How to approximate to the weight of material in an iron vessel."

A Great Establishment.—The latest statistics of Krupp's establishment are supplied in a book just published at Essen. In 1833 it had nine workmen; in 1848, 74. In July, 1888, it employed 20,960, of whom 13,626 were at Essen, and, including the families of the workmen, it supported a population of 73,769 souls, of whom 24,193 lived in the houses it provides. There are at Essen 1,195 furnaces of various constructions, 286 boilers, 92 steam hammers of from 100 to 50,000 kilogs., 370 steam engines with a total of 27,000 horse power, 1,724 different machines, and 361 cranes. Of coal and coke 2,735 tons are used daily, and eleven high furnaces of the latest constructions produce nearly 600 tons of iron per day.

The New Bridge Over the Dee.—The new railway bridge over the Dee which her Majesty is to declare open on the 22nd August, was successfully rotated by hand power for the first time on Saturday, in the presence of Sir Edward Watkin (Chairman of the Manchester, Sheffield, and Lincolnshire Railway Company), the engineer (Mr. Francis Fox), and the contractors (Messrs. John Cockrane and Sons). The structure, which is said to be the largest swinging bridge in the world, the next largest being at Leith with a span of 120ft., has a swinging girder of 287ft. in length, height 16ft., and clear width of open span 140ft, with two fixed spans of 120ft. each. The bridge will form the connecting link between the Manchester, Sheffield, and Lincolnshire and the Great Northern Railway systems and North Wales.

Electric Lighting in Newcastle.—The Newcastle-upon-Tyne Electric Supply Company, Limited, expect to be able to light interiors by the time of the British Association's meeting in Newcastle in September this year. They have secured a suitable sight for their works, on some ground between the Cinder Path and the railway lines of the Blyth and Tyne station, and the contract being let, the work of constructing the machine sheds will be commenced this week. They will, at the same time, proceed with the laying of wires (which will be all underground), so that there may be no loss of time when they are ready to connect and supply a current from the new works. The Company are about to issue a statement of the charges they intend to make for the light. From this statement it appears that a householder who uses five lights, burnt continuously, will do so at a cost of £4 10s. 3d. per annum. Ten lights, burnt continuously, will cost him £8 6s. 2d. This, they claim, is only 25 per cent dearer than gas, while they hope ultimately to make the electric light as cheap to users as gas now is.

An Engine Room Telegraph.—An electric engine room telegraph of a successful kind has been invented by Mr. J. B. Wallis, and introduced on a number of H.M.'s ships—Camperdown, Rodney, and others. The apparatus consists of a dial with a hand, which is moved to the points on the dial representing the orders to be transmitted to the engine room. This dial stands on the bridge, and is under the control of the officer on duty. The movement of the handle by him rings an electric bell in the engine room to call the engineer's attention to another similar dial which is provided for him, on which he reads the order transmitted to him. By an ingenious arrangement the engineer signals back that he has understood the order correctly, and the officer acknowledges the message by again ringing the bell. A similar apparatus has also been devised by Mr. Wallis for telegraphing from and to the engine-room the number of revolutions which the screw is making a minute, an indication of the speed useful in evolutions at sea. The same principle has further been applied by the inventor to the construction of a steering telegraph, by which the commander can direct the man at the wheel.

New Forge on Tyneside.—A new forge has been commenced at Wallsend as a branch of the Darlington Forge Company's works. It will chiefly produce marine work, crank shaftings, locomotive axles, &c., but other iron and steel forgings are made up to a large size. There is a large double-acting 8-ton steam hammer, fitted with two steam cranes and other needful appliances ; as well as a 5-ton and a 3-ton hammer, each fitted with steam cranes. The ingots for steel forgings will be supplied from the steel foundry at the Darlington Forge. The Wallsend Forge is under the superintendence of Mr. Putnam.

Compressed Air for Power Hammer.—The Eames Vacuum Brake Company, in their new forge shops at Watertown, run their hammers entirely by compressed air. The air is compressed by water power. It is said that they find not only economy, but greater efficiency, in the use of air for this purpose than with steam. The air pressure is kept at about 80lb. to the square inch, but if any specially heavy work is required it is quickly brought up to 100lb. The action is very quick and sharp, as the free exhaust causes no back pressure, and they are enabled to do with their largest hammer (10in. by 28in.) work that would require a larger steam hammer, using steam at the customary pressure. The compressor is placed in a separate building near the water-wheel. A reservoir is placed near the compressor to take the water of condensation, and another one is connected overhead with the hammers in the forge shop. Compressed air is also used for various purposes in the machine shop of the company. By the use of this compressed air in the hammer all trouble from condensation, which must be present to some degree with steam hammers, is avoided, and the shops are kept cooler without the heat radiated from the steam boiler, pipes, and cylinders.

Mason College Engineering Society, Birmingham.—A general meeting of this society was held on Wednesday, Mr. Richardson in the chair. Messrs. R. Pierce and G. L. Till were elected members. Mr. T. Arnall read a paper on "The Birmingham Tramways—Past, Present, and Probable Future." He described the permanent way and means of locomotion in each division—namely, horse, steam, and cable and electrical, which he ventured to think would be the means employed in the future. Of the last he said that for Birmingham at least the system of overhead conductors was impracticable. The underground conductor was more practicable ; but, on the whole, he considered that the secondary battery or accumulator system was the best, the primary battery at present being far too expensive. Mr. Arnall afterwards gave a table showing the expenditure per mile with steam locomotives and with horse traction. There was a long discussion, after which the sub-committee appointed to report on the three proposed routes for the summer excursion (Paris, South Wales, and Lancashire) presented their report, and ultimately a resolution agreeing to go to Lancashire and leaving arrangements to be made by the sub-committee was unanimously carried.

More Roburite Trials.—According to a contemporary, a party of about 25 gentlemen, including several connected with mining, proceeded to Glen Osmond on Tuesday to witness some trials of the new explosive roburite. The Gilles Glen Osmond silver mine was first visited, and the experiments here were chiefly directed to proving the absence of after fumes. The reports here were loud, and accompanied by smoke ; but there was nothing in the fumes that the most fastidious could take exception to. And when the lookers-on came to examine the power of the shot fired it was confessed that it had done its work admirably. Visits later on were paid to Target Gully and to the Glen Osmond quarry, at which latter place experiments were made to fully test the power of roburite. In one case a shot was fired, and on an examination being made it was found that the face of the stone had been cracked from end to end. To test the power of roburite Mr. Stokes placed a charge on a piece of railway metal. The result of the explosion was that the metal was broken into fragments. On measuring the rocks displaced and thrown down by the three charges of roburite on the high level quarry, it was found that rather over 90 tons of rocks were dislodged and rendered workable.

Removal of Aerial Electric Wires in New York.—We hear from New York that the work of removing the aerial telegraph, telephone, and electric supply lines in that city, with a view to forcing the electrical supply companies to use the subway system in such streets as contain it, has been vigorously prosecuted during the past week. An attempt on the part of the Western Union Telegraph Company to obtain an injunction in the federal courts having failed, the city authorities put a large force of men at work to cut and remove the wires and lower the poles. Unfortunately the work has been marred by casualties, one instant death and several injuries resulting. One lineman, who had climbed a pole, narrowly escaped with his life, as the rotten wood gave way, and the pole, unbraced by the usual telegraph lines, fell. It fortunately struck against a building, so that the operative was afforded a chance of escape, which he was quick to profit by. This accident showed that the poles were a distinct source of danger, as they became more and more decayed. A very impressive feature of the operations is the comparative darkness to which the city in these parts is delegated at night. The gaslamps are quite unable to supply sufficient light for the people, who have now been accustomed to electric illumination.

ILLUSTRATED PATENTS.

17,218. Vapour Burners, R. Wallwork and A. C. Wells, Manchester.

The oil is forced by a pump *b* into the reservoir *a*, whence it ascends the tube *e*. The supply to the burner tubes is controlled by the screw valve e^6, and solid impurities in the oil are intercepted by small gauze-covered openings in e^7. To permit of the burner being swivelled round to correspond with the direction of the wind, the pipe *f* is free to rotate in the stuffing-box e^1. The oil ascending the tube *f* traverses the tube f^2, f^3 to the casting f^4, into which screws the burner *g*, having apertures g^1 smaller than the burner aperture, so that any solids passing through the holes g^1 will readily escape from the burner *g*. The latter is protected by a hinged cover i^4, which is open below to admit air to the flame. A second cover i^1 protecting the tubes *f*, f^2, f^3 is hinged at i^2 to permit of its being turned back. The burner may be automatically turned in the direction of the wind by a vane carried from the casting f^2. The burner may be started by detaching the tube *f* and heating it, or by placing over it a tube containing fibrous materials saturated with oil. When ignited, this flame heats the tubes *f*, f^3 and generates vapour, which may be ignited as it issues from the burner *g*. A small aperture *g*x in the casting f^4 forms a pilot jet, which relights the main flame in the event of its accidental extinction. The main flame projects beyond the conical combustion chamber *h* and continues the evaporation in tubes *f*, f^3. Telescopic oil tubes may be used. To adapt the lamp to signalling purposes, the tubes *f*, f^3 are enclosed in a cylinder having a longitudinal slit normally situated beneath a hood covering the tubes. By means of a handle the cylinder can be oscillated so as to expose the flame laterally for signalling. Stops limit the motion of the cylinder, which, on releasing the handle, is restored to its normal position by a weight. A modification of this part of the invention is described.—December 14, 1887. [1s. 2d.]

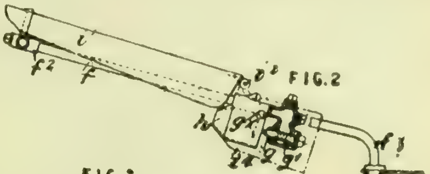


FIG. 2

FIG. 3

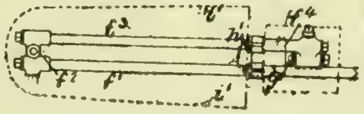
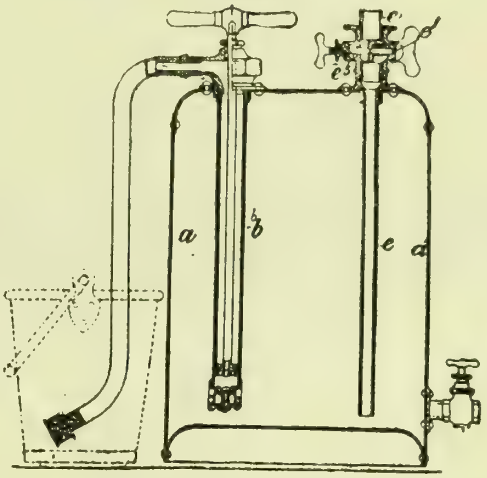


FIG. 14.



17,313. Governing Gas Engines, R. Wallwork, Manchester, and T. Sturgeon, Ilkley, Yorkshire.

The gas valve is actuated by a tappet lever worked from the slide through a stepped contact piece reciprocated by a cam, the tappet failing to depress the gas valve when the speed is excessive. In fig. 1 the cam Q slides the contact piece M over the top of the gas valve stem G, and when the speed is normal the thick part of the contact piece is directly under the tappet E at the time the latter is being depressed by the action of the projection B on the inclined lever C. When the speed is excessive the tappet E descends before the contact piece has re

FIG. 1.

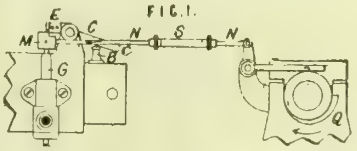
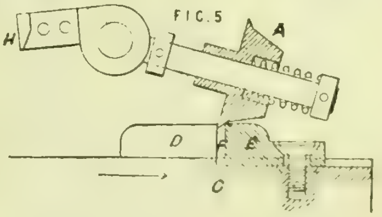


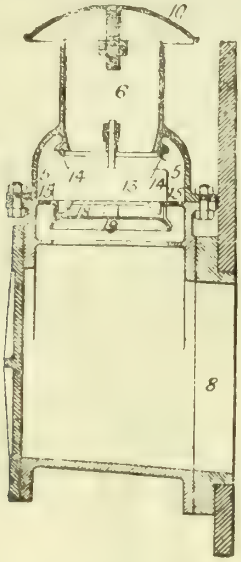
FIG. 5



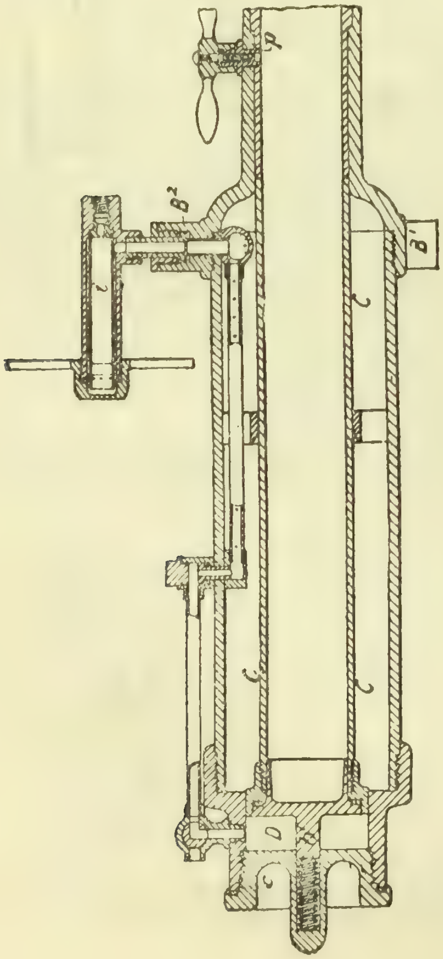
covered its position beneath it. The rod N may be adjusted in length by the coupling screw S for regulating the speed of the engine. Instead of the projection B the arrangement shown in fig. 5 may be used. A notch F adjustable in width and formed by projections D and E on the slide valve receives, when the slide is moving in the direction of the arrow, the sharp edge of the sliding block A on the inclined tappet lever, and by carrying it also to the right causes the lever to rise and the tappet H to be depressed. The projection E is slightly higher than the projection D, and when the speed is excessive the notch fails to catch the edge of the block A.—December 17, 1887. [8½d.]

17,421. Ships' Ventilators, J. Broadfoot, Glasgow.

To prevent the entrance of water at the air ports in the vessel's sides, ventilators with automatic valves are employed. A vertical section of one is shown. A casing 7 is bolted on the side round the air port 8, having at its upper part a diaphragm 15 surmounted by a second casing 5 provided with an adjustable hood 10. In the diaphragm, which is perforated, is a large central opening protected by a baffle plate 19. On the diaphragm rests a float 13, which, on entrance of water at the port 8, is lifted against an indiarubber ring 14, by which means the shaft 6 is closed and the entrance of water prevented.—December 19, 1887. [8½d.]



7,252. Pneumatic Ordnance, H. S. Maxim, London.



Consists in using compressed air charged with volatile petroleum or other combustible gas, instead of only compressed air. When the projectile has passed a certain distance down the gun, the compressed gas forces in the hammer of a percussion primer, thereby exploding the mixture of air and gas. A horizontal section of a suitable gun is shown in the figure. The gun is carried on trunnions B, B^1, through one of which the compressed air enters, passing on its way through the petroleum vessel *i*. The compressed air and gas enters the annular space round the tube C, and also enters the chamber D. Upon the chamber D being connected with the outside air, the difference of pressure on the flange C^1, C^2 causes the tube C to move rearwards, and allows the charge of air and gas to enter the chamber of the gun. As soon as the projectile has passed the opening *p*, the primer *q* is fired, and the explosive mixture ignited. A modified form of inlet valve is described, also a projectile for use with the gun. December 15, 1887. [8½d.]

Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

April 29th.

7082 Lamps, J. S. Hodgson and J. Hodgson, Manchester.
7084 Rolling Metals, J. Guest, Birmingham.*
7085 Steam Engine, G. B. Harkes and J. Harkes, London.
7088 Electric Measuring Instruments, R. Snowdon, Chesterfield.
7092 Gas Lighting, J. Byrom, Liverpool.
7095 Screwing Die, J. Wotherspoon, Glasgow.
7096 Welding Flanges, J. Wotherspoon, Glasgow.
7104 Couplings, P. Torissen, London.
7105 Printing Presses, J. G. Lorrain, London. (F. A. Bazin, France.)
7106 Motive Power, F. W. Cleveland and L. Dove, London.
7107 Rock Drills, A. Chapman, Limehouse.
7111 Pyrometers, H. Walker, Birmingham.
7127 Electric Railways, G. E. Vaughan, London. (S. Trott, Nova Scotia.)
7129 Arc Lamps, A. J. Howes, London.*
7142 Steering Wheels, C. H. M. Dörnte, London.
7143 Steam Turbines, Gustav de Laval, London.

April 30th.

7152 Generating Heat, H. J. Allison, London. (A. G. N. Vermilya, United States.)*
7168 Coupling, W. Ackroyd and A. Barraclough, Heckmondwike.
7169 Propellers, G. Chapman, Glasgow.
7170 Bending Iron, J. Wotherspoon, Glasgow.
7182 Lifting Jack, A. Warren, London.*
7190 Lifting Jacks, A. Jackson, London. (O. Jackson, United States.)
7196 Holding Together the Ends of Rails, S. Pitt, London. (G. A. Weber, United States.)*
7212 Rail Joints, E. M. Cooke, London.
7215 Batteries, C. B. Askew and J. K. Pumpelly, London.*

May 1st.

7227 Charging Machines, J. Elliott, Birmingham.
7228 Water Gauge, F. G. G. Dietze, Newcastle-on-Tyne.
7233 Gas Meters, T. Thorp, Whitefield, and T. G. Marsh, Lytham.
7234 Photographic Cameras, J. A. Morley, London.
7243 Rectilineal Engines, J. Hewitt, Newton.
7246 Motor, O. Burn, London.
7254 Warming Apparatus Boiler, T. W. Harrison, Birmingham.
7257 Counting Apparatus, J. S. Howden, Liverpool.
7262 Flywheels, O. Imray, London. (R. Mannesmann, Germany.)
7264 Steam Engines, C, Wells, Middlesex.
7266 Compressed Fuel, W. Hubbard, London.
7267 Refrigerating Machines, R. P. Pictet, London.
7272 Wrenches, A. M. Clark, London. (S. Cook, United States.)
7277 Sewing Machines, B. Drinkwater, London.
7278 Rapid-firing Guns, T. Nordenfelt, London.

May 2nd.

7291 Overhead Railways, W. Banning, Birmingham.
7301 Slide Valves, R. Marshall, Glasgow.
7313 Corrugated Pipes, J. W. Oldroyd, London.*
7317 Screw Spanner, J. G. Plater, London.
7318 Stoves, W. Vyse, Middlesex.
7321 Valves, W. Ashworth and F. Watson, Manchester.
7327 Fire-boxes, Tangyes, Limited, and W. Walker, Middlesex.
7331 Furnace Grates, E. W. Jones, London.
7340 Tramway Cars and Engines, I. Smith, London.
7342 Driving Ropes, A. Thomson, Glasgow.
7350 Clutches, A. L. Shepard, London.

May 3rd.

7374 Evaporating Brine, S. W. Wilkinson, Manchester.
7377 Valve Gear, F. Bosshardt, London. (J. R. Frikart, France.)
7392 Coal-cutting Machines, J. Haigh, London.
7396 Steam Turbines, R. T. Bells and E. W. Quirk, Liverpool.
7399 Brakes, W. Hartley, Manchester.
7411 Lock, R. Haddan, London. (H. Ludwig, Germany.)
7421 Motor, A. Hirschberg, London.*
7433 Pumps, G. Savin, London.

May 4th.

7438 Steam Boilers, F. D. Rose, Didsbury, Lancashire.
7448 Hand Shears, F. S. Firth, Bradford, Yorkshire.
7458 Valve Gear, T. T. A. Hansen and F. E. Jeffery, Gainsborough.
7497 Lubricators, W. Dale and J. Webber, London.
7500 Ores, O. Bilharz, London.*
7506 Electric Light in Railway Trains, I. A. Timmis, Westminster.
7518 Fire Alarm, A. W. Hidden, Galata, Constantinople.*

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE PRACTICAL ENGINEER,

MAY 24TH, 1889.

PERFECT STEAM ENGINES.

IN striving after perfect action in any class of practical work, and especially in steam-engine construction, it is always well to have clearly in mind the exact conditions to which it is our wish to approach as closely as difficulties will allow; and accordingly we purpose to describe, as shortly and plainly as possible, the exact actions which would occur in a perfect steam engine, if it were possible. In doing so we shall indicate the lines now commonly accepted by our best engineers, by following which they have realised the best results to be attained in practice. Comparatively recently it would have been impossible to do this, because of widely diverging opinions upon the various points, but now practical unanimity prevails, except among crotchet-mongers and those who have not taken the trouble to sufficiently inform themselves.

First, then, we must agree upon what we mean by a perfect steam engine, as the terms perfect heat engine and perfect engine have been used in quite a variety of senses more or less remote from what is commonly understood by the phrases. It is unnecessary to concern ourselves respecting perfect heat engines in this connection, as such ideals are interesting more from a theoretical than the practical standpoint. A perfect steam engine must, of course, have a perfect boiler; but meantime we shall consider the engine first, and we may define it as an engine in which all the available power of the steam supplied to it, under the conditions of use, is utilised in propelling the piston. It does not follow that all perfect steam engines are equally economical in their yield of power for a given weight of steam supply, because the engines may be applied to very different uses, and it is the business of the engineer to understand the varying conditions, and so arrange matters that he gets the best economy possible under each set of circumstances. Thus, the steam fire engine or the direct-acting steam pump act under conditions entirely different from the stationary mill engine or the locomotive, and it would be unreasonable to expect from all the same economy; however, in some respects the same points apply to all. In a stationary engine, for instance, expanding the steam to a predetermined pressure, if perfection were possible, to begin with there would be no clearance space between the piston and the cylinder cover when the piston was at the end of its stroke, and the steam admission and discharge would be so arranged that clearance from steam ports would be avoided. There would, in fact, be no waste space within the cylinder, and the piston in its movement would sweep through the entire contents.

The reason why clearance is injurious is easily seen when we consider an engine without cushioning, in which the exhaust does not close till the end of the stroke, and where consequently the pressure in the clearance space, at the moment of opening the steam supply, is only that of the condenser. Here it is obvious steam from the boiler must first be supplied to fill the space and raise the pressure to its maximum before it can act fully upon the piston. The quantity of steam so admitted is to a great extent lost. When cushioning is resorted to, as is done in all cases in practice, this loss is neutralised to a certain extent, but it is not completely obviated. Cushioning, of course, cannot be dispensed with, because it is necessary to apply pressure to the piston as it approaches the end of its stroke, in order to gently reverse the direction of thrust upon the main bearings, crank, and crosshead pins before applying full boiler pressure. Otherwise the engine would knock by too sudden reversal of pressures, and consequent rapid taking up of the slight slack of the brasses.

An entire absence of clearance is absolutely demanded by the conditions of perfect action, and the more clearance is reduced in practice within the limits of sufficient cushioning, the more nearly are the necessities of efficiency complied with. This is a point upon which some engineers still cherish erroneous notions, and we have often heard it stated that the proportion of clearance between the piston and valves was a matter of indifference, provided the exhaust closed early enough to cushion up to the full boiler pressure. In our opinion this idea is entirely erroneous, as loss occurs in two ways: Excessive cushioning greatly diminishes the available pressure in the engine by causing considerable negative work, or work done by the piston upon the steam; and the power spent in compressing the steam to full boiler pressure is not wholly returned at the expense of the steam compressed during the expansion stroke. The first cause of loss is sufficiently obvious, but the second requires a little consideration. Steam filling a cylinder open to the condenser consists of part steam, part water, but when compressed by the piston on closing the exhaust the water is in the main deposited, and the compression line follows more closely the adiabatic common to the gaseous state than that due to the saturation curve of steam. Consequently, when compressed to full boiler pressure, the temperature is higher than that of the boiler, and an expansive loss occurs in evaporating water or in heating the entering steam. This loss is inconsiderable at low pressure; but at a pressure such as 150lb. per square inch and with cushioning, not uncommon, especially in some types of American engines, it is quite appreciable and well worth saving. If the compression curve of a volume of steam were the same as its expansion curve, or the temperature rose upon the line of saturation, then the temperature at the moment of attaining full boiler pressure could not be in excess of that of the entering steam, and no loss would be occasioned. But under existing conditions great cushioning causes considerable loss.

It is, therefore, necessary to minimise clearance to the utmost in all types of steam engines where the greatest possible economy is desired, and cushioning should be avoided as much as is consistent with smooth running. The steam should be compressed to the full boiler pressure, but the volume so treated should be as small as possible. So much, then, for clearance and cushioning; in a perfect steam engine both would be absent.

In a perfect steam engine the valves and supply steam pipes would be so proportioned to the capacity of the cylinder and the piston speed that the full boiler pressure would be permitted to act upon the piston during admission; that is, there would be no throttling, and the discharge pipes to the condenser, as well as the valve ports, would allow of complete return stroke of the piston at a pressure as low as that in the condenser. The condenser and air pump at the same time would be proportioned so that the vacuum was equal to that of the lowest intended hot-well temperature.

To some extent these conditions are in conflict with the first two, as small clearances generally mean small port area, so that the only solution of the problem satisfying the necessity of large admission and discharge area consists in very short ports and valves close to the cylinder, as in the Corliss type. Attempts have been made to improve upon Corliss clearances by admitting and discharging steam through the cylinder covers, but there are many practical difficulties, although, in view of the large port areas and small clearances obtainable in this way, we think engineers might have done more than has been done in engines with ports and valves entirely removed from the sides and placed on the cylinder covers.

These complete the constructional conditions of perfect action within the cylinder, which also include absence of leakage either at the valves or by the piston, and so far design and ingenuity have in practice accomplished a most admirable compromise. We now come to the question of condensation and re-evaporation, not so immediately under constructional control. It is obvious that if steam under pressure be admitted to a cylinder of which the enclosing walls and cover, as well as the piston, are at the same temperature as the steam, then there can be no condensation during admission, and the weight of steam present, as calculated from the indicator diagram, will coincide with the weight of water known to be passed into the cylinder at each stroke. There will be no loss due to condensation. But although condensation may be prevented during admission, yet, after the supply has been cut off and the whole work done in the cylinder is done at the expense of the heat stored up in the steam, then liquefaction must occur to supply that heat. And, as the rate of the performance of work is greater than the rate at which heat can be supplied by convection from the sides, the temperature must fall. At the end of a stroke, therefore, in which steam has commenced perfectly dry, but not superheated, the cylinder contains a mixture of steam and water. If heat could be entirely prevented from passing from the steam to the cylinder, or from the cylinder to the steam, the problem would be a comparatively simple one, and there would be no harm or loss in the mere condensation due to the performance of work. An engine in which this occurred, in addition to the more mechanical necessities, would be a perfect steam engine, and would give the highest possible power which could be given by a steam engine using the given weight of steam within the prescribed pressure limits. But as metal must be used as a material, and its temperature must change to some extent with that of its contents, the practical problem is much more complex than the ideal one, and there are still grave differences of opinion as to the changes which really take place in actual engines. It seems settled and generally accepted, however, that a considerable proportion of the steam is condensed during admission in all engines—in some as much as 50 per cent, in others as little as 20 per cent—but much more exact experiment is still wanted to entirely settle the whole changes. What is wanted, then, is some means of keeping a cylinder at full boiler temperature during the admission part of the stroke, and preventing an influx of heat and re-evaporation at the lowest pressures. It is obvious that if water be present at all it will very quickly boil down to the lowest temperature of the steam, and so reduce the cylinder temperature when the exhaust valve opens. If, for instance, in a non-condensing engine, working expansively, the pressure at the end of the stroke is 15lb. per square inch above atmosphere, the temperature of any water in the cylinder is 250 deg. F., but immediately the exhaust valve is opened the release of pressure causes it to boil almost instantaneously, and the temperature at once falls to 212 deg. F. In a condensing engine, in the same way, the temperature tends strongly to approximate to that of the condenser. It is this fact which makes the use of a steam jacket on a low-pressure cylinder of very dubious advantage, and renders it quite probable that if a steam engine could be so arranged that the cylinder temperature was kept continuously much higher than boiler temperature, and condensation be prevented altogether, greater economy still might follow. In theory it is wrong to keep up the steam temperature during expansion, but the avoidance of the great loss of heat due to re-evaporation at the lowest temperature would probably more than compensate for the theoretical loss.

The best thing to be done next to preventing change of cylinder temperature, is to keep the steam in contact for as short a time as possible, and this is the advantage of high speeds. Compound and triple-expansion engines are also supposed to favour economy by limiting the range of temperature in each cylinder, and so causing the temperature of the walls to approximate more nearly to that of the live steam.

It seems to us that further improvement may be expected in steam engines by more careful attention to the points we have indicated. First, by the further reduction of clearance, and the proportioning of steam engines to allow of the minimum surface exposed per unit weight of steam. This, we think, may be done by arranging all the valves and passages in the cylinder covers instead of on the sides. Second, arrangements to heat up the cylinder to a temperature above boiler temperature by means of waste heat from the flues or other source. If this be done, pistons would require to be made longer than at present. Third, arrangements to collect the water from steam in separate pockets, draining from the bottom of the cylinder, so that as fast as it is formed by expansion it shall drain away, and be returned to the boiler without re-evaporation.

In this way it is quite possible to obtain a more close approximation to the power actually capable of being exerted by the steam used. Compound and triple-expansion engines should have all water drained away to the boiler in the intermediate chambers, so that steam only may pass from cylinder to cylinder. The subject is a most important one, in which we doubt not there is still considerable scope for improvement in steam consumption; and we quite agree with Mr. Willan's remarks at the Institution of Mechanical Engineers lately, that even with engines of moderate power a consumption of 12lb. of steam per indicated horse power per hour is quite within the bounds of possibility. We must now conclude, but shall consider other points and the question of boilers in an early issue.

ELECTRIC LIGHTING IN LONDON.

MAJOR MARINDIN has reported to the Board of Trade upon the application made by various electric lighting companies for power to illuminate portions of London, and the document is an interesting one, evidently the result of careful consideration of the evidence brought forward. The Board of Trade acts as the guardian of public interests, and is intended to prevent the growth of unduly powerful monopolies, while allowing sufficient inducement to promote the growth of practical electric lightning. Major Marindin considers that the science of electric lighting has now reached the point at which a supply can be made, and will prove of great benefit to the public. For this reason the wishes and opinions of local authorities in the areas proposed to be supplied should not upon general grounds be considered sufficient to exclude a company, unless the local authority should express its intention to undertake the supply, and give evidence that it proposes to apply for permission to do so. He also states that provisional orders are preferable to licenses, and should be identical as to supply, interference with streets, and, more than all, as to price. This he suggests should be at the rate of 8d. per Board of Trade unit. The London Company is now supplying at 7¼d., and the maximum in the St. James's and Pall Mall Company's license is 7d., but these competitors have exceptionally good areas. There should be a reduction in the minimum price per quarter irrespective of consumption. This varies with existing companies from £3 6s. 8d. in the case of the Notting Hill Company to £5 10s. in the Metropolitan Company's South London order. A fair minimum should be adopted throughout, as those charges are far too high. One of these companies has consented to a reduction to 13s. 4d. per quarter in a portion of its area. It is suggested that prices should be regulated by a dividend of 10 per cent to the shareholders, as with gas companies. Overhead lines are to be discarded, and the companies' mains carried in subways or conduits underground.

The subject is an exceedingly complicated one, but this report, based upon a great mass of evidence from the leading electrical and scientific reports, shows that although electric lighting has passed out of the stage of excitement, yet it is steadily progressing and making a field for itself. The difficulties are great, but are being surely mastered. We do not think that gas companies should look with alarm on electric lighting progress, because for a long time to come it must remain the more expensive illuminant. But the beauty of the light and its entire purity recommend it to all within whose means it comes. The Board of Trade, we observe, propose to consider the question of conductors, insulation, and subways, and issue rules as soon as possible. There is no reason to fear the accidents which have been of frequent occurrence in America, due to gas leakages getting ignited by the electric spark due to short circuiting, as our street gas mains are more carefully laid. Explosions of this kind need not, therefore, be anticipated. It is reassuring to find that overhead wires are to be discouraged, as the lighting of any considerable portion of a city in that way would cause grave and frequent accidents.

THE WELSBACH LIGHT.

THE story of the misfortunes of the Welsbach Gaslight Co., as told to its shareholders a few days ago by the chairman and directors, is most extraordinary even for a great speculative company, and it is most difficult to comprehend how its practical affairs could be so managed as to imperil its existence just on the eve of success. Our readers will remember that the Welsbach light consists of a Bunsen burner flame, over which is placed a hood or mantle formed of very refractory material, which is highly heated by the flame and gives out light. This mantle is formed by weaving cotton to the required shape, saturating with a fluid containing salts of Zirconium and other infusible rare oxides, drying carefully and igniting so as to burn away the cotton portion of the fabric. The hood or mantle which now remains has the same shape as at first, but it now consists of fine ash only, with just sufficient adherent power to keep together. In this respect it resembles ash from paper, which may often be observed to retain its shape when all the organic matter has been consumed; but of course the hood has much more tenacity than paper ash. Still it is extremely fragile, and the whole light-giving power depends on the nature of this fragile ash; if any impurity gets into the liquid used to prepare the hood, its resisting power is very feeble and its life is very short. The hood was intended to burn 1,000 hours, giving a good light the whole time; but, just after the company commenced operations in England, by some inadvertence the fluid deteriorated, and the lamps sent out, to the number of about 700 per day, became rapidly useless. They gave a fair light for a few hours and then failed. This speedily affected the business of the company by bringing the light into discredit, while the part payments made by sub-companies abroad for foreign rights had to be returned to avoid law suits.

Mr. Macteur said that the difficulty had now been overcome, and that the lamps now sent out gave a brilliant light for over 1,000 hours, while investigation had disclosed where the fault lay, so that there was no chance of trouble again. However, the shareholders have now to face a heavy loss as the result of last year's work, with the prospect of spending much more to re-establish the light in public favour. The light is an ingenious and beautiful one, but is much too fragile and delicate, we fear, to make substantial progress towards commercial success. If some means could be devised to make the mantle more coherent, no doubt it would prove a formidable rival to the regenerative types of lamp.

THE great superiority of our English railway system, both as regards speed and comfort in travelling, has long been recognised on the continent of Europe. The German State Railway directors have now resolved to follow us a little more closely in these respects, and with the beginning of June great increase of speed will be attempted on some of the lines. But it is very clear, says the Berlin *Borsen Zeitung*, that unless the German railways improve the construction of both rails and carriages, such speed will be utterly unsafe, as well as highly uncomfortable.

HYDRAULIC MACHINERY EMPLOYED IN THE CONCENTRATION AND TRANSMISSION OF POWER.—VII.

Pipe Joints, &c.

In our last article we described the usual methods of making the joints between sliding surfaces water-tight by means of animal and vegetable packings, either in a self-acting manner or by forcible mechanical compression of the packing material by means of glands or bolts, or their equivalents. In the present article we propose to treat similarly of the various methods of making the joints between surfaces, fixed with reference to each other, water-tight. The joints between such surfaces are made either by placing between them suitable sheets or rings of canvas, lead, copper, leather, indiarubber, guttapercha, paper, and various other materials, and forcing them tightly together by means of bolts and nuts, or their mechanical equivalents; or by using U or similar self-acting packings. In designing such a joint we have principally to consider the stress which must be brought upon the metal, of the bolts and nuts, in order to ensure water-tightness under a given pressure, and the dimensions which it is advisable to give the flanges, &c., in practice, in order that they may be of adequate strength to resist the stress thus brought upon them. The stress upon the bolts, considered as a simple tensile stress, consists of two parts in general—one due solely to the hydraulic pressure on the surface exposed to it, which may be exactly calculated when the extent of that surface is known, and the pressure per unit of area to which it is subject; and another part due to the elastic reaction of the surfaces themselves and that of the joint material between them.

To make this clear, we will consider a joint such as that illustrated by fig. 34, in which B may be a valve chest, for instance, and A its cover; the joint being made by truly facing the surfaces, painting them, inserting a sheet of brown paper say between them, and then drawing them forcibly together by screwing up the nuts and bolts which pass through the flanges. If the nuts be screwed up when pressure is not admitted to the valve chest B, a complicated stress is brought upon the metal of the bolts—mainly a longitudinal tension, but complicated by torsional stress due to the inclination of the helix of the screw-thread and the friction between the thread and nut brought into play by the twisting action of the spanner, and complicated in addition by possible bending stresses due to inequality or unequal yielding of the joint surfaces and flanges. For true surfaces and faced nuts, we may, however, treat the stress in practice as a simple tension. Let L be the length of the spanner used in inches, and F the force in pounds applied at its end by the workman in screwing up; then for ordinary bolts, having Whitworth threads, the total stress in tension on the metal of the bolt may be fairly taken at an average value of

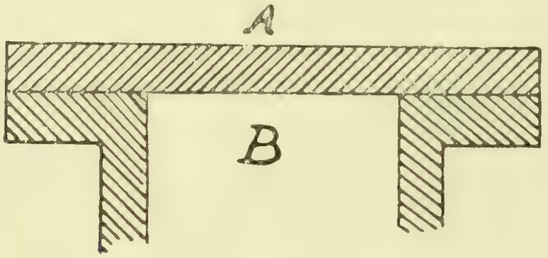


Fig. 34.

$$T = \frac{6\,FL}{d} \text{ in pounds.}$$

Where T is the whole stress on the bolt in pounds, considered as tensile, and d is the diameter of the bolt over the thread in inches, the stress on the bolt per square inch at the bottom of the thread may, of course, be found by dividing T by the area of the section at the bottom of the thread.

If now water be admitted to the valve box B, at a pressure of p pounds per square inch, and S be the surface of the cover A exposed to the pressure in square inches, the whole upward pressure on the cover A will be $p\,S$ in pounds, and this pressure may be transmitted to the bolts practically undiminished or increased, in addition to the stress T due to the screwing up, making the whole load on the bolts

$$= n\,T + p\,S = \frac{6\,FL\,n}{d} + p\,S,$$

where n is the number of bolts.

We say *may* be so transmitted advisedly, as the determination of the exact amount which will be added to the initial stress on the bolts in every particular case is highly complex, and indeed hopeless from an engineer's point of view, in very many cases depending, as it does, on the extensibility or compressibility of the various parts forming the joint. In practice we need not, however, enter into such an investigation; it is sufficient for our purpose to know that the whole load on the bolts of the joint is not likely to exceed the amount stated, viz.,

$$\frac{6\,FL\,n}{d} + p\,S;$$

so that if the effective area of the bolt section be proportioned to sustain this load safely, the error, if any, will be in general on the side of safety.

It is to be remarked that of the two parts of the expression for the whole load on the bolts, the one part—$p\,S$—is usually determinable with fair accuracy, whereas the other part—$\frac{6\,FL\,n}{d}$—can only be fixed by estimation. In fixing the value to be assigned in any particular case to this latter part, we may take a step towards a simplification of the expression by assuming that L bears a definite relation to d. For instance, let $L = m \times d$; then the load on the bolts will be—

$$6\,m\,F\,n + p\,S = \text{say W.}$$

Table I. has been calculated from this formula, assuming M = 16, and F = 50lb. for a 1in. bolt and = 100lb. for a 2in. bolt, and of proportionate values for intermediate diameters. The figures in the third column represent the maximum test load for good wrought-iron bolts, and are calculated on the basis of a maximum gross stress on the bolt, amounting at the bottom of the thread to 24,000lb. per square inch. The figures in the fourth column represent the test load, if an allowance be made for the unequal distribution of stress among the bolts corresponding to a reduction of 25 per cent in the effective strength of the joint.

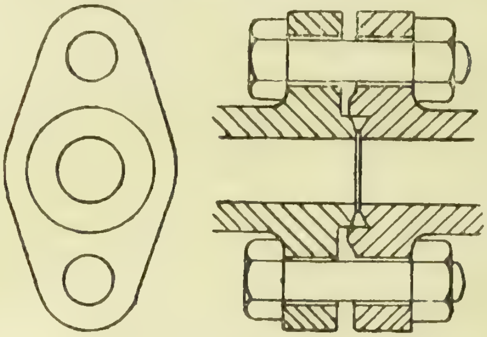


Fig. 35.

Table I.

Diameter of Bolt.	Stress due to screwing up = $6\,m\,F$	Maximum Net Test Load = $\frac{p\,S}{n}$	Net Test Load = $\frac{p\,S}{n}$	$\frac{S_1 + S}{S}$
In.	Lb.	Lb.	Lb.	
$\frac{3}{4}$	3600	3648	2736	2·31
$\frac{7}{8}$	4200	5844	4383	1·96
1	4800	8502	6376	1·75
$1\frac{1}{8}$	5400	11256	8442	1·64
$1\frac{1}{4}$	6000	15582	11686	1·51
$1\frac{3}{8}$	6600	20088	15066	1·44
$1\frac{1}{2}$	7200	24000	18000	1·4
$1\frac{3}{4}$	8400	33360	25020	1·34
2	9600	46080	34560	1·28

The test loads given in the third column may be adopted when there is a reasonable certainty of the bolts being screwed up so as each to take an equal share of the whole load; but in general it will be more judicious to limit the test load to the amount given in the fourth column.

Besides being of sufficient strength to resist the maximum load which can be brought on them in ordinary work, the bolts of a joint must also be capable of binding the joint surfaces together with sufficient force to insure its water-tightness. It is to be observed, however, in this connection, that the water-tightness of a joint does not depend wholly on its forcible compression by means of the bolts and nuts. In the case of a paint joint the adhesion of the paint to the surfaces assists in preventing the passage of water, and in the case of a properly formed gutta-percha or leather joint the internal water pressure, acting on the more or less yielding joint packing, assists in rendering the joint water-tight. The initial screwing up of the bolts must, however, put a sufficient pressure on the joint surfaces to bring into play and supplement these assistant actions. It may be taken as a good empirical rule that the pressure on the joint surfaces due to the screwing up of the bolts should be at least equal in intensity per square inch of joint surface to the hydraulic pressure under which the joint is required to be water-tight. This may be expressed symbolically in the form

$$6\,m\,F\,n \nless S_1\,P$$

if S_1 be the whole area of the joint. Hence there is a certain limiting relation between the area of the joint surface and that of the surface exposed to water pressure for each diameter of bolt. If the limiting relation be exceeded it will not be practicable for a workman, using an ordinary length of spanner and exerting an ordinary amount of pressure on the end of the spanner, to bring the surfaces together with sufficient force to ensure the water-tightness of the joint. The limiting ratio of S_1 to S is obviously, with the data assumed in Table I., equal to the number in the second column divided by the number in the fourth. The corresponding ratio of the whole surface to the outside of the joint to the surface exposed to pressure inside the joint, or $\frac{S_1 + S}{S}$, is given in column 5 of Table I.

Joints such as those illustrated by fig. 34 are, however, suitable only for low pressures. For medium and high pressures it is necessary to confine the joint material when used in grooves or recesses, in order that the internal pressure may be prevented from forcing it out, and also to take advantage of the effect of that pressure in adding to the water-tightness of the joint in the manner to which we have already alluded. The principles and data which we have exhibited above will still, however, be applicable, as will be readily understood, and may be directly applied to determine the necessary number and dimensions of the bolts.

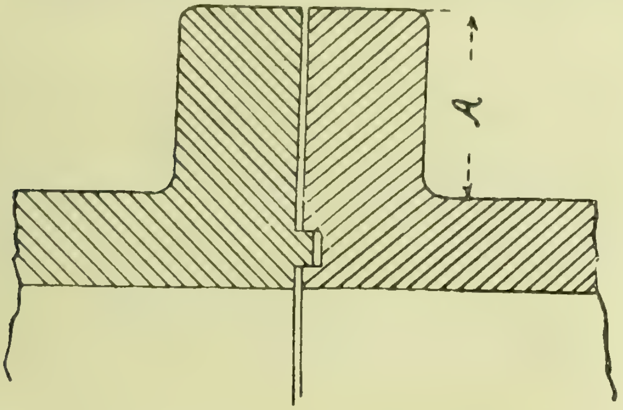


Fig. 36.

As a first illustration, we will take the well-known double-lugged Armstrong pipe joint (see fig. 35) so largely used for medium pressures of 500lb. to 800lb. per square inch.

In this joint a recess about $\frac{1}{2}$in. wide is turned in the end of one pipe and a corresponding projection on the end of the next length, which enters the recess, forming a space dovetailed in section, in which a guttapercha ring $\frac{1}{4}$in. in diameter is placed. The flanges are drawn together and the guttapercha ring compressed by means of two stout bolts passing through lugs cast on the pipes, as clearly shown in the figure. If D be the inside diameter of the pipe in inches, we have, in this case,

$$S = D\,\frac{2\pi}{4}$$

$$S + S_1 = (D + 1)\,\frac{2\pi}{4}$$

$$\text{Hence } \frac{S + S_1}{S} = \frac{(D + 1)^2}{D^2}$$

Let the test pressure of the pipes, when laid, be taken at 1,600lb. per square inch, then

$$\frac{p\,S}{n} = \frac{1600 \times D^2\,\frac{\pi}{4}}{2} = 628\,D^2$$

Hence, referring to Table I., for values of $\frac{p\,S}{n}$ we find $\frac{3}{4}$in. bolts will suffice for pipes not exceeding $\sqrt{\frac{2736}{628}}$ in diameter = 2·09in. The corresponding value of $\frac{S_1 + S}{S} = \frac{(2{\cdot}09 + 1)^2}{(2{\cdot}09)^2} = 2{\cdot}19$ Hence the tabular value, viz., 2·31, is not exceeded, and there should be no difficulty in making the joint by an ordinary amount of screwing up. Similarly, 2in. bolts will suffice for pipes not exceeding $\sqrt{\frac{34560}{628}}$ in diameter, or 7·42in. For pipes of this diameter $\frac{S_1 + S}{S} = \left(\frac{8{\cdot}42}{7{\cdot}42}\right)^2 = 1{\cdot}29$, and the tabular value, viz., 1·28, is slightly exceeded, a result which may be taken as indicating 7in. or 8in. as about the limit beyond which it is not desirable to employ so small a number as two bolts to make the joint. Proceeding as above, we find

in. bolts	suitable for	pipes not	exceeding	2·09in.	diameter.
$\frac{7}{8}$in.	,,	,,	,,	2·64in.	,,
1in.	,,	,,	,,	3·19in.	,,
$1\frac{1}{8}$in.	,,	,,	,,	3·67in.	,,
$1\frac{1}{4}$in.	,,	,,	,,	4·31in.	,,
$1\frac{3}{8}$in	,,	,,	,,	4·9in.	,,
$1\frac{1}{2}$in.	,,	,,	,,	5·35in.	,,
$1\frac{3}{4}$in.	,,	,,	,,	6·31in.	,,
2in.	,,	,,	,,	7·42in.	,,

The lugs may be made $1\frac{3}{4}$ times the diameter of the bolt in thickness, or a little more—a usual practice in the case of 5in. pipes, for instance, being to make the pipes 1in. thick in the barrel, the bolts $1\frac{1}{2}$in. diameter, and the lugs $2\frac{3}{4}$in. thick. The test pressure for such pipes before being laid is usually 2,500lb. per square inch, or somewhat in excess of that given in our table, page 160, in which the test pressure for a pipe 5in. diameter and 1in. thick is given as one ton per square inch.

Fig. 36 illustrates a form of joint similar to the Armstrong pipe joint, but in which a flat strip of guttapercha is employed instead of a round one as a jointing material, or in place of guttapercha a leather annulus may be used. The packing ring is here completely enclosed in a recess, and the joint may be used for the highest attainable pressures. The width of the groove need not exceed $\frac{3}{8}$in. in any case, and may, where desirable, be even less; and its depth may be $\frac{1}{4}$in.

If D be the diameter of the pipe, the outer diameter of the groove may be D + $1\frac{1}{4}$in., and its inner diameter D + $\frac{1}{2}$in.

$$S \text{ will then be } = (D + \tfrac{1}{2})^2\,\frac{\pi}{A}, \text{ and}$$

$$S + S_1 \text{ will be } = (D + 1\tfrac{1}{4})^2\,\frac{\pi}{4}.$$

$$\text{Hence} \qquad \frac{S + S_1}{S} = \left(\frac{D + 1\frac{1}{4}}{D + \frac{1}{2}}\right)^2 = \left(\frac{4\,D + 5}{4\,D + 2}\right)^2,$$

and the test stress on each bolt is—

$$\frac{(2\,D + 1)^2}{n} \times {\cdot}1963\,p,$$

n being the number of bolts, and p the test pressure in pounds per square inch, as above.

In the case of this description of joint it will not be profitable to employ large diameters of bolts for pipes of small diameters, for the reason that if a sufficient number of bolts be employed to enable a workman with an ordinary length of spanner and ordinary exertion to screw up the joint sufficiently tight to prevent leakage, large bolts, in the case of small pipes, will have an excess of strength to resist the additional stress brought on them by the water pressure. The limiting diameter of pipe for which a particular size of bolt is suitable will be found by equation

$$\frac{S + S_1}{S} = \left(\frac{4\,D + 5}{4\,D + 2}\right)^2$$

for this particular form of joint to the corresponding value in column 5 of Table I., and hence determining D. Proceeding in this manner, we find that—

$\frac{7}{8}$in. bolts	should not be	used for pipes	of less than	1·375in.	diam.
1in.	,,	,,	,,	1·8in.	,,
$1\frac{1}{8}$in.	,,	,,	,,	2·17in.	,,
$1\frac{1}{4}$in.	,,	,,	,,	2·78in.	,,
$1\frac{3}{8}$in.	,,	,,	,,	3·25in.	,,
$1\frac{1}{2}$in.	,,	,,	,,	3·6in.	,,
$1\frac{3}{4}$in.	,,	,,	,,	4·25in.	,,
2in.	,,	,,	,,	5·22in.	,,

The thickness of the flanges of pipes of the type illustrated by fig. 36 is more properly a junction of the diameter and pitch of the bolts than of the thickness of the pipe metal. The following is a rule which may be used with advantage to determine the proper thickness of the flange. Let d_s be the diameter of the bolts in eighths of an inch, and c the pitch or distance between the centres of two adjacent bolts, measured along the arc of the circle of bolt centres in inches, then the thickness of the flange should not be less than—

$$\frac{d_s}{9}\sqrt{\left(\frac{d_s+3}{c}\right)},$$

the width of the flange (dimension A, in fig. 3) being equal

$$\frac{d_s+3}{4}.$$

Hence we obtain the dimensions tabulated in Table II. for joints of the type illustrated by fig. 36.

If the thickness of flange, as given by the table, for any particular case be less than the thickness of the barrel or body of the pipes, the thickness of the flange should be made greater than that given in the table, or say not less than the thickness of the pipe.

TABLE II.

Dimensions of circular flanges of cast-iron pipes with tongued and grooved joints (fig. 36).

Diameter of Bolts.	Width of Flange A	THICKNESS OF FLANGE IN INCHES.							
		PITCH OF BOLTS IN INCHES.							
		3	4	5	6	7	8	9	12
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
$\frac{3}{4}$	$2\frac{1}{4}$	1·16	1	·9	·82	·76			
$\frac{7}{8}$	$2\frac{1}{2}$	1·43	1·23	1·11	1·01	·94	·88		
1	$2\frac{3}{4}$	1·7	1·48	1·33	1·21	1·12	1·05	1·	
$1\frac{1}{8}$	3	2·	1·73	1·55	1·42	1·31	1·23	1·16	1·
$1\frac{1}{4}$	$3\frac{1}{4}$		2·01	1·8	1·65	1·52	1·42	1·35	1·16
$1\frac{3}{8}$	$3\frac{1}{2}$		2·3	2·05	1·88	1·73	1·63	1·53	1·33
$1\frac{1}{2}$	$3\frac{3}{4}$			2·33	2·13	1·97	1·84	1·73	1·5
$1\frac{3}{4}$	$4\frac{1}{4}$			2·88	2·63	2·43	2·27	2·15	1·86
2	$4\frac{3}{4}$				3·17	2·94	2·74	2·59	2·24

IMPROVED BORING, SHAPING, AND SCREWING MACHINES.

WE illustrate here (fig. 1) an improved boring machine as constructed by the Britannia Company, Colchester, which is especially designed for large and heavy work. The boring heads are powerfully geared, and have steel spindles driven by strong spur and mitre gearing. The feed is variable, and is self-acting in either direction, while for surfacing work the spindles may be caused to remain stationary. For this purpose, and adjusting the spindle to bore work of different dimensions and arrangement, the heads are mounted on upright heavy and rigid slides having vertical adjustment by screw and hand wheel, and transverse adjustment by rack and pinion. The upright bar rests are made with socket heads to carry the boring bar and bushes, one bar rest at each side of the work to be bored. Both rests are adjustable vertically by screws and hand wheels. Eight changes of speed are allowed for, between cone pulleys and double gear. The machine we illustrate has $3\frac{1}{4}$in. diameter spindles, and can bore up to 24in. diameter and 42in. long. It has a double set of boring heads and bar rests. The foundation plate is 12ft. by 5ft.

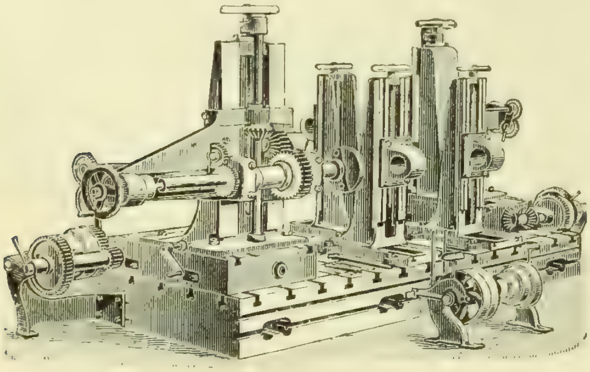


FIG. 1.

In fig. 2 is illustrated an improved shaping machine, in which the cut may be regulated from the head without the necessity of moving to the end of the bed, and the table is adjustable on the bed by the handle shown in front. It is arranged to be self-acting in all motions, and has a quick return linkage. The ram is indexed, and the tool-box is provided with slides for vertical or angular cuts, while a worm and quadrant are arranged for internal curves. The shaper seems to us an exceedingly handy and useful tool, calculated to facilitate work considerably.

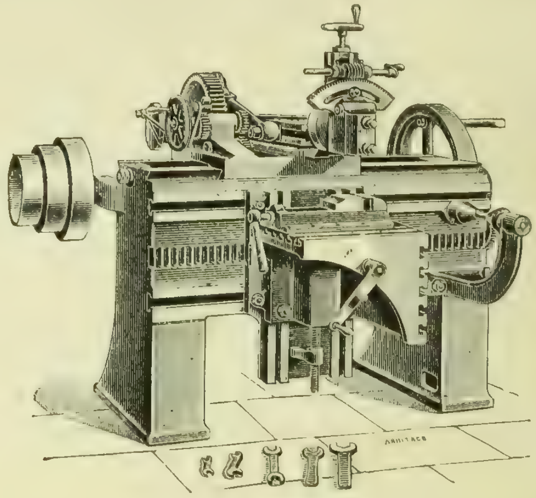


FIG. 2.

In fig. 3 is illustrated an improved screwing machine of specially simple design and arrangement. The headstock is constructed with a hollow spindle to pass rods or tubes of any length, and has a self-centreing chuck for gripping them. A clutch and lever allow the machine to be started and stopped instantly independently of the countershaft. The screwing head is carried by a saddle, which slides upon the bed; it is fitted with three tool boxes carrying tools similar to ordinary chasers, each held firmly in position by a set screw. The tools are moved to cut or release the work by a lever and cam, and the depth of cut is adjusted by a stop in a graduated face.

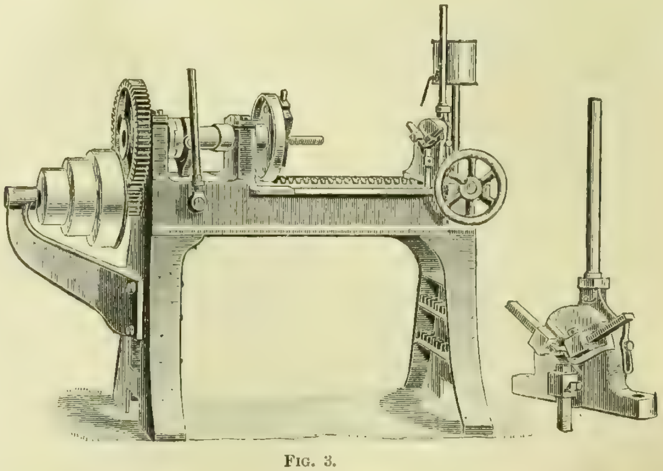


FIG. 3.

The important feature of the screwing head is the simple form of the dies, which are simply pieces of steel cut off the bar, put into the tool holder, and secured by set screws. They are then cut in the machine by the master tap, and when hardened are ready for use. By this method expensive fitting is entirely dispensed with. The machine possesses many advantages, and completes the thread at a single cut. The form of the dies allows the cutting edges to be plainly seen, and allows clear space to prevent choking with cuttings. The Britannia Company, Colchester, have spent much thought on these tools, and as they have great experience in work of this class, we do not doubt but that users will find them most satisfactory.

ROBURITE AS AN EXPLOSIVE IN COALMINES.

WITH the view of promoting discussion on matters specially appertaining to mining, the Manchester Geological Society has for the last two or three sessions arranged for special meetings to be held in the Mining School at Wigan. These meetings have not always met with the support that was anticipated, although for some time past the papers and discussions at the meetings of the society have largely dealt with matters specially interesting to mining engineers. Recently, however, a very important question in connection with the use of explosives in mines has been raised in several papers which have been read before the society, dealing specially with the use of roburite as an explosive. These papers have been read before several meetings held in Manchester, and they embraced one by Mr. James Hilton, on "The Use of Roburite in Coalmines," another by Mr. H. Brammall, on "The Effects of Roburite Fumes," and a third by Mr. William Watts, F.G.S., on "Roburite and other Explosives in Mining." The discussion on all these papers was specially referred to a meeting of the society to be held in Wigan, where they might be discussed by mining engineers specially interested in the question. This meeting was held on Friday, May 10th, in the Mining School, at Wigan, Mr. John Knowles (Messrs. Andrew Knowles and Sons, Limited, Manchester), the president of the association, occupying the chair. There was a large attendance of mining engineers connected with the Lancashire coalfield. Mr. Mawson (West Leigh), in opening the discussion, said he had had some experience in the use of roburite in the mines of the Wigan Coal and Iron Company, and he might add that he had seen all the experiments to which reference had been made in Mr. Hilton's paper. In these experiments attempts had been made in every possible way to cause an explosion, but on no occasion had the gas been fired. After some of the shots were fired sparks were seen, but these were all of a dull red character, and in no case was there any flame sufficient to fire gas. As to the fumes of roburite being injurious, they had not found this to be the case in any single instance, and so far as their experience went none of their men had been made ill by the fumes. There was, however, one weak point in connection with the use of roburite, and that was that the incautious handling of it might produce injurious effects, but he thought the roburite manufacturers had provided sufficiently for this by the very clear and definite instructions they issued as to the proper handling of this material, and in practical work, if cartridges of a suitable size were provided, there was no occasion for the workmen's hands to come in contact with the roburite. At the collieries he had charge of they had used roburite now for some considerable time, and the men were quite satisfied with it. It was very much less expensive than gunpowder, and not only did it do its work very well, but he might say, personally, he had found no case in which the health of the men had been injured by its use. Mr. C. F. Clarke (Garswood Coal and Iron Company) said that at the beginning of the year there was at their collieries a serious dispute—in fact there was a strike throughout the collieries for three weeks in consequence of the men believing their health was suffering through the use of roburite. An arrangement was come to with the men and their representatives that the whole question with regard to the use of roburite should be thoroughly inquired into, and two distinct medical practitioners were appointed, with power to call in the assistance of an analyst, to ascertain whether the fumes resulting from the use of roburite were at all detrimental to the health of the men engaged in the mine. The gentlemen who had been selected to carry out this investigation had been engaged making experiments under all possible varying circumstances and conditions, but he had not yet received their reports. In the meantime the workmen at the colliery were going on using roburite, just as they had been doing from the beginning, and he had not heard of any case in which the men had been injured by the fumes or by handling the roburite. Of course, from the first, very strict instructions were given to the shot-lighters as to the proper manner in which this explosive was to be used, and that they should not allow the roburite to come in contact with any portion of their bodies. He thought it would, however, be advisable if the society adjourned the further consideration of the subject until the report by the medical gentlemen who were making special inquiries into the matter had been received. After some further discussion, in which the opinion generally expressed was, that the use of roburite, with ordinary and proper precautions, was very much preferable to gunpowder as an explosive in mines, it was resolved that the matter should stand adjourned until the reports of the medical investigation now being made with regard to its use in mines were completed, and that when the reports upon these investigations were presented a special meeting of the society should be called to further consider the question.

THE SKILLED LABOUR MARKET.

THE following memorandum has been prepared for the *Board of Trade Journal* by the Labour Correspondent of the Board of Trade: "Nineteen trade societies have this month sent in reports showing the state of their respective labour markets. From these it is evident that there is no falling off in the activity which has recently been so distinguishing a characteristic of our chief industries. At the same time, however, it is to be noted that with the exception of the building trades, there is no improvement shown upon the figures of last month. In a few trades there is just the slightest increase in the number of unemployed workmen. This cannot, however, be considered as more than the ordinary fluctuation of the labour market from month to month, but it may also be regarded to some extent as an indication that the tide of trade is nearing high-water mark. The proportions of men on out-of-work benefit are yet somewhat higher than in the best of times, but this may to some extent be accounted for not only by improved methods of production, but by the very large amount of extra time being worked by the men employed, which naturally tends to restrict the demand for workmen. Those societies which have reported show a total membership of 192,973, many of them having increased in strength considerably during the past year. Of this total 3,798 are out of work, as against 4,000 for the same societies last month, a decrease of 202 only, all of which is due to the building trade. Last month the proportion per cent of unemployed was 2·17; now it is 2; so that the change is of the slightest. The iron and coal trades continue to be well employed, and are remarkably free from serious disputes. The great textile industries are fairly provided with work, but are not by any means so busy as the trades already referred to, or as the shipbuilding and engineering trades, which are in the full swing of prosperity. The boot, shoe, and general clothing trade is improving. The printing trade is but moderate, but the cabinet-makers are better employed than for some time back. Wages still have an upward tendency. In some cases advances have been given unsolicited, while in others arrangements have been made for some months ahead. The movement for another advance in the coal trade continues, and the question will probably remain an open one for some weeks to come."

AMERICA'S OIL SUPPLY.

Bradstreet's for the 13th April last, respecting the undeveloped supply of oil in America, says:—

"An article published in the Oil City *Derrick* recently contains some statements regarding the area and character of the illuminating oil-bearing territory which should be reassuring to believers in a possible future oil famine in this country. 'The oil regions, as now developed,' the article states, 'extend from Wellsville, N.Y., crossing Pennsylvania at nearly a 45 degree line to Dunkard Creek, in West Virginia. On an air line, this covers a distance of 204 miles in length, and, so far as developed, the belt is about 10 miles in width. The yield of the oil-fields up to March 1, 1889, was 340,133,997 barrels. About 150,000,000 barrels of this came from McKean County alone, and this county is still good for 20,000 barrels a day.' The total future production of this belt is beyond prediction. 'It has been noted,' says the article, 'that oil-bearing rock, wherever found, usually yields about the same quantity of oil to a given acre. The yield of oil per square mile of territory during the first 15 years of its existence is about 1,000,000 barrels.' It is considered certain, however, that each of the 204 square miles of territory will not yield this quantity. If it did, the total production there outlined would be about 2,040,000,000 barrels. 'This belt of 204 miles is a chain of pools, large and small, and until the area of each one is known the total yield would be simply conjecture.'

"The figures and estimates given relate only to the region where the illuminating oil of commerce is produced, namely, New York, Pennsylvania, and the Macksburg district, in Ohio. The great Lima field is not taken into account, nor Colorado, California, Kentucky, or Tennessee. 'It had been stated that, under the energy of the drill, the Ohio field might be made to yield 100,000 barrels a day. This is not improbable, since the Bradford field in July, 1882, produced 105,102 barrels each day of that month. The Bradford field had no large wells compared with the geysers of Ohio. Lima oil is worth but about one-seventh as much as the Pennsylvania product, and can never come into competition with it as an illuminant unless some new process of manufacture is discovered beyond anything now known. Its utility in the world's economy lies in the direction of fuel, and there is not much likelihood that it will ever be diverted from this field. Natural gas is the only fuel that can compete with it in cheapness, and that is not everywhere obtainable. Natural gas cannot be transported much above 100 miles, and oil-fuel may be carried to the end of the earth. As far west as Omaha it is now furnishing manufacturers a cheaper fuel than coal.'

"With the above large supplies of oil, both for illuminating purposes and for fuel, in sight, the writer of the article apparently sees little reason to fear an oil famine, as he states it, as among the immediate probabilities."

HYDRAULIC DOCK MACHINERY.

(Concluded from page 341.)

Another method is to place a tipping cradle on the metals, run the wagon on, and then raise the cradle and wagon and drop them into the hold of the vessel, in which may be placed a telescopic hopper with a movable bottom, the hopper being extended to its full length before the bottom is withdrawn, thus reducing the fall of the coal and preventing breakages. Vessels of 2,000 tons burden frequently enter the dock at Cardiff at high water one day, discharge their ballast, receive their outward cargo, and leave at high water the following day. Hydraulic coal tips are also constructed with one cylinder only, the fore end of the tipping cradle being checked during the latter portion of the stroke.

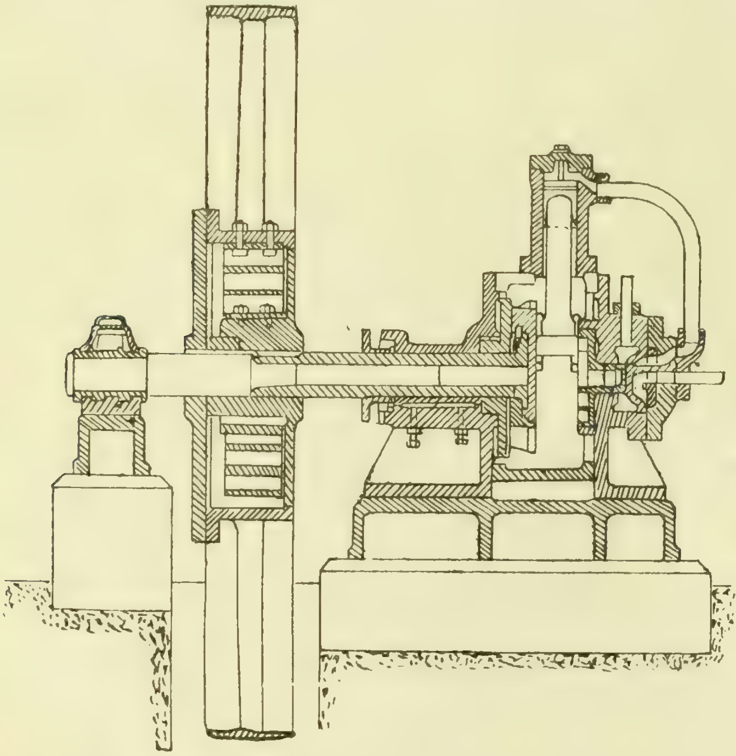


Fig. 15.

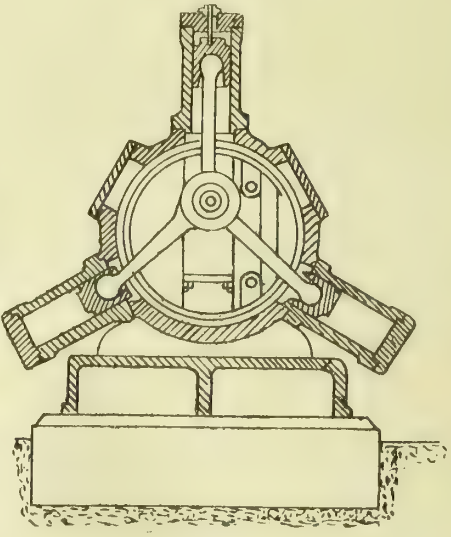


Fig. 16.

Recently, 1,050 tons of coal have been shipped in four hours from a movable tip, or 263 tons per hour. On the Aire and Calder Canal are used wrought-iron canal barges, manufactured by Messrs. J. Butler and Sons, of Stanningley, each containing about 120 tons of coal, which the writer understands are raised bodily out of the water at Goole by a hydraulic lift and tipped over, the contents being discharged in the collier alongside. The hydraulic lift is a very useful application of hydraulic power, and a vessel may be lifted either bodily out of the water, or lifted with sufficient water to float it, as in hydraulic canal lifts. The La Louviere canal lift on the Canal du Centre, Belgium, is the largest one of this description at present constructed. The height of the lift is 50ft. 6in., the length of the boxes between gates 141ft. 7in., width 18ft. 4in., depth of water 8ft. 6in, diameter of rams 6ft. 6¾in., weight to be lifted 1,100 tons, and the displacement of largest barge 400 tons. Two of these lifts are placed alongside, one box or lock always being at the high level, and the other being at the low level. The hydraulic cylinders are each made up of nine lengths of cast iron, each being 6ft. 9in. diameter inside and 4in. thick. The top length is 5ft. 2½in. long, the other eight being 6ft. 6¾in. long. Three of these were burst at 2,175lb., 2,280lb., and 2,190lb. respectively, or 9·78, 10·2, and 9·8 tons per square inch breaking strain. These cast-iron cylinders are hooped continuously with steel. The rams are of cast iron, 2·95in. thick and 63ft. 11in. long. The lift is operated by filling the box at the upper level with water to a greater height than the box on the lower level, so overcoming the friction and compensating for the difference of weight of the rams in water and in air; communication between the cylinders being made by suitable valves, the water flows from the extra weight cylinder to the other, raising it as the other falls, till the two boxes occupy just the reverse position to that at the commencement of operations. At the ends of the boxes are provided grooves, in which slide rising metallic doors, having their edges covered with indiarubber; the ends of the water-way are similarly equipped, and when the boxes come to a state of rest and the gates come face to face they are interlocked and raised by a hydraulic press, U-shaped metallic wedge pieces, faced with indiarubber, being used to form a tight joint between the moving box and the fixed end of the canal (*Engineering*, Oct. 12th, 1888). According to Professor Unwin, a difference of 1½in. in level is all that is required to work the lift; 50 tons of water is discharged from one cylinder to the other through a 10in. pipe in 2½ minutes, or 20 tons per minute. Below is a comparison of three hydraulic canal lifts :—

Name of lift....................	Anderton.	Fontinettes.	La Louviere.
Height of lift	50ft. 2in.	43ft. 0in.	50ft. 6in.
Length of box between gates	73ft. 9in.	132ft. 10½in.	141ft. 7in.
Width of box	15ft. 3in.	17ft. 0in.	18ft. 4in.
Depth of water in box..............	4ft. 5in.	6ft. 6¾in.	8ft. 6in.
Diameter of rams	2ft. 11¼in.	6ft. 6¾in.	6ft. 6¾in.
Weight to be lifted	250 tons.	770 tons.	1,100 tons.
Displacement of largest boat........	100 tons.	300 tons.	400 tons.
Pressure per square inch	532lb.	·	568lb.

The La Louviere lift is the first of a series of four allowing a difference of level of 202ft. in five miles, and it is suitable for vessels up to 113ft. long without rudder, or 128ft. 3in. with rudder, 16ft. 5in. wide and 6ft. 11in. draught. Each box is held in a frame composed of two side girders 148ft. long, 19ft. 8in.

deep at middle, and 13ft. 2in. at ends. The continuous hooping of the cast-iron cylinders was determined after test on a hooped length, which was tested to 2,265lb, when it was found that the cylinder expanded between the hoops, taking a form more or less barrel-shaped; the hoops were made 6in. long and 2in. thick.

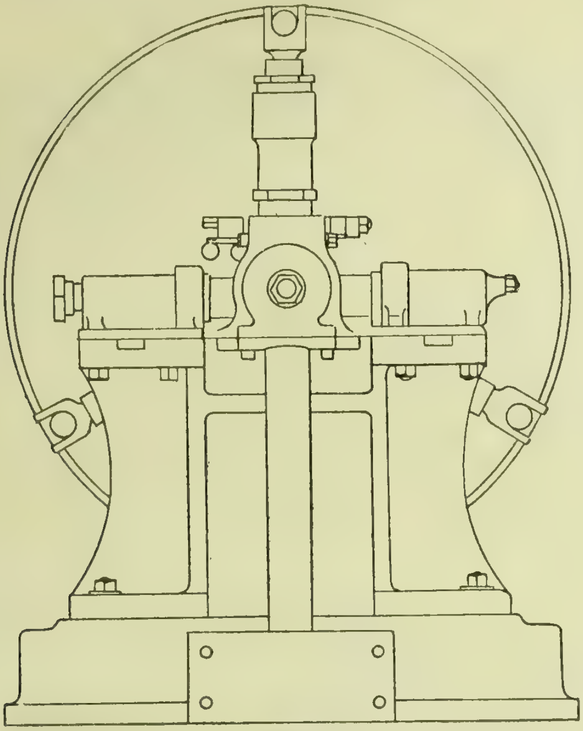


Fig. 17.

Four and three-eighths of an inch of water is run into the top box to work the lift, and this depth of water over the area of the box—*i.e.*, about 27 tons of water—is all that is used to transfer a vessel from one level to the other, or to lift one and lower the other at the same time. The machinery is worked by two turbines utilising the 50ft. 6in. fall from one level to the other. These actuate two double-acting pumps, which can deliver 847 cubic feet of water per hour to the accumulator, 21in. diameter and 25ft. 3in. stroke, loaded to 568lb. per square inch. The accumulator is only necessary to make good errors or leakages, and to work the gates, capstan, joint wedges, &c. For the Anderton lift on the river Weaver, Cheshire (the first of its class), is an accumulator with a ram 21in. diameter, 13ft. 6in. stroke, equal to about a 4ft. 6in. stroke of the lift. This is loaded to 532lb. per square inch, and it is necessary to use the accumulator for about 1-12th of the stroke, say the last four feet. It is, in the opinion of the writer, to an extension of this system of canal lifts that we must look for increased dock accommodation. If the weight of a vessel that may be raised in this manner in so short a time rises from a maximum of 100 tons to 400 tons, before long we may expect to see vessels of 4,000 tons, and perhaps upwards, treated in the same manner, and so sent on to towns which, owing to their being at present a few feet above the sea level, are not at present seaports, and this done without any extravagant use of water, and with but very few lifts, these being of greater height than in the old lock system.

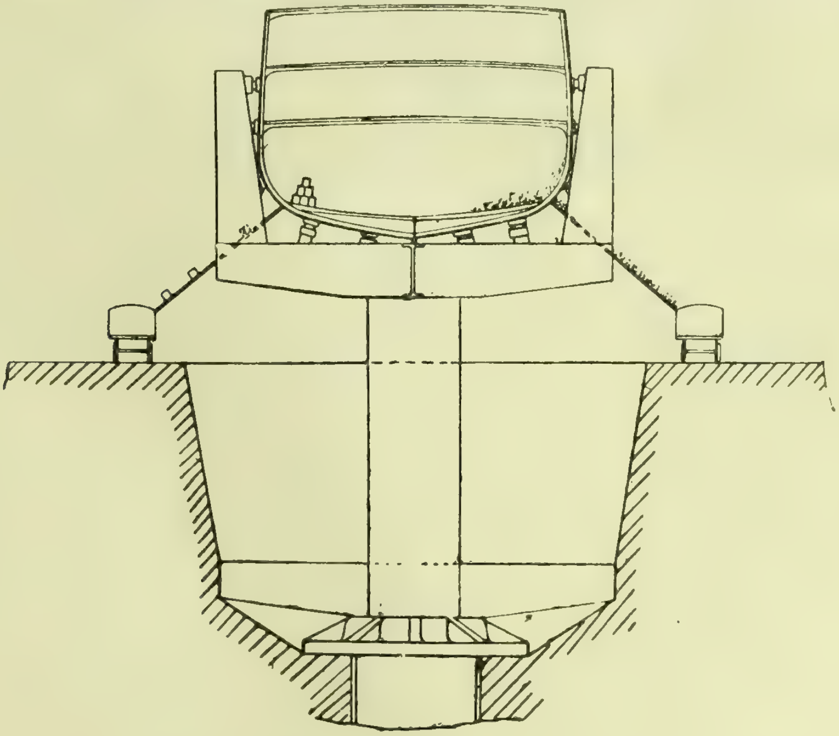
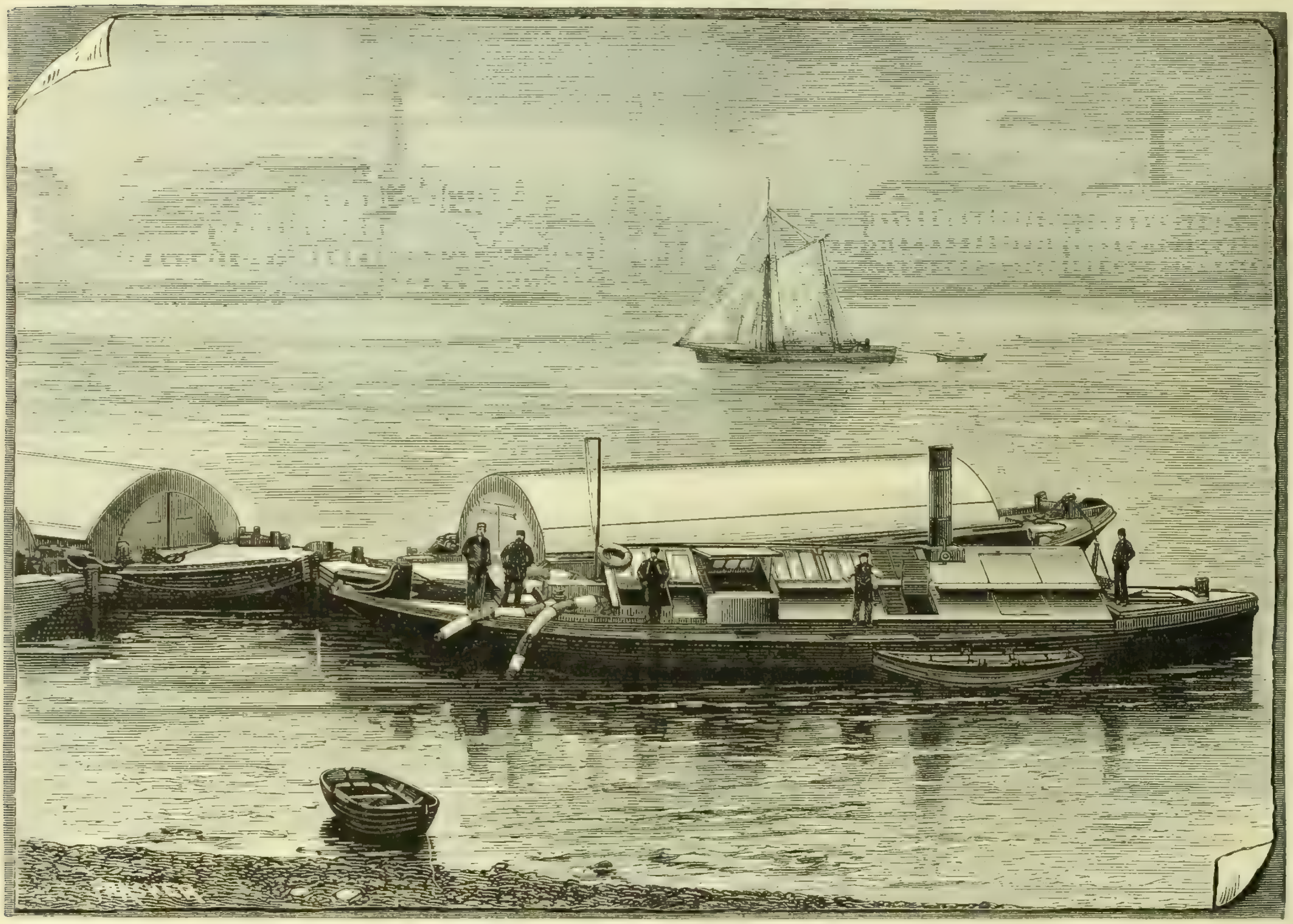


Fig. 18.

The application of hydraulic power to our docks has increased the dock accommodation threefold; *i.e.*, the docks are enabled to turn out three times the amount of trade that could be done in the same dock area before. It is to the improvement in dock machinery rather than to increase of dock area that we, as mechanical engineers, should devote our attention; *i.e.*, to the more rapid discharging and re-loading of the vessels, that the time they are in dock may be reduced to the lowest possible period, thus allowing more vessels to occupy the dock in a given time. The writer would suggest some such scheme as indicated in fig. 18, the vessels being brought into position over a hydraulic lift and raised above the level of the quay, so that its cargo may be discharged by gravity direct into the railway wagons and carts on to travelling conveyor bands, or to elevators taking the cargo direct into the storage warehouses, and depositing it just where desired, suitable discharge openings being provided in the bottoms and sides of the vessels, opened and closed by hydraulic or other gear. When empty the vessel may at once make way for another, and be taken to a lading dock, where whole trains may be raised by a hydraulic lift, and the vessel loaded, the whole of the discharging and reloading being rapidly and effectively performed by gravity. As far as the writer is aware, this is a novel suggestion, but there is nothing improbable in it. Very large vessels have already been lifted out of the water by a direct hydraulic lift, and others by pontoons, so that there is no difficulty or danger in raising the vessel, and the discharging from the bottom of the hold is only an extension of the hopper barge principle, and advantage may be taken of the period during which the vessel is high and dry to examine thoroughly below the water line, she being sent to the dry dock if any repairs, &c., be necessary.

REFRIGERATOR BARGE.

CONSTRUCTED BY THE PULSOMETER ENGINEERING CO., LIMITED, ENGINEERS, LONDON.



THE engraving above illustrates a type of floating mechanical refrigerator designed to overcome the difficulties of discharging provisions from the cold chambers of import vessels, and intended to obviate the deterioration in quality arising from partial thawing. The machinery is the design and construction of the Pulsometer Engineering Company, Limited, of Nine Elms Works, London, S.W., and uses anhydrous ammonia by their now well-known mechanism under Puplett's patents. The condition of meat arriving in the import vessels is generally good, but as it must be transferred from the vessels to cold air stores on shore, it has hitherto been subject to an increased temperature during transit. Various methods have been tried to keep it cool, but when large cargoes have to be handled the difficulties are great, and some deterioration has generally followed. The barges built for the Tibury Lighterage Company, which have now been at work for nearly twelve months, and during that time have conveyed and landed in good condition many thousands of tons of frozen meat, consist essentially of a cold-room barge and a machinery barge. The cold room and the cold-producing mechanism are thus on separate barges, so that the heat of the engines is quite separated from the storage room. Each storage barge has capacity for about 50 tons of meat, and is roofed and insulated by charcoal between double wood lining walls, with felt and paper packing. A coil of pipes in the roof connects by valves to an inlet and outlet main, which, in turn, are coupled by flexible hoses with the freezing machine upon the other barge, and a current of a strong solution of chloride of calcium, reduced by the mechanism to −10 deg. Fah., or 42 deg. Fah. below freezing, is circulated through them.

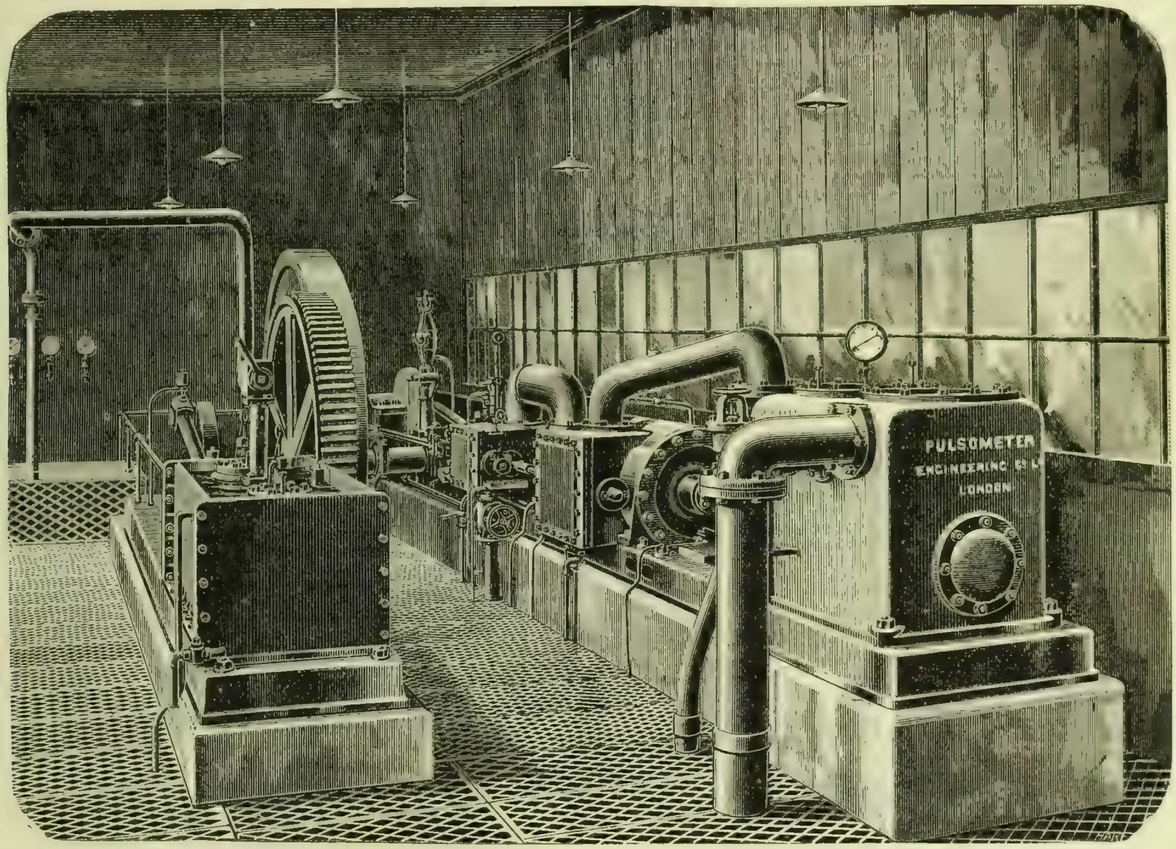
The machinery of one refrigerator barge is capable of cooling and maintaining the temperature of six storage or cold-room barges to 20 deg. Fah., so that one apparatus can deal with a total of 300 tons of meat. The amount of cold chloride solution remaining in the pipes of such storage barge, after disconnecting from the refrigerator, is sufficient to maintain a low temperature and preserve the cargo for several days, as it takes some days for the temperature to rise to the freezing point.

On page 363 we illustrate the type of mechanism which is used in those under Puplett's patents. It consists of a horizontal tandem compound condensing steam engine, which has high and low pressure cylinders of 11in. and 21in. diameter respectively, and a stroke of 30in. The high-pressure cylinder has an ordinary slide valve, and a cut-off valve, controlled by Meyer's gear, while the low-pressure cylinder has the D slide only.

The main bearings are 6½in. diameter by 12in. long, and the brasses are in three parts, with both vertical and horizontal adjustment, while the crosshead is arranged for a weight of 24lb. per square inch of wearing surface. The diameter of the air pump is 10in., and it has a single-acting plunger of gun-metal, working in a gun-metal bushed gland. The pump valves are rubber, with brass guards, and are twenty in number.

Ammonia is used as the refrigerating medium, and it is now considered to be, when properly handled, the best and most economical means of obtaining cold by mechanical work. Although the action of evaporation machines is now generally understood, it is well to state it shortly. Ammonia, when compressed sufficiently, and kept at a moderate temperature, becomes liquefied, and when rapidly evaporated by means of a pump drawing off the vapour, the liquid ammonia boils, and consequently the heat is rapidly abstracted from it to convert it to the gaseous state again. By this means great cold is produced. In this machine the arrangements are very perfect both from a mechanical and theoretical point of view, and by the patented improvements a much higher temperature of condensing water can be used. In a machine in work at Birmingham last summer, although the temperature of the water was as high as 90 deg. Fah., the liquefying pressure was only 175lb. per square inch, and the machine easily maintained its ordinary output of ice, notwithstanding the heat. The ammonia compressor and expanding pump are horizontal, double-acting, with two inlet and two outlet valves falling to their seats by gravity, and so avoiding the use of springs. It is driven, as will be seen from our illustration, by spur gearing, from the engine shaft, and the wheels are proportioned so that it runs at half the engine speed.

The lift of the pump valves is regulated from the outside by screw stops passing through the valve covers, and an arrangement of spindles passing through the screw stops allows the valves to be raised from their seats or reground without removing the covers. The compressor piston rod has two stuffing boxes, with a clear space or chamber between them, which is filled with oil, and connects by two pipes to a reservoir; any ammonia gas which escapes the first packing flows into the oil and passes up one pipe into the reservoir. From this it is withdrawn at each stroke of the pump and returned to the apparatus. By this method all loss of ammonia is absolutely avoided, so that the packing may be left without adjustment or renewal for upwards of twelve months, working night and day. A fixed amount of gaseous ammonia is withdrawn by the pump at each stroke from the liquid, and by causing rapid evaporation it produces intense cold, which is communicated by suitable means to the circulating fluid. The ammonia condenser is formed of U tubes, with steel junction pieces, to allow any tube to be replaced if found defective. Two multitubular refrigerators are used, in which the liquid ammonia surrounds the tubes, and the circulating liquid passes through them by pumps.



The working temperature of the chloride of calcium solution ranges from 11 deg. to 14 deg. Fah.—that is, from 21 deg. to 18 deg. Fah. below freezing.

We are informed that from careful tests of one of these machines the cost of making 25 tons of ice does not exceed 1s. 6d. per ton, and the cost of fuel is less than 1s. per ton of ice produced, while the cost of ammonia does not exceed one farthing per ton of ice made. The machine illustrated produces 25 tons of hard, transparent ice in every 24 hours, in blocks 9in. thick, each weighing nearly 2 cwt; and maintains at a temperature below the freezing point four large chambers for storing provisions. These results speak for themselves, and we have great pleasure in congratulating the Pulsometer Engineering Company on the success they have attained in dealing with a most difficult branch of engineering.

MIDLAND GAS MANAGERS' ASSOCIATION.

WATER-GAS.

THE spring meeting of the above association was held at the Royal Hotel, Matlock Bath, on Thursday afternoon, May 16th, under the presidency of Mr. C. Taylor, of Derby (president of the association), and there was a representative assembly of gas managers from different parts of the Midlands. In the morning the party visited the locomotive works of the Midland Railway Company at Derby, under the guidance of Mr. F. Holt, the manager; and they also visited the Litchurch Works of the Derby Gaslight and Coke Company, through which Mr. Taylor conducted them. They afterwards drove to Matlock Bath, much enjoying the beautiful scenery through which they passed.

At the meeting of the members at Matlock Bath there were papers on the agenda by Mr. J. F. Bell, of Stafford, and Mr. W. T. Tew, of Warwick, but there was only time to take the paper by Mr. Bell, which was on the subject of water-gas, to which considerable attention has been attracted of late. He said that it was now nearly a century since water-gas was first produced, and during that period over one hundred patents had been taken out in America alone for its production. It was noticeable, however, that the patents of the present day were almost identical with those produced years ago. However, much time, energy, and skill had been brought to bear on this method of gas making, especially in America, where a number of water-gas companies existed. The comparative prevalence of water-gas in that country was no doubt due to the fact of anthracite being cheaper and more easily obtained in many places than bituminous coal. He found coal-gas in America was universally sold cheaper than carburetted water-gas, the average price for the former being 9s. 6d. per 1,000 cubic feet, and for the latter 10s. 6d. per 1,000. When they remembered they had in America plenty of anthracite coal well adapted for making water-gas, and abundance of cheap oil for carburetting the same, and yet could not sell it cheaper than coal-gas, they saw at once that carburetted water-gas could not possibly compete in England with coal-gas, which was sold at one-third the price charged in America, even supposing it was equally suitable for domestic lighting, which was not the case. He believed there were in America over 1,000 companies which made coal-gas, and about 150 which supplied water-gas. The latter were gradually decreasing, and it was evident that the manufacture of water-gas there was not a very formidable rival. So much for the threatened substitution of carburetted water-gas for coal-gas; but a mixture of both might in the future become a reality, especially if anything like panic prices should be charged for gas-coal. He then examined the theory of the manufacture of water-gas and the practical results, entering into considerable details in the matter, and accompanying his remarks with tables to enable the members to verify his calculations. His comparison of the relative cost of coal-gas and water-gas was materially in favour of the former; and in conclusion, referring to the question of the suitability of water-gas for distribution, he said it was a well-known fact that carbonic oxide was a deadly poison, and to distribute a gas containing over 40 per cent of this dangerous compound would be unwise in the extreme. He found that, taking a period of nine years, 124 persons in New York alone died through inhaling water-gas which had escaped into the air they breathed, and this he compared with eight deaths during the same period from the effects of coal-gas. From experiments made in Germany with an apparatus specially contrived to contain water and "producer" gases and air in various proportions, it was found that a fatally poisonous mixture was an atmosphere containing only 1 per cent of water-gas, and 1·5 per cent in the case of producer gases. These gases were devoid of smell, and unless mixed with some pungent vapour, so that an escape could be detected at once, lamentable accidents were sure to attend the introduction of these gases. In America, where they had some experience with this water-gas, the States of Massachusetts and New Jersey had passed laws forbidding the sale of gas containing over 10 per cent of carbonic oxide, though the water-gas people had used every effort and spent thousands of dollars to have these laws repealed. The claim that water-gas was superior to coal-gas was delusive, for if supplied carburetted, which was the only practical method of distributing it as a gas for illuminating purposes, it was found almost impossible to maintain it at a uniform candle power. His conclusions were altogether against the chance of water-gas competing successfully with coal-gas in England.

Mr. Bell's paper was received with much applause. Discussion on it was deferred, but a hearty vote of thanks was passed to him, on the motion of the president, seconded by Mr. H. Hack (Birmingham).

The president entertained the members at dinner at the Royal Hotel in the evening.

THE IRON AND STEEL INSTITUTE.

The proceedings of the spring meeting of the Iron and Steel Institute were resumed on Thursday, 9th inst., at the Institute of Civil Engineers, Great George Street, Westminster. Sir James Kitson, Bart. (Leeds) presided; and among the large number of members present were Sir Isaac L. Bell, Sir Henry Bessemer, Mr. D. Adamson (ex-president), and several German delegates, also members of the institution.

The discussion on the paper read on the previous day by Mr. J. H. Darby, of Brymbo, on the manufacture of basic open-hearth steel, was proceeded with. Mr. Darby, in his paper, recorded his own experiences of the process, and explained in detail the many scientific processes by which he arrived at the results sought for. The steel produced gave about 24·5 tons tensile strain per square inch, and 15 tons elastic limit, with an elongation of 31 to 33 per cent in eight inches. He attached great importance, if uniform results were required, to the composition of the pig-iron. A suitable pig was as necessary in the basic as in the acid process of steel-making, but it offered no more difficulty in manufacture. Mr. Wailes (Wednesbury) was quite certain that the very finest quality of steel must be looked for as the product of the open-hearth basic process. Mr. Stoddart (Rotherham) said that the Park Gate Works had recently spent some £80,000 in the erection of new steel works for the purpose of making steel bars and plates by the open-hearth basic process. They obtained slabs from Brymbo which gave very good results, and his directors decided to adopt the open-hearth process. In the basic steel they had a metal which would give everything they had been accustomed to obtain from the best Yorkshire iron at something like one-third the price. Mr. Winsor Richards (Cleveland) was of opinion that the best form of furnace for this process was the rectangular furnace. It should be long, and capable of holding twenty tons of steel, and he considered they could easily get up the tensile strength of thirty tons by adding a little more manganese and increasing the carbon.

Mr. B. Schroedter (secretary of the Iron and Steel Association, Dusseldorf) read a paper on the progress made in the German iron industry since the year 1880. The writer stated that the production of iron ore in Germany since that year was, in 1880, 7,236,840 metric tons; the value being £1,722,674. The years 1882, 1883, 1884, and 1885 showed an increase on these figures. In 1886 there was a falling off, but in 1887 the production was 9,351,106 metric tons, and the value £1,700,263. In 1888 it was 10,664,789 tons, the value being £1,998,200. The alterations in the production of ore was in consequence of the invention of the Basic Bessemer process. The production of pig iron in Germany for the same years was stated to be, in 1880, 2,729,038 tons, and there was an annual increase, except in 1886, when there was a slight falling off, until in 1888 the production was 4,258,471 tons. As to the blast furnaces, in 1880 there were 314, with 246 in blast; while in 1887 there were 271 furnaces, with only 212 in blast. The production of finished iron was, in 1880, 1,358,487 weld tons, and 660,591 ingot tons; while in 1888 the quantity of weld iron was 1,547,357, and ingot iron 1,785,354. The exports showed an increase up to 1887, and then a slight decrease was experienced. That was due on the one hand to the fact that the demand on the world's market, especially for rails and wire, by the United States had become less, while several countries—as, for example, Russia—had almost entirely closed their market; and, on the other hand, to the fact that the home (German) consumption had increased very considerably at, for the most part, lucrative prices. The German ironmasters had endeavoured for a number of years, at great expense, to open up new fields for the application of iron, more especially in building construction, as a substitute for stone and wood, and they were by degrees reaping the fruit of these endeavours. On the whole, the paper stated that the retrospect was highly gratifying for the German iron workers. A satisfactory and continuous development was shown, which also awakened good hopes for the future. The President, during the discussion on the paper, said he was glad to notice that the home consumption of Germany had increased—(laughter)—and he thought it would be a good thing if English ironmasters would endeavour to instruct architects in the use of steel and iron for constructive purposes. (Hear, hear.)

Dr. Edwin J. Ball followed with a paper prepared jointly by himself and Mr. Arthur Wingham on the subject of the influence of copper on the tensile strength of steel. The paper stated that it had long been a matter of discussion whether true alloys of copper and iron could be produced, and great divergence of opinion had existed as to the influence exerted by small quantities of copper on the mechanical properties of iron and steel. This divergence of opinion led the writers to endeavour to obtain some definite results connected with this subject. They came to the conclusion that it would be seen that within certain limits copper did not prejudicially affect the mechanical properties of steel; and this to some extent agreed with the theory recently put forward by Professor Roberts Austen. In view of the fact that their experiments were of necessity conducted on a small scale, they submitted their results to the institute in the hope that the question would undergo a more complete examination, which the preliminary experiments would appear to justify.

Mr. Hugo Sack, of Dinsburg-on-the-Rhine, next read a paper on "Universal Rolling-mills for the Rolling of Girders and Cruciform Sections." He said that in the face of the multifarious applications and the continuously growing use of girders and similar sections, it was a remarkable fact that the quality of this kind of iron had not as yet attained the perfection which nowadays was required of rolled-iron. While all other products of rolling mills were submitted to the severest tests, yet with the iron under notice people were content with much less strength and a proportionate increase of weight instead. The writer then went on to explain a new system of rolling, which he claimed would produce the desired result, and would consequently be a great improvement on the present method.—In the discussion, the aim of the inventor of the mill was commended in so far as it sought to squeeze every face and part of the metal equally, although some of the speakers declined to commit themselves to an opinion that he had secured the best method for accomplishing this object.—Sir Henry Bessemer said that the paper was well worth the attention of the manufacturers of girders, as he thought it was a step in the right direction, and was pretty nearly all that might be required.—The discussion having been very brief, and as the attendance of members had thinned towards the afternoon, the President adjourned the proceedings until the members of the Iron and Steel Institute met again, on February 10th, at Westminster, and concluded the proceedings of the spring meeting. Mr. A. Pourcel contributed a paper on the application of thermal chemistry to metallurgical reactions. The writer thought that the opinion of Mr. Pattison, who had stated that the subject was still in its infancy, was slightly pessimistic, and hardly justified in the field of organic chemistry. He came to the conclusion from a long series of experiments. Two main facts were presented, viz., that silica did not decompose phosphate of iron, and that the temperature played only a subordinate part in the elimination of phosphorus. These views were forced upon him, and they completely upset the ideas he had acquired. Thermal chemistry in its application to metallurgy not only might be fertile in new views of the reactions, of which the theory was not firmly established, but the discoveries of the application would leave them less less at the mercy of empiricism. In the subsequent discussion a general feeling was expressed that they were only on the threshold of the subject, and Mr. Snelus (Workington) undertook to prepare a paper on the subject, giving the results of many experiments he had made in the same direction. Mr. Fred Gautier, of Paris, contributed a paper on the Thomasset testing machine. The paper stated that what was required for a testing machine was an exact measure of the strength, and an easy control of the power employed. The ideal testing machine would be such that the effort supported by the bar to be tested would be continuous, without shocks, and that the result should be measured exactly without the hand of the operator. The Thomasset machine was designed to work on this basis. Some of the members considered that the old lever-testing machine served all purposes, but Mr. Adamson thought the machine a very useful one. The discussion was not prolonged, as the members will see the machine itself in Paris in the autumn. A second invitation from America to spend a portion of the autumnal meeting of next year at the Alabama coal fields and ironworks was accepted.

A PRESENT NEED IN THE ENGINEERING PROFESSION.

(Concluded from page 296.)

To obtain the widest use and best advantage from these engineering laboratories, they should, as already indicated, be for public business, operated on a good commercial basis, with proper technical control, provided with trained engineers and specialists to conduct the trial and read results aright. Here, then, for test of material, process, or appliance, the engineer or others interested could send their material for proof and practical trial on a working scale, and at fair cost obtain reliable results, sending, if required, their own experts to watch or guide the work.

With such opportunities as these establishments should provide there is not likely to be wanting the means for profiting thereby. Besides commercial work, calling for more or less elaborate experiment, and yielding often new and important data, there would be special investigations in the interest of science and its useful application, promoted by private bounty and by such associations as are engaged in related work, or are benefited by its results.

Having thus briefly presented a suggestion of the means for meeting a much-felt want in the profession, I venture to refer, in conclusion, to an effort that has been made to carry out the suggestion and apply the plan in practice.

During the past year an establishment has been completed, and has already a record of eight months of successful practical operation, to which the name of St. Louis Sampling and Testing Works has been given. It includes a full line of machinery and appliances on a commercial scale for the crushing, sampling, milling, and concentration of ores; the washing, coking, and steaming test of coals, and for other related work, by the carload, or in lots of larger size. Special pains have been taken, in providing and setting this machinery, to secure every possible facility for varying the conditions and methods of operation, due attention being given also to such accessory apparatus as may contribute to more accurate trial and the reliable record of all working parts. Laboratories for assay and chemical work, and for physical tests, are provided to guide and control the work as well as promote investigation. Trained and experienced specialists are connected with each department, that the needed intelligence and skill for the most effective utilisation of these appliances may not be wanting.

So far the work has been mainly of a commercial character. This has developed to a very encouraging extent, and has been the means of proving the efficiency of the plant and its usefulness to the public. Even for the short time it has been in operation it would be difficult to estimate the amount of money that has been saved to many who were rushing blindly into the erection of expensive plants, or ignorantly experimenting with one costly process after another on a lavish scale. In the prosecution of this commercial work many valuable data have been obtained bearing upon important metallurgical problems, and special investigations have been undertaken from time to time to make the information thus gained more complete.

In several instances members of the profession have made use of the opportunities offered, and themselves conducted investigations to solve some special metallurgic problem in the interest of clients, or to test on a practical working scale some modification of process or new mechanical device.

In the education of students in metallurgy and engineering these works are performing also a most useful office. Indeed, it would be impossible to over-estimate the value of such advantages as are there offered the students of Washington University for becoming thoroughly familiar with the construction and use of the machinery and processes relating especially to mining and metallurgy. No argument should be necessary to convince members of the profession, or those who have occasion to employ young mining engineers or metallurgists, of the importance of practical training in works on a commercial scale.

In this way, it will be seen, a step has been taken still further in advance in the direction already indicated as important to the development of the profession and the many interests it serves. How far this movement will be successful, or in what measure it will fulfil the mission for which it was undertaken, will depend, in a large degree, upon the manner in which those connected with it discharge the responsibilities of their office, and the extent to which encouragement and assistance are given by those likely to be benefited by the work. Much, however, will depend upon the members of the engineering profession, and how far they make use of these and similar opportunities for advancing the interests of their calling.

MARINE ENGINE TRIALS.*

Report upon Trials of the Steamship Meteor.

Steamer.—The steamship Meteor is a steamer belonging to the London and Edinburgh Shipping Company, and permission to test her engines was most kindly given to the committee by Mr. Thomas Aitken, the manager of the company, who, with his staff and all the officials on board the ship, have done their utmost to facilitate the work of the trial. The Meteor is a vessel of 261ft. in length between perpendiculars, 32·1ft. in breadth, and 19·3ft. in depth moulded. Her registered tonnage is 692 and gross tonnage 1,223, under deck 958 tons. Her displacement on the day of the trial, when the mean draft was 15ft. 1½in., was 2,090 tons.

Engines.—She is fitted with triple-expansion engines, made by Messrs. J. and G. Thomson, of Clydebank, Glasgow. The high-pressure cylinder, originally 29in. in diameter, has been rebored to 29⅜in. diameter; the intermediate cylinder is 44in. diameter, and the low-pressure 70in.; the stroke of all three cylinders is 4ft. The piston rods are all 7in. diameter; the tail rod of the high-pressure cylinder is 4·45in. diameter, and the tail rods of the other two cylinders 4·37in. diameter. These rods have been measured; and the stroke of the engine has also been measured, and found to be exactly 47·94in. instead of 48in. There has been no opportunity of measuring the diameters of the cylinders.

The three cranks are spaced at equal distances apart, and follow in the order—high, intermediate, low.

The cylinders are made with separate liners, and are jacketed at the sides but not at the ends. The net length of the jacketed space is about 4ft. Live steam is admitted separately to each of the jackets, each having its own reducing valve. The jackets are drained through pockets provided with gauge glasses, and during the trial water was always kept visible in these gauges. The clearances of the high-pressure, intermediate, and low-pressure cylinders are given by the makers as 12·4, 9·3, and 8·02 per cent respectively.

Each cylinder is provided with a piston valve or valves, single for the high-pressure cylinder, and double for each of the others. The valve gear is the ordinary link motion, and during the trial the high-pressure motion was linked up as much as possible, giving a nominal cut-off of 26in.; the intermediate and low-pressure motions were not linked up. The valve gear was left untouched during the whole of the trial. The surface condenser has 3,200 square feet of condensing surface. The screw propeller is four-bladed, having a diameter of 14ft. 10in., and a mean pitch of 23ft. The actual area of the blades is 78 square feet, and the projected area 57·6 square feet.

The engines had been overhauled last at the annual survey, which took place March 1 to 14, 1888.

Boilers.—The boilers are two in number, each double-ended, the total number of furnaces being twelve. They are of steel, with Fox's corrugated flues, and have a diameter of 13ft. 6in. and a length of 16ft. The total grate surface in the trial was 208 square feet, and the total tube surface 5,760 square feet, the ratio between the two being 1 to 27·7. The total heating surface is 6,648 square feet, or 32 times the grate surface. The mean diameter of the flues is 3ft. 3in. The firebars are of ordinary description, 3ft. long, 1in. broad at top in body, and about 1½in. at the ends, the air spaces being thus about ½in. wide. There are 25 bars in the width of each furnace, and therefore 50 bars in each grate. There is no air admission at the bridge or anywhere except from the front and from below the bars. The tubes are 2½in. external diameter and 6ft. 4½in. long. The furnaces and tubes open out into a common combustion chamber. The two boilers have one chimney in common, whose internal diameter is 7ft. 3in.; the external diameter of the outer chimney is 8ft. 3½in. The chimney has a total height of 61ft. above the centre of the lowest furnace.

The total weight of the engines and boilers, including water in condenser, pipes, and boilers, and also spare gear, is 390½ tons.

Object of Trial.—The object of the trial was to measure the coal, water, and indicated horse power as accurately as possible, and over as long a period as possible.

Coal Measurement.—For weighing the coal a spring balance was used in each stokehole. From the spring balance was suspended a large basket, holding about 140lb. of coal; this, being filled, was hoisted by tackle, its weigh noted, and the coal then thrown upon the stokehole floor. About six baskets were filled and emptied as rapidly as possible, one after the other, first on the starboard side, and then on the port side of the stokehole floor, giving thus two weighed heaps of about 800lb. of coal each. The time at which each heap was finished (that is, completely put on the fires) was noted, and no more coal was weighed out until the floor was clear. A continuous record of coal thrown on the fires was thus kept, which plots out into the line of coal consumption shown upon the diagram. The fires were not cleaned during the run, but the cleaning commenced when the trial was over, and the ashes and clinkers were weighed before being thrown overboard. The coal was Scotch, from the Shawfield pit in the Wishaw district, its price at Leith being 7s. 6d. per ton. It has been analysed, and its calorimetric value determined by Mr. C. J. Wilson, F.C.S., of University College, London, with the following results:—

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*Report of the Research Committee of the Institution of Mechanical Engineers by Prof. Alex. B. W. Kennedy, F.R.S., Chairman.

Carbon	70·31	per eent.
Hydrogen	4·88	,,
Water	10·68	,,
Ash	3·46	,,
Nitrogen, sulphur, and oxygen	10·67	,,
	100·00	

These figures are the mean of two almost identical analyses. Reducing the hydrogen to the corresponding value of carbon, each pound of coal, not allowing of course for the bad lumps which formed the greater part of the clinker, is thus equivalent to 0·878lb. of carbon, and its calorific value may be taken as 12,790 thermal units.

Furnace Gases.—The temperature of the gases passing up the chimney was observed at intervals throughout the trial, the thermometer used being placed at the level of the upper deck, or about 12ft. above the top of the boiler. The thermometer was long enough to reach over 2ft. into the chimney. It was a mercury thermometer, having the space above the mercury filled with compressed nitrogen, so as to enable it to give readings far above the ordinary boiling point of mercury.

Samples of the gases from the chimney were collected during the trial, and placed in sealed bottles over mercury. Unfortunately, however, all the samples taken, except one, were spoilt before they reached the laboratory for analysis. The analysis of this sample has been made by Mr. C. J. Wilson, and is given later on.

The chimney draft was measured by a U-gauge at the place where the furnace gases were collected.

Feed Water Measurement.—The feed water was measured on its way from the hot well to the feed pump, the latter being a Worthington pump, entirely separate from the engine. A 4in. pipe was connected with the hot well, and terminated in a 4in. two-way cock, by means of which the discharge could be turned into either one or two measuring tanks. At the bottom these tanks were connected to another 4in. two-way cock, through which the feed pump could be made to draw from either of them. The tanks were so tilted that one corner was lower and another corner higher than all the rest, so as to render their filling and emptying more certain. They were fitted with glass water gauges and with relief pipes. The method of operation was as follows: The hot-well discharge—which contained the condensed steam passing through the cylinders, the jacket condensation, and also the steam used for heating the feed water, as well as the other quantities mentioned in the next paragraph—was allowed always to run into one or the other tank, and filled each one up in turn in about 3½ minutes. By means of the lower cock the feed pump was put into connection with the tank into which the hot well was *not* discharging, and emptied it in about 2½ minutes. For each tankful there was therefore about one spare minute in which to ensure its complete emptiness or fulness and to note the temperatures, &c. During this time the feed pump had to be stopped, being started again directly the next tank was full. After the trial the tanks were re-erected with all their connections at University College, London, and water carefully weighed into them. It was found that one held 1,808lb. and the other 1,785lb. of water at 62 deg. Fah.; and also that the probable error of the filling and emptying as carried out on the trial was not more than 2lb. in each tank, and was equally likely to be *plus* or *minus*. It seems, therefore, that the method of water measurement used, although very laborious, must have given very closely accurate results. A more elaborate system with storage tanks, which was preferred by the committee, could not be carried out for want of room on the vessel. The temperature of each tank was taken, so that a very good average value of the feed-water temperature was obtained.

The steam made by the boiler, corresponding with the measured weight of the water, all went to the main engine, except the small quantity required to drive the Worthington pump, which may be fairly considered comparable with the quantity required for the feed pump of an ordinary engine. The circulating pump, the dynamo engine, the winch engines, the steering engines, &c., were all worked from a donkey boiler, which was specially kept going for that purpose. The exhaust from the circulating-pump engine, and also that from the dynamo engine, were both taken into the condenser, and therefore were measured through the feed tank on their way to the boiler again. These additions to the ordinary air-pump discharge more than made up for the various losses of steam through the engine; so that from time to time part of the hot-well discharge had to be thrown away, and not taken back to the boiler. The whole of the pipe connections between the boilers and engines, which were of very great complexity, were carefully examined before the trial, to make sure that no unintended communication existed.

Power Measurement.—Indicator diagrams were taken at half-hourly intervals throughout the whole trial. Six Crosby indicators were used, one on each end of each cylinder; the connections in all cases were through only a few inches of large pipe, having in no case more than one bend.

The revolutions were noted half-hourly on the counter, all gauges being read at the same time.

General Conditions.—The general conditions as to speed, power, steam pressure, frequency of stoking, and so on were all those of ordinary working on a southward journey, and were fixed beforehand by the chief engineer.

Results.—The principal results and their leading points are the following:—

Duration of Trial.—The trial, which was made on a voyage from Leith to London, commenced at 1-30 a.m. on Sunday, 24th June, and ended for the engines at 6-36 p.m. and for the boiler at 6-39 p.m. upon the same day. Its duration was therefore 17 hours 6 minutes for the engines, and 17 hours 9 minutes for the boilers. This small difference of three minutes arises from the fact that the signal for ending the engine trial—that is, for taking the last reading of the counter—was given three minutes before the water in the boiler gauge glass reached the level from which it had started. The weather was fair throughout.

Fuel.—The coal used in the after stokehole was 16,675lb. upon the starboard side and 16,831lb. upon the port side. In the forward stokehole these amounts were respectively 18,242lb. and 16,945lb. The starboard boiler therefore used 34,917lb., and the port boiler 33,776lb. of fuel. The total quantity was 68,693lb., or 4,005lb. per hour.

At the end of the trial it was found on cleaning the fires that the ash amounted to 1,671lb., and the clinker to 2,806lb., in addition. The ash was therefore 2·43 per cent of the total fuel, the clinker 4·08 per cent of the total fuel, and the two together 6·51 per cent of the total fuel.

The mean temperature of the escaping gases, deduced from thirty-eight observations, was 791 deg. Fahr. The chimney draft was constantly about 5-16ths of an inch of water. The sample of furnace gases which was brought successfully to analysis gave the following results by volume:—

Carbonic acid	12·5	per cent.
Carbonic oxide	0·8	,,
Oxygen	5·4	,,
Nitrogen	81·2	,,

This sample was collected at 11-30 a.m. under normal conditions of working. During the greater part of the trial the fires were worked very thick, indeed as thick as possible, and they were so at the end of the trial; as already mentioned, they were not cleaned during the trial. Very much smoke was always emitted after stoking; but while no stoking was actually going on there was not much smoke. The times of stoking were noted frequently; and on the average it was found that stoking occurred in each stokehole about every 24 minutes, all the fires being stoked one after the other as quickly as possible.

Feed Water.—The mean temperature of the feed water, which was heated before leaving the hot well by an apparatus devised by Mr. Clephane, the chief engineer of the ship, was 163·1 deg. Fahr.; it was very fairly constant between 160 deg. and 170 deg. during the whole trial. At this temperature the amounts of water contained by the two measuring tanks are 1,771lb. and 1,749lb. respectively, these figures being found by calculation from those already given. During the trial the larger tank was filled 145 times, and the smaller 146 times. The total quantity of water used was therefore 512,150lb., or 29,860lb. per hour.

Speed.—The counter read 1,439,668 at 1-30 a.m., when the trial commenced, and 1,513,318 at 6-36 p.m., when the trial ended. The total number of revolutions made by the engines was therefore 73,650, the time being 17 hours 6 minutes, which gives the average rate of 71·78 revolutions per minute. The maximum number of revolutions per minute for any half-hour was 72·4, and the minimum 70·9.

Pressures, &c.—The mean barometric pressure during the trial was 30·34 inches of mercury, or say 14·9lb. per square inch. The mean boiler pressure was 145·2lb. per square inch. The other pressures were as follows:—

High-pressure jacket	130·0lb.	per	square inch.
Intermediate jacket	77·5	,,	,,
Low-pressure jacket	56·8	,,	,,
First receiver	36·5	,,	,,
Second receiver	6·2	,,	,,

All these pressures are given above the atmospheric pressure. They were observed every half-hour throughout the trial. The gauge for the boiler pressure was checked by a standard gauge; the other gauges were not checked, and their readings must therefore be taken as approximate only. The average pressure during admission to the high-pressure cylinder (from measurements of diagrams) was 134·4lb. per square inch. The actual initial pressure (or pressure just at the commencement of the stroke) was practically the same as this in the top diagrams, and 6lb. or 7lb. higher in the bottom diagrams. The difference between the average admission pressure and the boiler pressure was thus (assuming the gauge to be correct) 10·8lb. per square inch. The mean reading of the vacuum gauge was 24·78in. of mercury, or 12·17lb. per square inch below the atmosphere.

(*To be continued.*)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

POWER OF LOCOMOTIVE ENGINES.

To the Editor of "The Practical Engineer."

SIR,—In reply to "Locomotive Engine Driver," I send you the following: In the first place, nominal horse power is a term seldom, if ever, used in connection with a locomotive; neither is indicated horse power much used; but the formula used to find the tractive force may be easily converted into indicated horse power (probable). This formula is as follows:—

$$T = \frac{d^2 l p}{D} \quad \text{where}$$

d = diameter of cylinder in inches.
l = length of stroke in inches.
p = mean pressure on piston in pounds per square inch.
D = diameter of driving wheel in inches.
T = tractive force (probable) at rails in pounds.

This stated in words is: Multiply the diameter of cylinder in inches, squared by the length of the stroke in inches, and by the effective mean pressure on the piston in pounds per square inch. This, divided by the diameter of the driving wheel in inches, gives the probable tractive force in pounds at the rails.

To convert this into probable indicated horse power, divide the answer just found by the resistance per ton due to any velocity, and the result is the number of tons—including the weight of itself—the engine will pull at such assumed velocity on a level. If on an ascending gradient, the resistance per ton due to gravity must be added to the resistance due to velocity, or, if descending, subtracted. To find the resistance in pounds per ton due to velocity: Square the speed in miles per hour, divide by 171, and add 8, and the result is the required resistance. To find the resistance due to gravity in pounds per ton: Multiply the number of pounds in a ton by the rise in feet, and divide by the number of feet in which such rise takes place, and the result is the required resistance. Speed in feet per minute equals miles per hour multiplied by 5,280, multiplied by 60. Speed in miles per hour may be obtained as follows: Multiply the diameter of the driving wheel in inches by 2, and divide by 11; call the result seconds, and the number of revolutions the driving wheel makes in that number of seconds is the number of miles per hour at which the engine is travelling.

Having found the different weights, resistances, and speeds, then (probable)

Indicated Horse Power on a Level.—Multiply the gross weight in tons of engine and train by the number of feet per minute at which they are travelling, and by the resistance in pounds corresponding to such speed, and divide by 33,000. The result is the indicated horse power required.

Indicated Horse Power on an Ascending Gradient.—Multiply the gross weight of engine and train in tons by the number of feet per minute at which they are travelling, and by the resistance in pounds corresponding to such velocity, plus the resistance due to gravity; divide by 33,000, and the result is indicated horse power.

Indicated Horse Power when on a Descending Gradient.—Proceed as above, making the resistance due to gravity a negative quantity.

The above rules assume that the road is straight and in good order; also that there is no undue friction in engine or train. A bad road, frequent curves, stock out of repair, strong head or side winds, and internal disturbances in the engine itself, may increase the resistances 50 per cent. Not the least of the internal disturbances in the engine is want of or improper balancing, a point on which the paper mentioned is somewhat misleading.—Yours, &c., DREADNOUGHT.

QUERIES AND REPLIES.

23. **LIGHT MIXING MILL.**—I want names and addresses of makers of hand-power mixing mills suitable for mixing two light chemical powders. It must be simple, and require little power to drive.—EASTERN.

Answer.—Messrs. W. H. Bailey and Co., engineers, Salford, make mixing mills such as you require.

45. **BOILER SOLUTION.**—Would some practical reader inform me as to the advantage or disadvantage of using paraffin as a boiler solution? My employer has been recommended to use one pint per week. Size of boiler, 15ft. by 4ft., fired externally; no ventilation except through manhole on top of boiler. Would any explosive gases be left behind after emptying boiler for cleaning, thereby causing danger on entering with an exposed light? I should be glad of someone's opinion of the above.—COVENTRY.

Answer.—I beg to state that I have used it now for some number of years, and can speak very highly of it; and I may further say that we clean a boiler every other week—size of boiler, 28ft. × 7ft. 6in.—and after cleaning I generally put about 14lb. of common washing soda and two pints of paraffin, but have not found any gases to remain upon opening of boiler again; neither do I think from personal experience there is any danger. I have found it to be very good for removing scale from off my boilers. If "Coventry" blows his boilers off, say on Saturday, and takes his manhole lid off and enters it for cleaning, say on Sunday morning, he will find it will be quite safe to enter with a naked lamp, as I do myself, and have never found any gases to remain.—T. K.

44. **RESISTANCE OF PIPING TO WATER.**—Will you kindly permit me through the medium of your paper to ask if any of your correspondents will answer the following question, viz.: In a rising main of 3in. per yard, 400 yards long, composed of 200 yards of 4in. and 200 yards of 2½in. pipes, a pump is required to force through those pipes 30 gallons of water per minute. Will the resistance offered to the pump vary, and, if so, how much in each case, if the pipes were laid in the following order—

1.—200 yards 4in. pipes next the pump.
200 „ 2½in. „ delivery end.
400

2.—200 yards 2½in. pipes next the pump.
200 „ 4in. „ delivery end.
400

3.—100 yards 4in. pipes next the pump.
100 „ 2½in. „ the above.
100 „ 4in. „ „
100 „ 2½in. „ „
400

4.—100 yards 2½in. pipes next the pump.
200 „ 4in. „ the above.
100 „ 2½in. „ „
400

5.—100 yards 4in. pipes next the pump.
200 „ 2½in. „ the above.
100 „ 4in. „ „
400

6.—If the pipes were laid alternately—one 4in. pipe and one 2½in. pipe—throughout the entire range?—MEDIUM.

Answer.—In answer to above question on the resistance of piping to water, I beg to say that the friction of the water in such a main of pipes, delivering such a quantity per minute as here described, is equal to a head or column of water of about 7·048ft. high; and the difference of friction caused by the eddies at the junction of the larger and smaller pipes, as arranged in the methods 1, 2, 3, 4, and 5, will be so slight as to be almost inappreciable in comparison with the total friction. But in arrangement 6 the case is very different, as there is an eddy at each joint in the main, and although the effect at each joint is trifling, yet the sum total of their large number will make a considerable amount; and I am not aware that any experimental data are published that would give any assistance in determining what the amount under such conditions may be.—W. A.

35. **LOCOMOTIVE DRIVING WHEELS.**—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

36. **NUT CAST ON IRON SCREW.**—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and ⅜in. pitch.—SUBSCRIBER.

38. **DUPLEX MINING PUMP.**—Which is the best duplex action mining pump for use with compressed air, taking into account compactness and first cost as well as economy?—S.

39. **SEPARATE CONDENSER.**—Which is the best separate condenser for use with high-pressure engines, and state advantages?—H.

40. **BARFFING CAST IRON.**—Can any of your readers inform me whether cast iron which has been subjected to the process known as "Barffing" will withstand the action of a boiling solution of weak sulphuric acid? Also, can you give me the name and address of any firm where this process is carried out?—WORKS MANAGER.

41. **HOT-WATER PIPES.**—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft.? What book may I get on arrangement of greenhouse?—WATER-HEATER.

46. **LINING SHAFTING.**—Will some reader inform me the best way to put up some shafting in line with some already up; also some at right angles to it? I want to know how to line it up, and how to get the position of the plummer-blocks; they will be bolted against upright pillars.—R. D.

TO CORRESPONDENTS.

VALVE GEAR, Cheltenham.—You can silence the exhaust of a 4-H.P. portable engine very effectively by arranging a closed chamber, of about 3ft. high and 18in. diameter. Lead in the exhaust pipe from the engine at the top pointing downwards, and half fill with water, the pipe to come within about 3in. of the water. Provide an exit pipe from the top of the chamber, and have a drain pipe to keep the level of water constant. This arrangement, we know from experience, effectively silences the noisiest of engines. We shall give a description, with illustration, in an early issue.

R. A. G., Wellington.—Write to the Secretary, Leeds Association of Engineers and Draughtsmen, Leeds, who will no doubt oblige you if the paper has been printed.

J. M., Brixton.—We are much obliged for your drawings and description of your invention, but it is not suitable for illustration in our columns.

A NEW CHANNEL STEAMER.—The new Calais mail steamer which has been built for the London, Chatham, and Dover Company, and which will be placed on the service next month, has been named the Calais-Douvres, the name having been taken after the popular twin ship, which is now to be finally withdrawn from the service. The new vessel is built entirely of steel, and to insure additional safety in case of collision has been divided into nine water-tight compartments. The dimensions of the vessel are as follows: Length between perpendiculars, 325ft.; breadth, 36ft.; depth, 21ft. 6in. It is calculated that she will be the fastest cross Channel steamer afloat, and will make the passage between the English and French coasts easily in an hour. The vessel is being luxuriously fitted throughout, and, in addition to a fine deck-house and state saloon, has a large number of private cabins. The steamer has been constructed with a view to combine steadiness with speed, and has all the latest improvements in machinery and fittings. She will be lighted by incandescent electric lamps, and has been provided with embarkation arc lights.

MISCELLANEA.

Ground has just been broken in Edinburgh for the construction of a cable tramway, which, when finished, is to run between Princes Street and Stockbridge Park.

An examination of the Anson, at Portsmouth, has disclosed the fact that the beams supporting the barbettes were cracked by the simultaneous discharges of her 67-ton guns during the testing of the gun mountings.

THE USE OF CONTINUOUS BRAKES.—A Board of Trade half-yearly return shows continued progress in the use of continuous brakes on railways. In 1881 there were only 39 per cent of engines running and 48 per cent of carriages fitted with such brakes, but at the end of the last half year these numbers had risen to 94 and 91·5 per cent respectively.

CASTINGS WITHOUT SAND.—A Wakefield foundryman's patent is said to abolish sand in casting pipes. "In superheated steam or gas-jacketed metal moulds" pipes are cast which are uniform, sound, and true as if turned or bored by a lathe. The pipes so cast are not porous, and they have other excellent qualities, it is said. It would almost appear that sand in casting has been matter in the wrong place.

ELECTRICITY IN NEWCASTLE.—Mr. Milburn seems to have made a happy speech at the first meeting of the Newcastle and District Electric Lighting Company. He very neatly described the light to be supplied—"an innocuous and exhilarating and artistic light." He admitted that it would be at a higher price than gas, however; and if the gas companies will but continue to cheapen the price of their light, there will be room for both in the city.

A GREAT AND FAST PASSENGER STEAMER.—The first trip of the new passenger steamer Puritan, of the Fall River Line, from New York to Newport, viâ Long Island Sound, was made on the 24th April with much success. She attained a speed of over twenty miles an hour, with 65lb. of steam. When her new machinery is worked down and full power applied, which is 110lb., it is believed she will surpass in velocity any passenger boat afloat.

A HUGE ENGINE.—An engine for rolling steel rails, and believed to be the largest ever made for the purpose, is being erected at the works of the Palmer's Shipbuilding Company, Jarrow, by Messrs. Galloway, Limited, of Manchester. It has two cylinders of 6ft. stroke, and when working up to its full speed is capable of exerting 10,000 horse power. The crank-shaft is 21in. in diameter, and the forging for this shaft weighed over 40 tons. The weight of the entire engine is about 300 tons.

LAUNCH OF A LARGE OIL STEAMER.—On Friday, May 17th, Messrs. Craig, Taylor, and Co. launched from their Thornaby shipbuilding yard, Stockton-on-Tees, the largest vessel that they have as yet built. Her dimensions are as follow: Length over all, 301ft.; breadth, 37ft.; depth moulded to spar deck, 26ft. 8in. The vessel will carry about 3,200 tons all told, is specially constructed for carrying oil in the bulk in thirteen compartments, and is of the highest class in Lloyd's spar deck rule. She is rigged as a three-masted schooner.

ACCIDENT AT AN OLDHAM MILL.—A serious breakdown took place a few days ago at the shed of the Westwood Spinning Company, Oldham, causing a stoppage of work. The flywheel was broken, the arms of which were strewn about the engine-house, others going through the roof, damaging the adjoining buildings. The pinion wheel was also smashed, a large piece alighting in the card-room. Several narrow escapes occurred. Great damage was done to other portions of the engines, which only recently underwent extensive repairs.

On the 21st ult. the new screw steamer Cape Clear, built by Messrs. W. Dobson and Co., Low Walker, to the order of Messrs. W. Milburn and Co., Newcastle, was taken to sea on a trial trip. This vessel, which is a very fine cargo steamer, is built on the improved well-decked principle, and is of the following dimensions: Length, 265ft.; breadth, 37ft.; depth (moulded), 18½ft. She is fitted with powerful machinery by the North-Eastern Marine Engineering Co., of Wallsend, having cylinders 20in., 33in., 54in., with a stroke of 39in. The engines embrace all the most modern improvements and appliances, and during the trial ran with perfect smoothness, giving every satisfaction to all concerned.

THE NICARAGUA CANAL.—We hear that work on the Nicaragua Canal is likely to be indirectly started—so to speak—during the present month, inasmuch as dredging and pile-driving machinery and plant are expected to commence operations at Greytown for the purpose of opening the harbour for construction purposes for vessels of from 15ft. to 18ft. draft. To this end nothing more is required than to construct a short brush and pile pier to divert the shore current caused by the trade wind, and then to dredge a channel through the bar. The shore current tends to move sand westwardly along the beach, and so to close up the harbour. The work of permanent improvement to 30ft. draft of water will not be undertaken until a railway has been built some 17 miles inward to the great divide rock cut, and work on it has so far advanced as to furnish adequate rock spoil for the construction of the permanent pier of breakwater. Offers have been received already from bankers, it is said, for the entire proposed issue of bonds, on terms which cannot be called high, if not so good as is desired by the promoters. The prospects could hardly be better, it is believed, for the early beginning of work on the canal proper. The first point to be attacked will be necessarily the great divide rock cut. It is three miles long, and contains about 8,000,000 cubic yards of solid basalt rock, overlaid by from 2ft. to 20ft. of earth.

DYNAMITE SHELLS.—A New York correspondent intimates that J. W. Graydon's invention has for its object to enable shells loaded with large quantities of dynamite to be fired from ordinary guns with the usual powder charge. The improvements consist mainly in sub-dividing the shell charge into a number of small portions or pellets, each consisting of dynamite enclosed in a flexible envelope or paraffined paper. A further subdivision of the charge may also be effected by means of partitions, perforated or otherwise. In order to prevent the dynamite from becoming fired by the heat generated by the explosion of the ordinary propelling powder charge in the gun, the shell charge is entirely surrounded by an envelope of non-conducting material, such as asbestos cloth.

LAUNCH OF A STEAMER AT STOCKTON.—On Thursday, May 16th, Messrs. Richardson, Duck, and Co. launched from their building yard at South Stockton a steel screw-steamer of the following dimensions, viz.: Length over all, 307ft. 4in.; breadth extreme, 40ft.; depth in hold to tank top, 19ft. This vessel has been built for Messrs. Thos. Wilson, Sons, and Co., of Hull, under the personal superintendence of Mr. J. F. Wilkins, the owners' surveyor. She has a long raised quarter deck, with a long bridge joined to the forecastle, and a double bottom, on the cellular principle, extending fore and aft for water ballast. Her engines, by Messrs. T. Richardson and Sons, of Hartlepool, are triple expansion, and have cylinders 22½in., 37in., and 61in., with 39in. stroke. As she was leaving the ways the vessel was christened "Douro" by Miss Stothart, daughter of Mr. James Stothart, Stockton-on-Tees.

THE DEVELOPMENT OF THE GAS ENGINE.—Messrs. Crossley Bros., Limited, of Gorton, who were the first to introduce gas engines to this country, have just completed two pair of double-cylinder engines for a paper works at Godalming which are the largest and most powerful gas engines ever yet constructed. Each pair of engines is 100 horse power, and in addition embraces a number of improvements, the chief of these being a new system of ignition known as the tube ignition, dispensing with the old slide arrangement, which was rather a weak point in the gas engine. With regard to the economy of working, these engines, which are driven on the Dowson gas principle, are guaranteed to work with a consumption of coal not exceeding 1½lb. per horse power per hour, and we understand that Messrs. Crossley are prepared to make engines of a similar type to work with the same weight of consumption of coke.

THE FOUNTAINS AT THE PARIS EXHIBITION.—One of the many features of the Exposition Universelle, now being held at Paris, is a set of magnificent illuminated fountains, the production of Messrs. Galloway, Limited, Manchester, who were contractors for similar constructions for the Exhibitions at South Kensington, 1886; Manchester, 1887; and Glasgow, 1888. The present fountains are, if possible, more effective and beautiful than their predecessors. There are over one hundred nozzles, varying from three-eighths of an inch to about two inches in diameter. There is one centre jet with a ring of jets surrounding it, then a circle of jets somewhat smaller than the centre one, each of these being also encircled by a ring of jets; and, again an outer ring having other forms of jets, also a system of sprays which are arranged for giving a feathery, fern-like display, which is very effective. Eighteen hand-fed electric lamps, the total power being equivalent to over a quarter of a million candles, are used to illuminate the sprays of water. Before each lamp are provided slides containing tinted glasses. These slides are arranged in such a manner as to allow of any change or combination of colour, the whole of them being controlled by one man.

IMPORTANT EXPERIMENTS ON THE EIFFEL TOWER.—A Paris correspondent of the *Daily News* says M. Jannsen, of the Academy of Sciences, claims to have made a discovery which upsets part of the theory on the analyses of celestial bodies by means of the spectroscope. Last Sunday week the electric lamps of the Eiffel Tower were turned on the Meudon Observatory, which is 7,800 metres (four miles seven furlongs) away. He reckons that the mass of air lying in a given section of that length at the height of the tower is equal to the atmospheric mass above. M. Jannsen argues from this that the number of molecules of air encountered by a beam of light sent from the Eiffel Tower to the observatory is about the same as that met by sunlight on its way to the earth when the sun is near the zenith. He then shows that if the analogy holds true, the belief that the sun contains oxygen is unfounded, and that its spectrum contains the characteristic oxygen rays; this is due to the oxygen of our atmosphere. One of the fundamental theorems of spectral analysis is that the width of the characteristic bands of a gas is proportionate to the number of molecules that intercept the light. Now, in the experiment referred to the most important rays of the oxygen group were precisely similar to those of the solar spectrum. The conclusion M. Jannsen draws is that there is no oxygen in the sun.

ILLUSTRATED PATENTS.

17,175. Phonographs and Phonograms, G. E. Gouraud, Surrey.—(A. Edison, Llewellyn Park, New Jersey, U.S.A.)

Fig. 1 is a top view of the complete machine. Fig. 4 an end elevation, and figs. 9 and 11 are central sections of the recorder and reproducer respectively. The frame consists of a top plate A and bottom plate B formed each with four arms, and connected by vertical posts *a*, to which are attached the yokes of four magnets C, C¹, C², C³, each projecting towards the next post *a*, to which its pole pieces are connected by non-magnetic bars *b*. The poles project inwardly, forming a circle, within which is mounted a flywheel D¹ carrying armatures D², which pass close to the poles of the electro-magnets. A commutator is placed on the shaft of the flywheel, and the connections from the battery are so arranged that a continuous rotary motion is given to the flywheel D¹. A swinging weight arm d^2 breaks the circuit when the speed becomes too great; a slow and regular motion is thus produced. On the top plate A is journalled the shaft F carried by supports h^1, h^2 in the centre and at one end respectively of the machine. The shaft F projects beyond the support h^1 and is there free to receive the tapered phonogram cylinder G, which is held on the shaft by a spring pin h^3. Its inner end is made as a bevelled wheel *i*, which is driven by a bevelled friction pinion on the vertical shaft of the flywheel D¹, and pressed against the cylinder by a spring. Between the supports h^1, h^2, the shaft F is cut with a very fine screw-thread *j* having ratchet teeth; on the outside is a hand-wheel j^1. Parallel to the shaft F is a guide rod H on which slides a tube *k*, to which is attached at one end the holding arm I carrying the recording and reproducing apparatus, and at the other the guide-arm *l* engaging with the screw *j*, with which it is kept adjustably in contact by the spring l^2. On the arm I at m^2 is pivoted the frame I¹, made in the form of a spectacle frame with two eyes; the movements of the frame are limited by the set screws m^4 in the horns m^3, so that either the recorder or the reproducer (which are fixed one in each eye) is in operating position. Fingers with adjusting screws n^2 rest on a guide-rod K, which supports the frame at the desired elevation another rest H¹ is provided to support the arm I, which is thrown back. Passing through the arm I is a cutting tool L, pressed by a spring *o* against the cylinder, and I adjusted by a screw o^1. This cutter L is designed to turn off the surface of the cylinder. Above the frame I is a plate M with a tube M¹ connected to the hearing and speaking tube; the recorder and producer are each swung under M¹ as desired. The recorder N (fig. 9) is a circular plate with a central opening p^1, and a light diaphragm N¹ free at its edges. The steel recording-point p^2 is secured to its centre by wax, &c., and passes through a lever p^3, in which it is secured by a spring p^4; a rubber tube p^5 covers its intermediate portion. The lever p^3 is pivoted at p^6 and rests against a block *q*, faced with rubber q^1 and adjusted by a screw q^2. A spring q^3 with rubber face q^4 gives the diaphragm an initial strain. This arrangement limits the amplitude of vibration of the diaphragm. The reproducer (fig. 11) has a plate *o*, with an opening *u*, and a thin animal membrane o^1 secured by two rings u^1, u^2. A fine spring wire u^3 forms the reproducing point and is attached to the diaphragm by a piece of rubber u^4. The phonogram P may be made in sections, and is formed of strong base material, such as plaster of Paris, covered with wax, &c. A scale on the guide rest *k* allows the instrument to be set to any particular point. A pan T is provided to collect shavings. A heated burnisher is sometimes placed above the cutter L, consisting of a platinum strip heated by electricity, or a silver strip heated at one end by a spirit lamp.—December 14th, 1887. [11½d.]

FIG. 1.

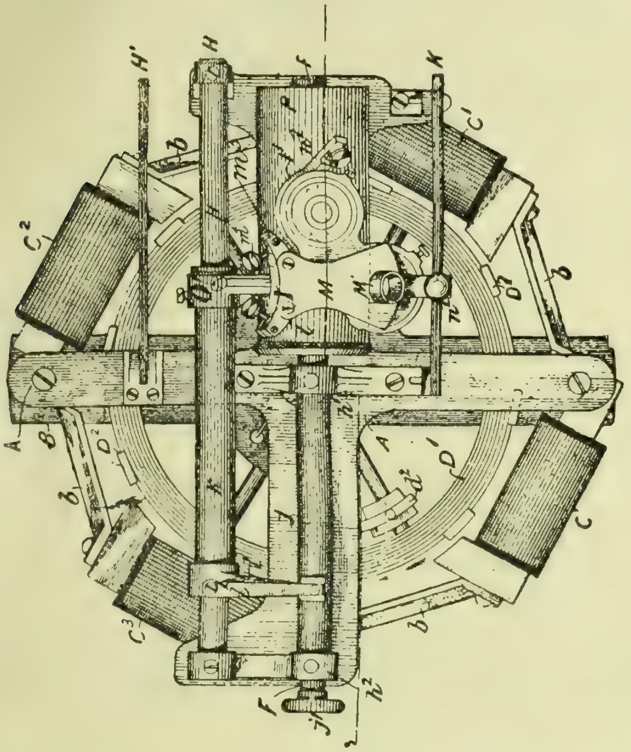


FIG. 4.

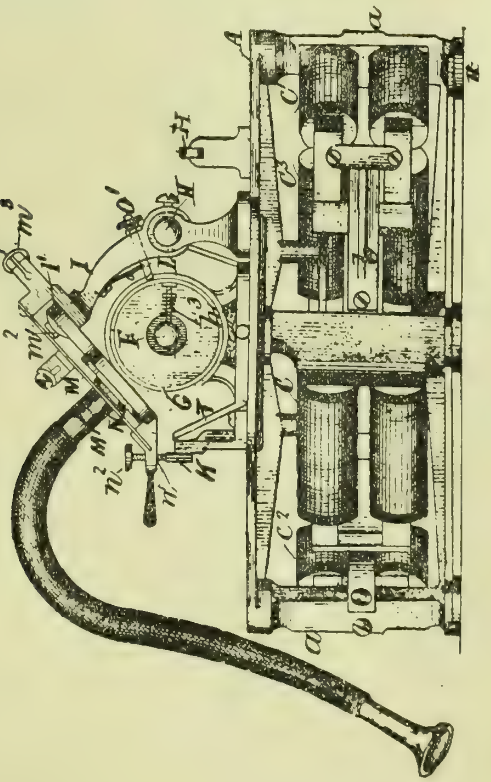


FIG. 9.

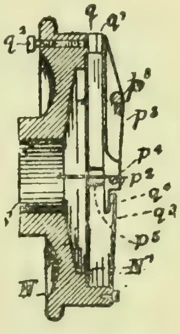
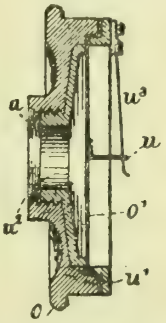
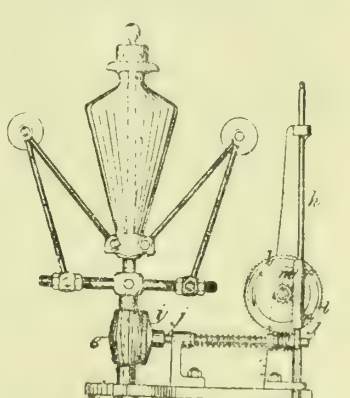


FIG. 11.



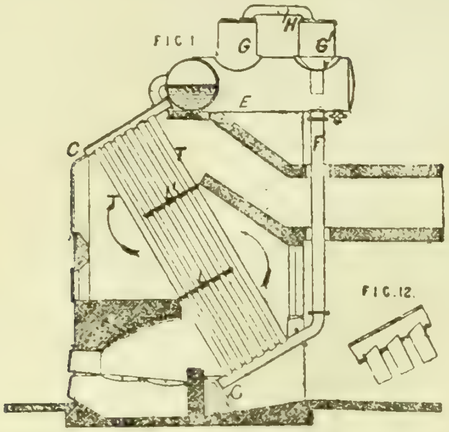
17,496. Engine Governors, S. Dawson, Mossley, Manchester.

The governor, in addition to operating the throttle valve through a lever in the ordinary manner, is furnished with an auxiliary mechanism, by which, upon a slight departure in either direction from its normal position, the governor further operates the throttle valve by shifting the fulcrum of the said lever. The drawing shows an example of the arrangement, though the invention is not confined to any particular form of governor or mechanism. On the shifting spindle of the governor are two sleeves *d* and *e*. The former of these operates the lever *f*. This is connected with the throttle valve by the rod *g*, and is fulcrumed at f^1 to the end of the verticle rod *h*. The latter sleeve *e* has a double coned surface, which frictionally drives a dished disc *i* by its upper or lower edge, according to whether the governor rises or falls. This disc, through the shaft *j*, drives the toothed and friction gearing *l*, *m*, whereby the rod *h*, and thereby the fulcrum of the lever *f*, is raised and lowered.—December 20, 1887. [8½d.]



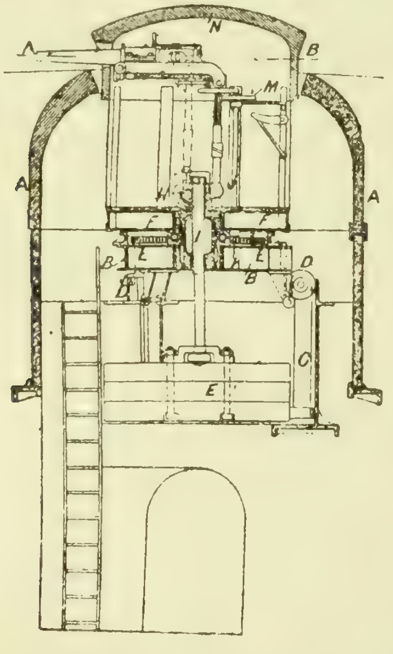
17,697. Sectional Steam Generator. P. Hanrez, Brussels.

Consists in improvements in the general arrangements and details of water-tube boilers. The inclined tubes T opens at their ends into upper and lower sheet-iron headers C, C¹. The headers may each be formed of a single chamber or of several narrow passages corresponding to the number of vertical tube-rows. Steam is delivered from the upper header C into the transverse portion of the T-shaped steam and water drum E. Thence it enters the dome G, and if not drawn off to the motor from the steam pipe H, passes into the dome G¹, whose bottom is enclosed by the funnel-shaped pipe I dipping below the level of the water within the drum. The return pipe F may be dispensed with by cutting the ends of the water tubes as shown in fig. 12. By this means the steam issuing from the tubes frees itself without counteracting the course of water along the sides of the header and allows circulation to take place in the tubes themselves. The partitions L, L¹, determining the course of the furnace gases, are made up of narrow sections and are supported in place by collars around the tubes. The tubes and lower header are suspended from the upper header C, which is secured to the metal framework of the boiler. By this arrangement free expansion is allowed for.—December 23, 1887. [8½d.]



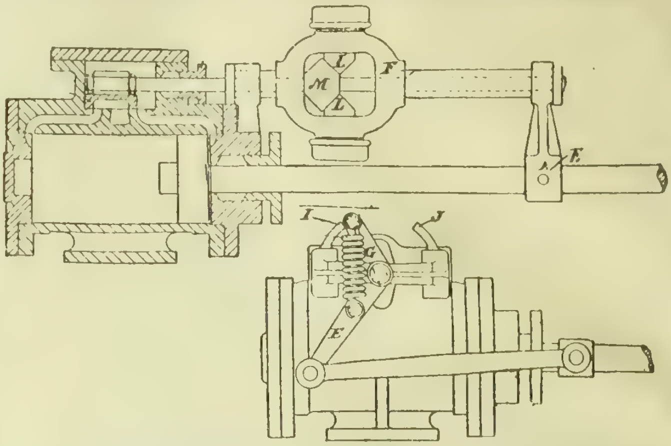
17,702. Turret Mounting for Quick-firing Gun, T. Nordenfelt, Westminster.

The platform is made in two parts, the upper one F being provided with training gear M, J, K, L, while the lower one B is supported by chains C passing over the pulleys D to the counterweight E. The upper platform carries the pinion H, which gears with a tooth rack I pivoted to the counterweight. The mounting is projected by the armour A and carries a domed roof N, which is raised as shown when the gun is to be fired. The gun slide is provided with elevated gear and with a screw for running the gun in and out.—December 23, 1887. [11½d.]



17,720. Valve Gears for Fluid-pressure Engines and Meters, J. H. Holmes, Newcastle-on-Tyne.

Relates to such engines as direct-acting steam pumps, or water meters of the piston type, and consists in an arrangement wherein the valve is shifted by a spring, which is compressed and made to pass over a dead centre by the movement of the piston rod. Two arrangements are shown illustrating the application of the invention to oscillating valves, and one to sliding valves. Oscillating valves, operating: The valve is rocked by an arm G having a limited movement between two stops I, J. On the same centre, and reciprocated from the piston rod, is a lever E connected with the arm G by a spring. Thus, as the piston rod approaches either end of its stroke, the direction of the pull of the spring passes from one side of the arm to the other, resulting in a corresponding movement of the valve. In another arrangement the spindle of the valve carries a rhomboidal cam block grasped by the extremities of a U-spring attached to the lever E. The action is similar to that in the first device. Sliding valves, operating: A casing F slides on the valve rod through a limited distance, terminated by stops, acquiring its movement from the piston rod. The casting is formed with a central open portion, in which are a pair of sockets turned towards the valve rod, containing a pair of spring-protuded V-pointed studs L, L. These bear against a double V-block M on the valve rod, so that when the casting F is shifted at the end of each stroke by the piston rod, the points of the V studs pass over those of the block, with the result that the valve is given a movement in the opposite direction.—December 24, 1887. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

May 6th.

7522 Electric Ignition, H. Sumner, Kilmarnock.
7524 Steam Boats, C. Clough, Halifax.
7525 Stone Cutting, S. Dearden and W. Dearden, London.
7526 Arc Lamp, A. U. Alcock and H. Galopin, Manchester.*
7528 Velocipedes, H. Tolley and C. Truman, Birmingham.
7529 Railway Cars, W. Smith, Aberdeen.
7531 Abating Smoke, H. J. Newcome, Shenley.*
7533 Ignition of Gas, H. Sumner, Kilmarnock.
7535 Lubricating, J. E. Farrow, J. Worthington, and J. M. Carson, Manchester.
7539 Condensing Smoke, J. T. Ellis, London.*
7543 Moulding, The Metallurgical Patents Co., Limited and J. E. Bott, London.
7544 Speed Register, Ernest de Pass, London. (E. Millery, France.)
7552 Artificial Fuel, W. E. Gedge, Middlesex. (P. J. Leteneur, France.)
7560 Nut-locking Devices, A. Vogt, London.
7561 Governor, La Société Douge Frères, London.

May 7th.

7594 Gas Engines, E. Crowe and H. Crowe, Middlesbrough-on-Tees.
7597 Dry Galvanic Cells, C. H. Mehner, Liverpool.
7601 Steam Engines, P. D. Bowie, Hull, Yorkshire.
7604 Air Compressors, H. C. Sergeant, London.*
7605 Automatic Valves, H. C. Sergeant, London.*
7606 Channelling Machines, H. C. Sergeant, London.*
7608 Motors, W. H. Clayton and C. A. Soring, London.*
7629 Moulding, F. Köhler, London.*
7643 Journal Boxes, R. W. Moffett, London.*
7644 Gas, J. T. Key, London.
7645 Conduits, G. W. Cook, London.*
7646 Brick-making Machine, H. Kefershein, Germany.
7654 Ammonia Plant, P. J. Davies, Middlesex.

May 8th.

7665 Couplings, H. Krätke, London.
7669 Controlling Machines, R. Thomas, Liverpool.
7676 Pipe-cutting Machines, A. Morton, Birmingham.
7678 Weighing Machines, J. Jamieson, Glasgow.
7701 Air Propellers, A. Scott, Barnsley.*
7704 Carding Engines, G. Hurst, London.
7738 Propellers, H. C. Vogt, London.

May 9th.

7748 Steam Engines, S. Robinson, London.
7752 Water Gauges, T. B. Winter and C. Winter, West Newcastle.
7763 Hollow Bridges, F. Naylor, London.
7785 Steam Engines, R. Kennedy, Glasgow.
7791 Pulp Engines, H. E. Newton, Middlesex. (R. Kron, Germany.)

May 10th.

7808 Electrical Alarum, A. Julian, Basingstoke.
7842 Mechanical Stokers, W. Sunderland, Halifax.
7843 Wheel Gearing, W. J. Brewer, London.
7847 Water Gas, R. S. Baxter, Broughty Ferry.
7848 Refrigerating Chambers, W. Howlin, London.
7854 Carburetted Air-gas, G. P. Armstrong, London. (G. Jaunez, France.)*
7858 Drivers' Valves, G. Westinghouse, jun., and F. Moore, London.
7862 Earthenware Pipes, W. J. Bassett, London.

May 11th.

7868 Electric Meters, W. Emmott and W. Ackroyd, Halifax.
7870 Electric Generator, J. Gozo, London.
7885 Pistons, J. H. Mitchell, Halifax.
7886 Hardening Steel, W. Potter, Manchester.
7889 Gas Regulator, J. Taylor, Nottingham.
7890 Starting Machinery, J. Taylor, Nottingham.
7891 Hoists, J. Taylor, Nottingham.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE
PRACTICAL ENGINEER,
MAY 31st, 1889.

THE WATER-GAS MANIA.

SOME time ago we discussed the proper uses of gaseous fuel, and enumerated several of the purposes to which it could be applied with advantage, including metallurgical operations where a high temperature was required, and boiler work such as welding. At that time the large water-gas companies had not been floated, and public interest had not been aroused to the extent which now very generally prevails. It is difficult for engineers well informed upon the subject to understand the water-gas mania—for we fear that it must be so designated—as no great advance or new discovery has been made, and the knowledge of the matter remains pretty much as it has done for many years back.

We fear that investors in these companies labour under some illusions regarding the nature of their property, and its probable future as a competitor with ordinary coal gas. It is not our purpose to deprecate in any way the advance of the industrial application of gaseous fuel, or under-value the legitimate use of cheap gas for manufacturing purposes or for the production of power; but, nevertheless, we consider it our duty to warn the public against the indiscriminate investment of capital in amounts far in excess of legitimate requirements, and therefore in sums which cannot be expected to be profitably employed or to yield fair dividends.

In our opinion, the sums already subscribed are considerably in excess of the present possibility of profitable employment, and it is to be hoped that investors will be warned in time, and decline to find any further capital for water-gas schemes. It may be said that it is rather the province of the financial journals to discuss matters of this kind; and so in many cases it may be. In the present case, however, it lies with engineers to inform those interested of the engineering purposes to which water gas can be applied, and to estimate the probable extent of those applications.

The name water gas is to some extent misleading, as it seems to indicate a gas prepared from water only; however, it has the sanction of years of use, as the first water-gas processes date from the beginning of the century. The earliest process proposed was as follows: Coke or anthracite was heated to incandescence within a retort by an external fire, and water was slowly dropped upon the coke or steam passed over it. If the temperature was sufficient, the incandescent fuel decomposed the water, and the carbon combined with the oxygen to form carbonic acid gas, while the hydrogen was liberated. The carbonic acid, coming in contact with further masses of incandescent carbon, was decomposed, and formed, with added carbon, the gas carbonic oxide. The gases evolved by the action were therefore hydrogen and carbonic oxide, in about equal volumes. The reaction absorbs a great amount of heat, which has to be supplied through the walls of the retort by the combustion of the fuel outside, and this constituted the main difficulty of the process, as it was hardly possible to supply heat fast enough, and at the same time ensure durability.

The Lowe and Strong water-gas process was invented over twenty years ago to overcome this difficulty, and it forms the basis of the method now prominently brought forward. A generator cylinder was lined with refractory material and filled with fuel (coal or coke), ignited and raised to incandescence by blowing up with air; then the air supply was cut off and steam passed through the incandescent fuel, carbonic acid and hydrogen were formed and collected in a gasholder, the temperature quickly fell, and after a short time the steam was cut off and the air blast again applied to get up the heat again. To prevent loss of heat while "blowing up," the gases leaving the generator at that time were discharged through a regenerator formed with bricks, and the steam on its way to the fuel was passed over those bricks and highly heated. In this way most of the heat passing away in the heating stage was picked up by the steam before decomposition, and all the gas obtained was comparatively free from diluting nitrogen.

In the apparatus at work in Leeds under the supervision of Mr. Samson Fox the regenerative process is omitted, and the diluted gas produced by the "blowing up" is not burned in a regenerator, but is conducted to the works' steam boilers and burned under them to raise steam. In this way, according to Mr. Fox's calculation, published in a paper read before the Hull and District Institution of Engineers and Naval Architects,* the large amount of 88·5 per cent of the total heat of the fuel is obtained in the form of gas, and 38 per cent of the original heat of the fuel is obtained as water gas, while 50·5 per cent is the weak producer gas. The strong gas obtained by blowing in steam is known as the water gas, and it consists of about 52·5 per cent by volume of hydrogen, 45·7 per cent of carbonic oxide, and about 2 per cent made up of oxygen, nitrogen, and carbonic acid. The weak gas known as producer gas contains 31 per cent of combustible.

The fact that so large a quantity of the total heat is discharged with the weak producer gas at once limits the usefulness of the new method to cases where that gas can be utilised for steam-raising or some other purpose. For this reason alone it is exceedingly improbable that the process could be applied to the lighting of a city to compete successfully against ordinary coal gas. A water-gas works, established to supply a city, would require to find some means of utilising one half of the whole heat of the fuel consumed in water-gas manufacture, and produced in the form of a diluted gas containing only 30 per cent of combustible constituents. Now, it is difficult to see in what way this gas could be efficiently utilised unless it were made slightly richer by the addition of some water gas, and distributed in separate mains for heating and power purposes. This would, however, add very considerably to the cost per 1,000 cubic feet of gas, as the interest on the large amount of capital so absorbed would form a large proportion of the total expense. It should not be forgotten that although water gas represents 38 per cent of the total heat of the fuel from which it is produced, and coal gas only 22 per cent, yet in the case of coal gas there is the saleable residue, coke, as well as other saleable residuals, the first of which represents a considerable further proportion of the heat of the fuel, and the other a considerable money value per ton of coal. The coke and residuals go a long way to make up for the necessity of more expensive fuel for coal gas, even when the whole heat of the water-gas process can be utilised; but if the weak producer gas had to be burned uselessly, then we are distinctly of opinion that ordinary coal gas is by far the more economical.

There is still another point upon which we have not touched. Water gas burns with a non-luminous flame, and must be further treated before it can be used as an illuminant. In America, where the older process is used, and by means of the regenerator no weak producer gas is formed, over 100 towns, including a portion of New York, are illuminated by water gas; but cheap oils are decomposed into gas and mixed with it so as to make it give a luminous flame. This considerably increases the cost, and as a matter of fact coal gas is cheaper than water gas there, and is sold on an average at 9s. 6d. per 1,000 feet, while water gas costs 10s. 6d. Although both gases would be much cheaper in this country, yet it is difficult to see why the relative proportions should change. It is true that here the magnesia comb is to be utilised, and the light is to be obtained by incandescence. But incandescence methods have been as yet commercially unsuccessful, even with the ingenious and well-known Welsbach light; and we fear that the experience of American gas engineers has conclusively proved that carburetting is the only practical process.

In view of these circumstances we do not hesitate to affirm that water gas can never hope to compete with coal gas as an illuminant for large towns so long as our present rate of coal supply maintains. Should coal at any future time become very scarce and dear, no doubt it might be necessary to use the cheapest possible fuel to make water gas, and then add hydro-carbons from oil or richer coal; but that contingency does not require consideration in the immediate future. For motive-power purposes, such as supplying gas engines, it has no advantage over the well-known Dowson gas, unless distributed from a central works to the users; then no doubt gas engines would work better with it than with the Dowson.

The really legitimate use of the water gas is for the purpose to which Mr. Samson Fox has applied it, namely, welding and working iron, and when so used at any works it will no doubt be advantageous to adopt it for lighting purposes as well. But, after all, this application is comparatively limited, and, so far as we can see, quite insufficient to profitably employ a capital anything like £1,000,000, the sum, we observe, stated as probably subscribed to water-gas companies and sub-companies.

A NEW WHITE LEAD.

A COMPANY has been formed to manufacture a new white lead, which is stated to possess important advantages over the ordinary compound, viz., in permanence of colour in a bad atmosphere and increased covering power for a given weight. The ordinary white lead of commerce, when free from adulteration, consists of carbonate of lead formed by exposing rolls of pure sheet lead to the action of the fumes of acetic acid and carbonic acid arising from decomposing tan. After some months of exposure, the lead is thickly crusted with carbonate, which is then scraped off and ground in water. The process is slow and expensive; many attempts have been made to supersede it, but hitherto without success. The new white lead is not the carbonate, but the sulphate of lead. It is not what chemists are accustomed to call white lead at all, but nevertheless the sulphate prepared by the new process is said to surpass ordinary white lead for all purposes to which that substance is ordinarily applied. It is prepared directly from galena by roasting in a furnace, and condensing the fumes or vapour of sulphate of lead, which is formed by the oxidation of the sulphide. The sulphate is collected from the condenser, washed with weak acid, and after drying is ready for the market. We understand that this process, besides being very rapid and continuous, is much safer for the workpeople engaged upon it, as the sulphate is much more insoluble than the carbonate, and therefore but slightly poisonous.

White lead of the old kind has been found so admirably adapted for many purposes that users will naturally be slow of belief in any substitute; but we hope, nevertheless, that its new rival may have a fair trial. Without doubt, if found superior, it will in time be generally adopted.

Sulphate of lead, we can readily understand, will be very stable in colour, as the sulphuretted hydrogen which exists in sufficient quantity in our town air to slowly blacken ordinary white cannot affect it.

STREET AND RAILWAY TRAFFIC IN LONDON.

MR. J. S. JEANS has read an interesting paper on this subject at a meeting of the Society of Arts, full of statistics relating to the extensive growth of the Metropolis during the last thirty or forty years.

At the beginning of the present century the population of London was less than 1,000,000; at the present time, assuming an average annual increase of 50,000 since the census of 1881, when the population was returned at 3,816,000, the number of 4,250,000 must have been reached. With all this increase in population there must necessarily be a proportionate increase of traffic, and Mr. Jeans said that with regard to passenger traffic by railway, omnibus, tram-car, and river steamers, the number of passengers carried annually was some 470,000,000, being nearly twelve times the present population of the United Kingdom.

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* See *Practical Engineer*, p. 88, vol. iii.

In view of this, we think the proposed Electrical Underground Railway will be very acceptable as a relief to the conjested traffic which now exists in the metropolis.

There are, no doubt, strong objections to the increase of underground ways of communication in London, and it is quite true that wherever the underground railway penetrates property depreciates in value. Still, on the other hand, we have to face the inevitable alternative of an extension of the street traffic, which is already rendering many of our principal thoroughfares almost impassable.

But as Mr. Jeans points out, within 12 years the increase in the number of passengers carried on the six metropolitan railways that chiefly deal with local traffic has been about 72,000,000, or, including season ticket holders, probably about 100,000,000. The limits of carrying capacity have almost been attained, and the time is not far distant when some other means of transport will have to be provided.

We agree with Mr. Jeans in thinking that the subject is one that would be worthy of prizes offered by some body such as the Society of Arts for suggestions as to the best means of mitigating the evils that now beset our street traffic, whether by new systems of transport, by additional lines of railway or tramway, or by any other practical methods.

ENGINE PATTERNS.—I.

Introduction.

In this series of articles I shall describe some methods of pattern construction adapted to more difficult sections of engine work, including in this cylinders, valves, guides, covers, crossheads, condensers, flywheels, &c.; and shall give more than one example in most cases. I trust that these descriptions will be of interest to the class of men to which the writer belongs. I shall assume that my readers are pattern-makers, and will quite understand tools, appliances, preparation of stuff, drawings, and so forth. Acting on that assumption, I shall not enter into details of an elementary character in the descriptive articles. Perhaps, however, it will be best for the benefit of the members of other branches of engineering, and for the amateur and general reader, who take an interest in these things, if I impart to this first article, a somewhat elementary character, and discuss principles.

In the first place, there are no rigid rules of construction in patterns. Because a man has been accustomed to work on one particular set of lines, it does not follow that his methods are the best that can be devised. Some one else may devise a more excellent way. The same man will employ different methods at different times. Further, there are few patterns which do not admit of more than one mode of construction; and of two or more methods each may sometimes happen to be equally good. Also, alternative plans have to be considered from two or three points of view. One, the primary, consideration, is that of the safest, simplest, and on the whole most convenient method of moulding; another is that of the strength, durability, and permanence of the pattern itself; and yet another in some cases, convenience, and utility of reversal and alteration. In patterns formed intricately these points will open up a wide field for thought and scheming, and no pattern-maker who is not pretty well acquainted with moulding as well as with his own trade can settle them in a manner satisfactory to himself and to the foundry men. Examples bearing on these points will be noted as they arise.

Unless drawings to full size are sent out into the shops, it is quite necessary in all except the simplest work to make such drawings to work from, the object being to measure thereby precisely the quantities of stuff required, to fit awkward joints with precision, as in building up various work, to ensure correspondence of prints, core boxes, and patterns, so that the risks of excess or diminution of metal shall be lessened, and the making of templets for various sections, and also sometimes to judge appearances and just proportions. But to save labour, in many cases, drawings of the more involved details only may be done, omitting the plainer work. Sometimes the work itself is utilised for sectional drawing, a broad face of pattern or core box being improvised for the purpose, the sections belonging thereto being lined out in their exact position thereon. This is pattern-makers' work. Here finish is not essential, but accuracy is, because it is impossible to ensure correct correspondence of cores and patterns without careful attention to details in drawing out. Nothing looks much worse than to see metal thick in one part and thin in another. Sometimes differences of this kind are not observable in the casting, but the moulder sees them in the mould, and in any case, when considerable in amount, they are a hidden source of weakness. In intricate passages, much curved in more than one plane, it is often impossible, or at least very difficult, to show the curves complete on a board. Then two or three principal sections are drawn, and the patterns and boxes worked partly with templet, partly by the eye, and the first core or cores made for trial. Afterwards the box is modified, if found necessary, to the shape required.

There are certain fundamental matters which should be regarded in the making of engine patterns. The first relates to the soundness of portions which have to be machined. Where possible these should be cast downward in the mould. But there are many cases when they must be cast in the top. Thus a main slide valve will have to be faced in both top and bottom, and there can be no choice of method. One face must unavoidably be in the top, and the moulder will probably run through a skimming chamber and mould in dry sand.

In cylinders it would generally be desirable to cast the valve faces down, because the presence of only a few small blow holes about the edges of the ports would be sufficient to condemn the casting. But if the valve face is cast down, there must be a portion of the bore in the top, and there the metal will consequently be more open than is desirable. So the general practice is to cast the cylinder with the axis of the bore vertical, and to allow the lighter metal to accumulate in an annular "head," which is subsequently turned or slotted off. Then there is necessarily some considerable risk of an unsound valve face occurring, because dirt is apt to lodge underneath the bend of the cores. Various precautions are therefore taken to lessen the risk of such lodgment, and to allow very free exit for the gases. Chief of these are, pouring the metal from the top and bottom simultaneously, so that it is kept both in constant agitation and hot, by which devices the risk of lodgment and stagnation of dirt underneath the core edges is much diminished; grooves are also filed in that edge of the passage core which is uppermost and abutting against the main body core, in order to allow of the free exit of gases coming from below.

The casting of a cylinder on end does not necessitate a jointing of the pattern transversely to the bore. The jointing takes place longitudinally, and the cylinder is moulded upon its side, and when the mould is finished and cored up it is turned bodily upwards for casting.

The materials used for engine patterns are usually yellow pine for those of large size, and mahogany for the smaller ones. In the case of standard patterns, from which large numbers of castings will be required, even the larger ones will be made of mahogany. Red deal may be employed for the plainer core boxes, but is seldom used to any great extent. For some patterns, again, which are small and moulded many times, cast iron or gun metal are the most suitable materials. In such parts as slide valves, cylinder covers, glands, and pistons, plate or machine moulding may be profitably resorted to.

It is almost superfluous to say that timber for engine work should be of the best, and well-seasoned. But it may not be so obvious to all that the greater the number of pieces of which these patterns are composed, the less risk there is of subsequent change of form accruing. There will be dozens of separate pieces in a cylinder of ordinary type, and this elaborate building up is true economy in the end. Engine work is worth nothing if not accurate. There are so many faces and centres which are mutually dependent, and whose correct relations are essential to perfect results, that too much care cannot be taken in working closely to dimensions, and in so selecting materials and building up in detail that the work shall stand the usage of the foundry and atmospheric influence.

All jointed patterns, as cylinders and work of similar character, should be very true in the joint faces, because those faces are utilised for gauging and squaring dimensions and lines and other faces from. In building them up, a joint board should be employed. This fulfils the same purpose for the pattern maker that the marking-off table does for the fitter. It consists of three or four narrow strips of stout board laid together edge to edge, with slightly open joints, and battered and screwed. The face is then planed over with as near an approach to accuracy as possible, until straightedge and winding strips reveal no error. Boards of this character may vary from 3ft. to 6ft. in length, by from 18in. to 3ft. in breadth. The stuff should be stout, say from 1½in. to 2in. in thickness. Upon these boards cylindrical work is built up with lagging strips, the pattern joint being laid upon the face of the board. Also work in more or less advanced stages is laid upon the board, and measurements taken up therefrom with scribing blocks, calipers, or rules; or faces are tested and adjusted with set squares therefrom, or other faces are made parallel therewith by means of straightedges laid across, and their distances measured from the board face. Sometimes the work bench itself is used for these purposes. But it is not a good plan, because benches are seldom quite true, and their surfaces, even though generally level—that is, not winding—become rough and uneven with use. Moreover, it is more convenient in large work to use a joint board supported on trestles, and so leave the bench clear for working upon—its proper function.

In reference to shrinkage, I should say that, as a rule, an allowance of ⅛in. in from 12in. to 14in. is correct. But there is a difference in castings of different sizes, and judgment must be used. In small cylinders and cored-out valves the shrinkage will be almost nil, the presence of hard cores apparently checking it. In dimensions as low as 8in. or 10in., then, he can work to standard rule. But in large work, notwithstanding the presence of cores, the shrinkage will be nearly of the usual amount.

The most important sections of cylinder work are the ports. They are so narrow, and so little allowance can be left for filing or milling out, that it is of the first importance that they be very accurately placed, both in reference to spacing, and at right angles with the bore. It is better when avoidable not to join the prints for the port cores across their centre lines, because one half then comes in the cope, and the cope therefore has to be lowered over half of the depth of the cores, involving risk of their disturbance. It is preferable to make the prints for these cores in the steam chest core box, or else to make port cores in one with the steam chest cores.

The allowances for machining will depend upon the character of the work. The larger the casting, the greater the liability to variations in size, due to breaking and mending up of the moulds; the greater the uncertainty of the amount of shrinkage, and the more likely are the cores to become out of truth. Since, also, most of the dimensions of faces are of great importance, it is wise to allow something extra where experience tells us there is uncertainty of the issue. In small cylinders the allowance for boring is usually ¼in., but ⅜in. is a better allowance in those of over 10in. or 12in. diameter, while in those of 3ft. or 4ft. ½in. is not too much. On valve and other faces formed directly by the pattern, ⅛in. is usually sufficient. In faces formed by cores, it is sometimes desirable to increase this.

All small engine work should be protected from atmospheric influence, and from the moisture of the foundry moulds. Paint or else shellac varnish are used, it matters little which. The first coats should be thin, to penetrate the grain fibres, and so prevent the entrance of moisture; the second or third coat will have more body to form a glaze of sensible thickness, which will facilitate delivery. A very good plan, especially when work is intricate and cast in jobbing foundries away from the pattern shop, is to use three different colours, one for core prints, and one for faced portions, and the third for the ordinary unfaced surfaces of the castings. This will often prevent mistakes where intricate cored work is concerned, and it will give the moulder a better chance so to arrange his runners and risers, and position for pouring, that the casting shall be soundest and cleanest where it requires facing, boring, or turning. J. H.

DOWNIE'S SEGMENT PISTON PACKING.

Notwithstanding the numerous types of packing rings in use, there is still room for improvement in securing perfect steam tightness, together with absence of friction and uniform pressure all round the cylinder, especially in large marine engine pistons. Messrs. H. and C. Grayson, of 179, Regent Road, Liverpool, have manufactured a new type of metallic piston packing recently, and have applied it successfully to a large number of steam vessels. We illustrate it fully on page 375, and an examination of the drawings will show that it consists of a series of segments AA, and form two or more rings, and riveted together so as to overlap and leave considerable freedom between the segments. Inside of this segmental ring is a brass ring B, also cut in segments, but arranged to break joint with the divisions in A A, and having snugs or projections, which are pressed upon by springs C. The springs cause each of the brass segments to press gently outwards, so that every portion of the outer ring is pressed against the cylinder, and the riveting gives the segments sufficient liberty of movement to allow of its pressing against the cylinder.

Referring to our illustrations, fig. 1 is a plan of the piston showing rings and springs, together with sections of various parts. In that figure the sections J J J J J show different methods of applying the invention to different pistons.

Fig. 2 is a view of the packing ring and spring from the interior, and fig. 3 is a vertical section through the piston.

We are informed that the pressure upon the packing rings is so uniformly distributed over the whole surface that a very slight intensity is required to keep the rings quite steam-tight, and the wear is quite inappreciable. The engineer of the steamship Pallas, after the vessel had made four voyages to Calcutta and back, in all some 64,000 miles, with Downie's rings in the engines, opened up the cylinders, and found the walls like glass and the rings in perfect condition, so that he put on the cylinder covers again without touching them. He states that to all appearance they will run as much again without the necessity of readjusting, and that although he had used no lubricant whatever.

As the parts are very light, the packing is very easily handled, and all vertical wear is prevented; one man can handle all, and they can be passed through a manhole in the cylinder cover, which is sometimes an advantage.

THE USE OF SPIRIT AS AN AGENT IN PRIME MOVERS.*

The paper which I have the honour to submit to you this evening has been prepared at the request of the Council of your Society, and deals with the use of spirit as an agent in prime movers. It is not intended to treat of the adoption of spirit or liquid hydrocarbons, such as petroleum, when used as a substitute for coal as fuel, which is an entirely distinct subject, but with the use of volatile liquids in lieu of water, to produce power, when converted by heat from the liquid to the vapour state, in the same way that power is obtained from the conversion of water into steam.

I may mention that in the year 1856 this subject attracted much attention in France, and as a matter of fact, several large steamers were built and ran between Marseilles and Algiers, in which ether was evaporated in combination with steam for working the propelling machinery. I am indebted for the information concerning these vessels to Mr. F. K. Barnes, late of the Admiralty, who visited and made a passage in one of them in order to report to the British authorities concerning their performance. The engines were on the Du Tremblay system; the steam, after having performed work in one cylinder, instead of going at once to the condenser, was used to evaporate ether in a tubular evaporator, by which means a portion of the remaining heat in the steam was absorbed instead of being wasted; the ether vapour so produced was used in another cylinder, the additional power thus obtained being a clear gain. These steamers ran, making regular voyages, for some years, but were ultimately abandoned. To more clearly explain the main features of this system I would ask you to refer to the diagram No. I (on the wall) which gives an outline of the arrangement. A is a steam boiler; B is an ordinary inverted direct-acting steam-engine; C is the evaporator containing a number of tubes through which the exhaust steam from B passed; the body of this evaporator contained ether, which absorbed heat from the exhaust steam, and was converted into vapour, which passed on and worked the ether engine, D; E is the surface condenser in which the ether was condensed.

The gain obtained is clearly due to the ether taking a portion of the heat of the exhaust steam and turning it to useful account, which would otherwise be wasted in raising the temperature of the condensing water. The ether used evaporates at about 104 deg. Fah.; it will therefore be seen to what a low temperature the steam or water can be brought down, and still be useful in evaporating the ether.

The system was no doubt economical as regards fuel, but the ether was so difficult to keep that a renewal of about one gallon per hour was required to make good the leakages. There was also serious risk of explosion on account of the leakages, because the

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* Paper read by Mr. A. F. Yarrow, before the Society of Arts, 22nd May, 1889.

DOWNIE'S SEGMENT PISTON PACKING.

CONSTRUCTED BY MESSRS. H. AND C. GRAYSON, ENGINEERS, LIVERPOOL.

(For description see page 374.)

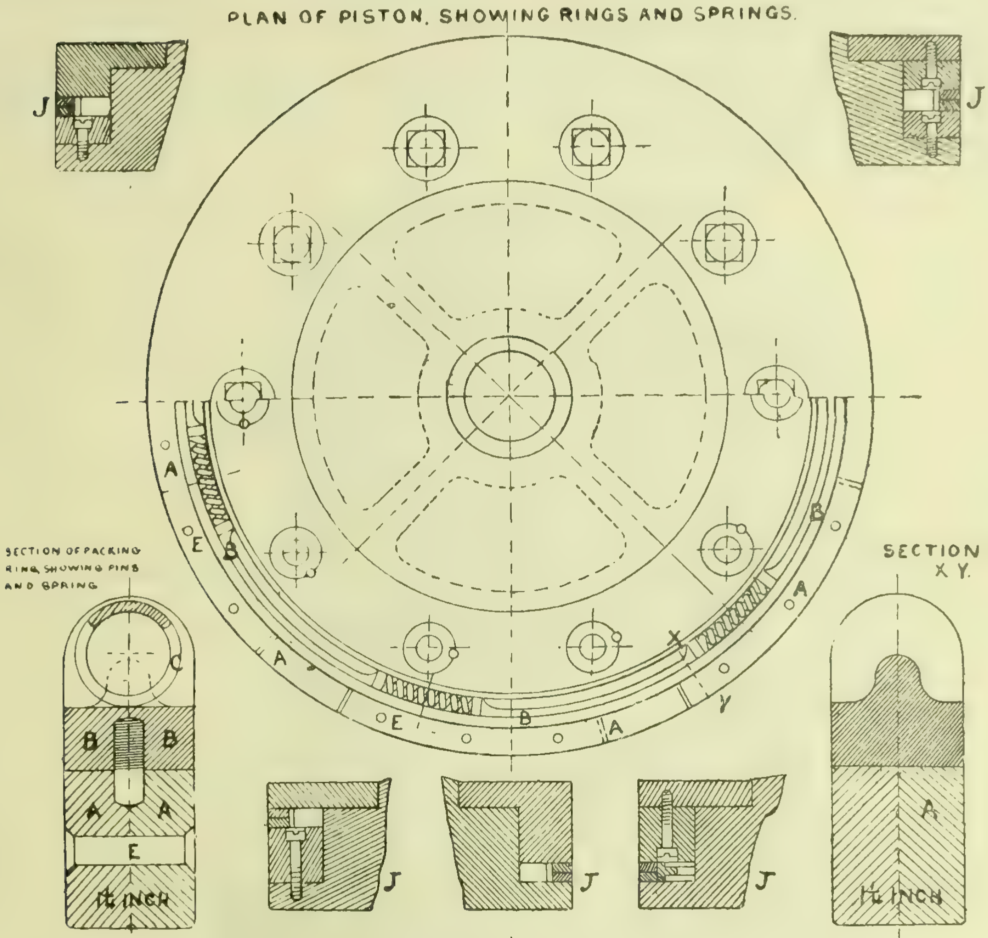

PLAN OF PISTON, SHOWING RINGS AND SPRINGS.
J
A
B
E
C
X
Y
SECTION OF PACKING RING, SHOWING PINS AND SPRING
SECTION AT X Y.
1½ INCH

Fig. 1.

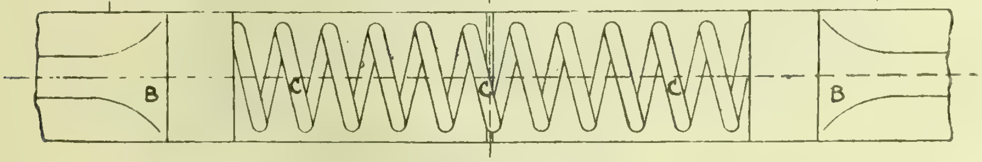


Fig. 2

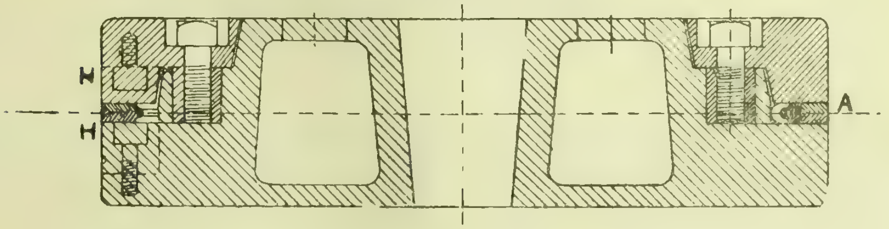


Fig. 3

ether, when free, rapidly vaporises, and when in this state is explosive if mixed with the atmosphere. The difficulties which at that time had to be dealt with are, however, now greatly reduced. Ether being the spirit used, was far more costly than other volatile liquids which are available now, and, consequently, any leakage then represented an important item in the working expenses. Also, at that period, means for obtaining good workmanship were not available to the engineer as they are at present, and I may mention that accuracy of workmanship and soundness of materials are essential points in dealing with the vapour of these volatile liquids, as it penetrates joints and castings which no steam would do; in fact, an amount of care is necessary beyond what is needed in the best steam-engine practice, and sufficiently good work was not available thirty-two years ago.

My attention was first drawn to the subject by the success of some small boats lately built in the United States, propelled by spirit vapour, and we took the matter up with a view to investigate it, and see whether the results would justify our going fully into the matter with a view to its further development. I am glad to say that these preliminary investigations look promising; the results obtained I propose to lay before you this evening.

The apparatus with which our experiments were tried I shall now proceed to explain, and trust to be able to make the whole arrangement perfectly clear to the meeting. It will be seen that we have a small steam engine, of ordinary construction, which actuates a shaft and flywheel in the usual way. There is a brake attached to the shaft, with a spring balance and index; also a revolving counter, so that we are enabled to obtain the actual power developed. There is also fitted to this little engine an ordinary indicator, from which to obtain diagrams.

The steam boiler has no special feature about it; it has simply a combustion chamber and a straight flue through to the funnel. There is no attempt at economy of fuel, because there was no object in so designing it; all we wished to obtain being the comparative results on a common basis. The heat is obtained by means of ordinary gas, burnt in a large Bunsen burner made by Messrs. Fletcher and Co., of Warrington. We selected gas as the means of heating because the exact quantity could be accurately regulated and recorded, and with this view there is attached to the inlet pipe a gas meter. From the boiler to the engine is led a steam pipe. The exhaust from the cylinder passes out and terminates in a coil of pipe immersed in a tank of running water for the purpose of condensing the steam; this tank is on the right-hand side of the apparatus. From there the condensed steam runs into a hot well, and passes on to the feed pump on the engine, and is forced back into the boiler, so that an entire circuit is made. This completes the arrangement for working the engine by steam.

Now, for the corresponding system, when spirit vapour is used, inside the upper part of the boiler is a copper coil, the inlet to which is at the side, and the outlet at the top, whence it passes to the engine. The exhaust pipe from the cylinder is led in this case into the tank on the left-hand side of the apparatus, where the vapour is condensed and passes on to the hot well, thence to the pump, and is forced back into the coil inside the boiler, thus making this circuit complete.

(To be continued.)

AN IMPROVED CANDLE-MOULDING MACHINE.

A VERY considerable amount of study and care has been devoted to the design and manufacture of candle-moulding machinery, which has resulted in the construction of exceedingly efficient machines. Messrs. J. and W. Barlow, of Moss Bridge Ironworks, Rochdale, have had great experience in the design and manufacture of these machines, and they have recently produced a new machine in which one defect, common to all the older types, has been very neatly overcome.

In order that our readers may thoroughly understand it, we illustrate at fig. 2 the older type of machine for producing candles with plain ends, for which the arrangements are well adapted. It consists essentially of a series of moulds arranged above a set of spools, upon which candle wick is carried, and having fitted within them a number of pistons. The moulds are stationary, but the pistons are movable, and are attached to a rising board actuated by racks and pinion gear. The wicks pass from the spools through the pistons and rods to the candles from a previous operation held above the moulds in clamps, and are thus self-centred. It may be stated that at the first operation a dummy set of candles are cast in order to hold the wicks for the next set. After that each set of finished candles holds the wicks in position for those following.

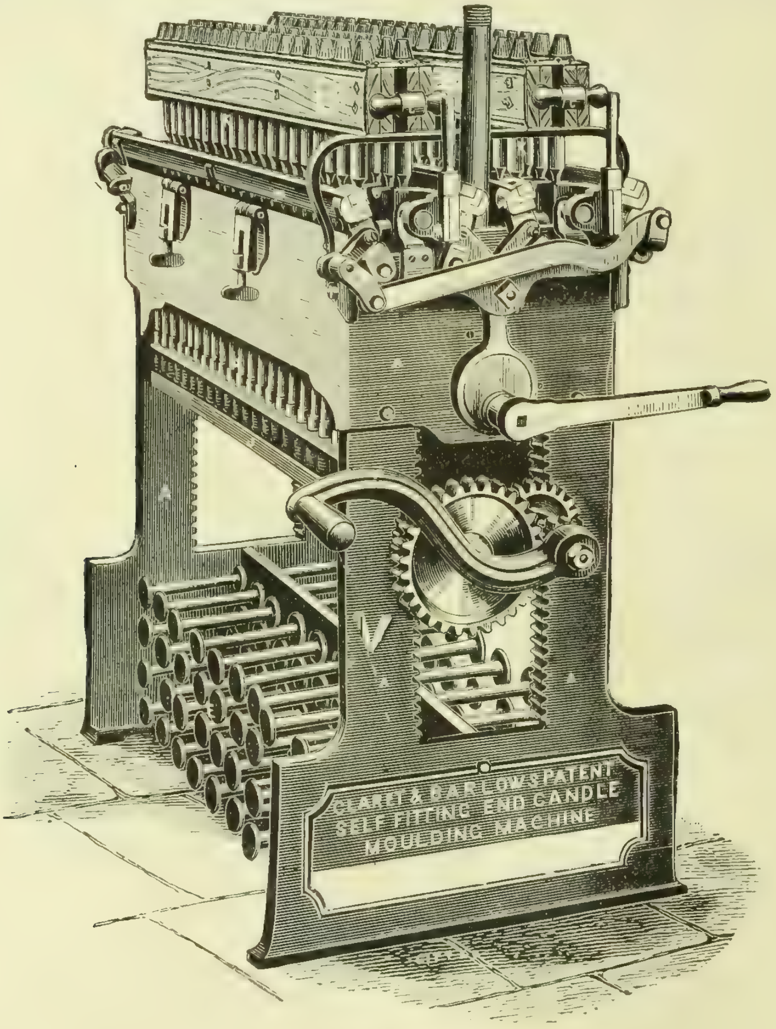


FIG. 1.

So far this is the mode adopted in making plain candles, but in the well-known self-fitting candles, with conical ends, a great deal of hand work has been hitherto necessary in order to mould the conical end of the candle, which is cast upwards, and a separate plate has been provided. This makes it impossible to use the continuous wicking arrangement, and Messrs. Barlow have very cleverly adapted the requirements to the necessities of the case by a device embodied in the machine shown in fig. 1. It consists of a frame and water box A, in which box the moulds are enclosed and surrounded by water. It is found that candles take a higher polish when the moulds are cooled.

Pistons D, perforated for the wicks, pass into the moulds, and are attached to the wrought-iron driving or lifting board J. Clamps B, above the machine, serve to hold the candles when ejected, and are opened out by eccentrics, controlled from the handles C C. The iron rods for carrying the wick spools are seen on the lower part of the machine. The action is similar to that already described, but the plates covering the top of the moulds are each made in three parts, and controlled from the lever H and the levers N. Assume the candles made by the last operation to be held in the clamps B, with their conical fluted ends upwards, and the wicks stretch from their tips to the spools below, passing through each mould.

On moving the levers H N N, the top plates, one of which is marked M, fold over and cover the moulds, but the holes making the conical ends are formed in the plates. There are four rows of moulds in the machine, and three plates above each pair serve to make the four rows of conical holes. In the centre plate of each pair the halves of two rows are formed, and the two outer plates, closing on the moulds and fitting to the edges, form the other halves of the holes, so that when the six plates are all in position four series of holes are formed by their junction, just as if the plates were solid. The material is run in the usual way, and at the proper time the levers H N N are moved to open out the external plates, and turn the inner ones on edge, when the candles are free to be ejected by winding up the driving board J carrying the pistons. The two racks seen in the frame and gearing, driven by a handle, serve for this purpose. The clamps B are opened by the handles or levers C, and when the candles pass through by the action of the pistons, they are gripped and held by closing. All is now ready for a fresh operation. After moulding a set of candles, the wicks in the set held in the clamps are then cut, and the finished ones removed.

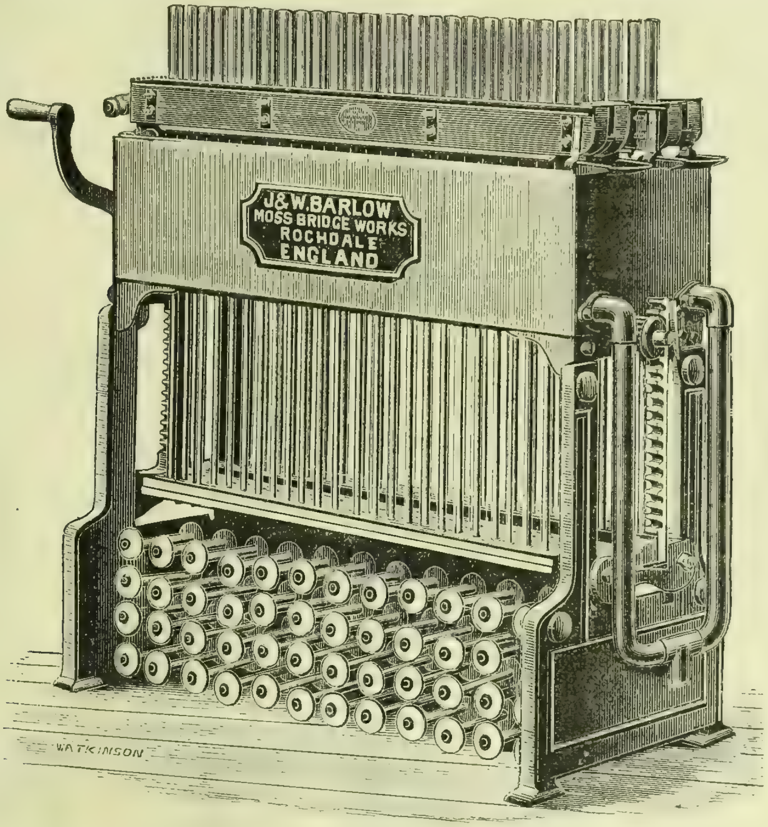


FIG. 2.

We are informed that this mechanical top plate accomplishes admirable work and saves a great deal of time, so that candles with self-fitting ends can now be moulded at no greater cost than those without. The machine may be operated four times an hour, with an output of 448 candles.

The machine is also fitted with other improvements of the Messrs. Barlow, among which we may mention a spring attachment of each piston to the driving plate, which allows each to be a perfect fit in its mould, and makes them independent of each other. Should some obstruction seize one the others are not prevented from reaching the bottom of the stroke, and thus uniformity in the length of the candles is attained, while the perfect fit of each piston prevents loss by leakage. The moulds, too, are not of the usual cast construction, but are rolled and drawn by a special process, which secures great smoothness of surface. We are informed that Messrs. Barlow are perfecting a machine to make ornamental candles of any pattern. This we hope to describe in a future issue.

DISTILLATION OF MINERAL OIL FROM PEAT IN BRAZIL.

THE *Bulletin de Musée Commercial* for the 20th April last, with respect to the distillation of mineral oils from peat in Brazil, says :—

"Under the heading of 'Brazilian petroleum,' the *Comercio* of Amazonas gives interesting details respecting the distillation of peat, which is carried on by a large firm at Marahu. Up to the present there have been worked 10 beds of an area of 82 hectares 9,640 metres square. The value of the beds may be gathered from the fact that solid peat is met with up to a depth of 150ft. without any signs announcing the end of the bed being found.

"The firm employs at the present time 300 workmen, and 33 boilers, with washers, stills, refrigerators, steam sawmill, foundry, forges, &c. The workshop, fitted with the latest improvements, can produce 3,000 cases per month. The paraffin will be used for candles; the plant is being set down which will produce 80 tons monthly. Besides, from the raw material itself a lubricating oil for all kinds of machinery is extracted.

"The concessionnaires have constructed a large quay, 14ft. deep, where two ships of 900 tons have already been berthed to be unloaded."

A new rotary engine has been patented by Mr. Marcellus, A. Buford, Thompson's Station, Tenn., U.S.A. The casing has steam inlet and exhaust chambers, a main driving shaft being mounted to rotate in the casing, while a wheel with central discs having inlet openings in their peripheries is secured on the shaft, exhaust discs being secured to the central discs, and the construction is adapted to the use of steam, air, water, or other suitable fluid.

NEWALL'S HIGH-SPEED ENGINE.

CONSTRUCTED BY MESSRS. J. F. BLYTH AND CO., ENGINEERS, LONDON.

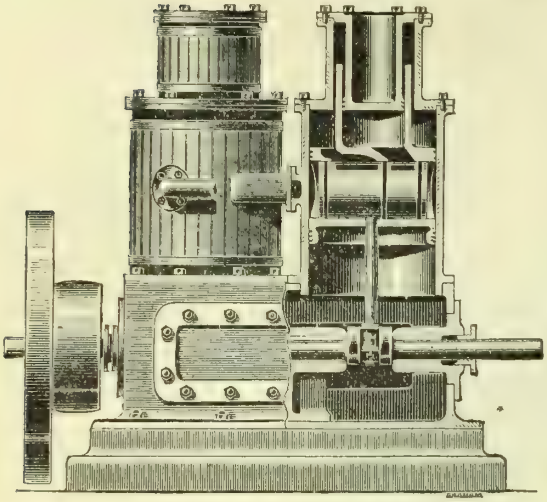


Fig. 1.

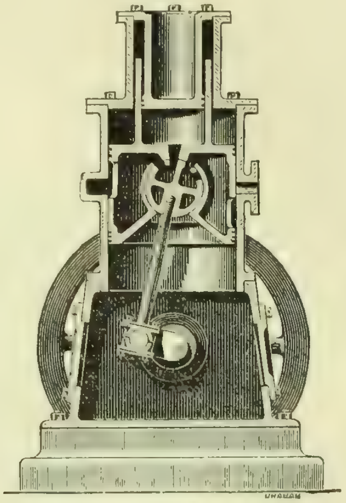


Fig. 2.

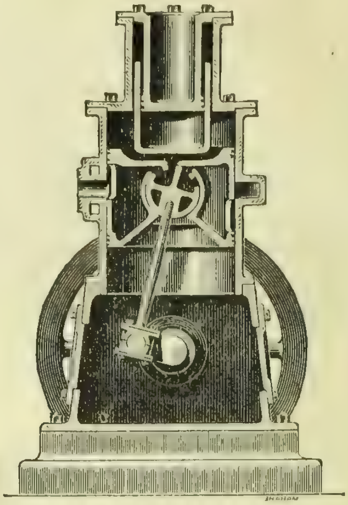


Fig. 3.

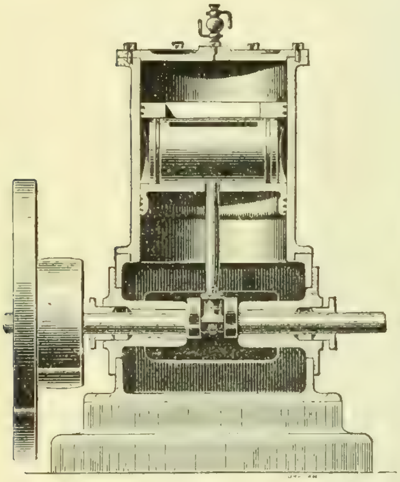


Fig. 4.

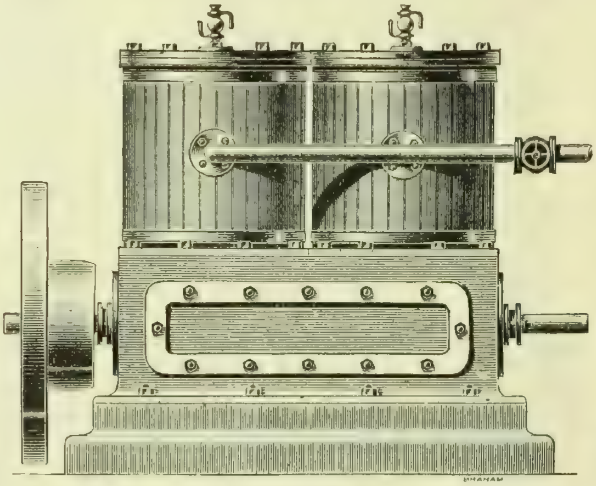


Fig. 5.

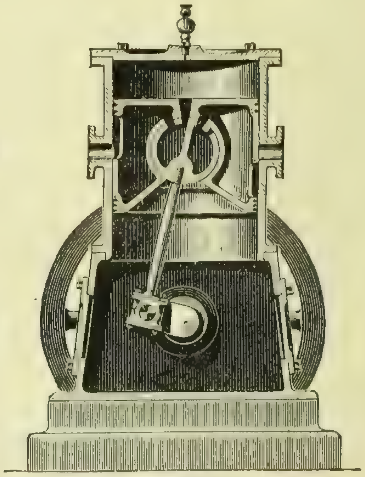


Fig. 6.

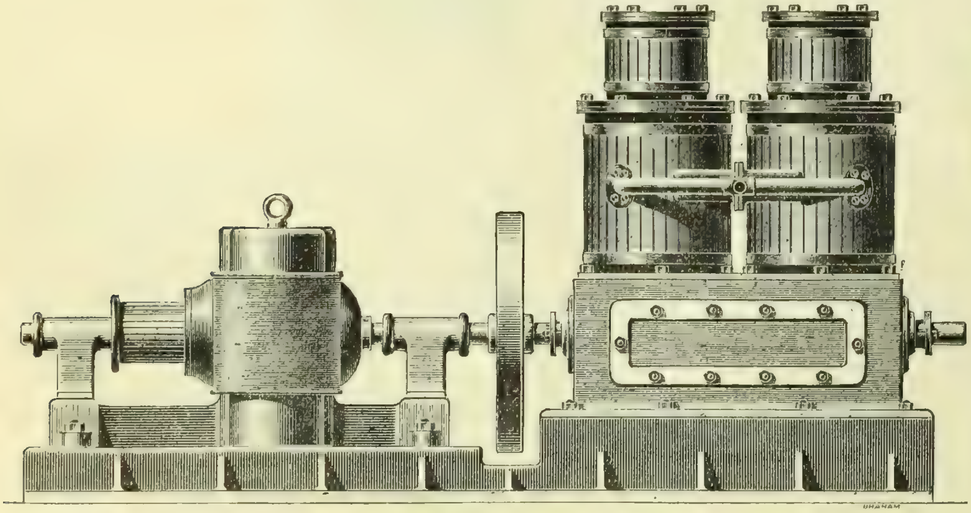


Fig. 7.

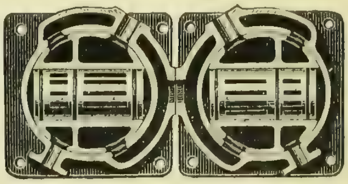


Fig. 8.

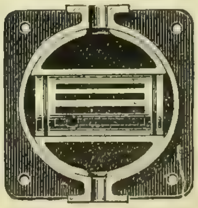


Fig. 9.

In high-speed steam engines it is very desirable that the working parts should be few and of the greatest possible simplicity if success in smooth and uniform running is to be attained. This has been attempted in many ways, and various ingenious engines have been produced, of which some have been very successful, and others, after a more or less brief existence, have disappeared from the market. Messrs. J. F. Blyth and Co., engineers, 219, West Ferry Road, Millwall, London, E., have introduced an extremely simple and ingenious form of high-speed engine, Newall's patent, which presents features of novelty well worth careful consideration. Like many high-speed engines of the present time, each piston is single acting, and so all the brasses are kept in compression. It is arranged either as simple or compound, and its principal peculiarity lies in the arrangement whereby the slide valve and eccentric are entirely dispensed with. The connecting rod end, instead of terminating in the usual crosshead pin, is attached or forms part of a cylindrical oscillating valve, so that while the crank pin is crossing the top and bottom centres at the extremes of the piston stroke the valve is moved to the positions of steam admission or exhaust, depending on whether the piston is about to ascend or descend. Referring to our illustrations, figs. 1, 2, and 3 show the details of a compound engine.

At fig. 1 the two cylinders are seen, one of them in section showing the cylindrical valve and its attachment to the connecting rod. In the compound engine the cylindrical valve is divided into two portions and has two sets of ports, one controlling the high-pressure cylinder and the other the low. The high-pressure steam first passes from the annular port through the piston to the valve, and enters the internal ring or cylinder, as shown in fig. 2. As the piston moves down the steam is admitted to the interior of the piston by the slot port shown. On reaching the bottom of the stroke the valve oscillates and the supply port closes, while the discharge port opens, the steam on the return stroke passes by the valve through the other side of the piston, and a port in the side of the cylinder to the low-pressure piston of the other engine, which is the annular surface surrounding the internal ring.

Fig. 3 shows the arrangement of ports and passages admitting to the low-pressure cylinder and discharging from it. The steam from each high-pressure cylinder passes, during the exhausting stroke, direct to the adjoining low-pressure piston through ports in the sides of the cylinders and through the pistons and valves. The fact of the oscillating valve receiving its movement from the connecting rod causes the steam to be carried or the exhaust to be kept open during nearly the whole stroke. But the expedient of admitting steam by the sides of the pistons allows of any period of cut-off in either cylinder, and permits any desired amount of cushioning, determined simply by the length of the port in the side of the piston.

Figs. 4, 5, and 6 show the arrangement of the simple engine in which the valve is not divided into two separate parts, as it has only to supply and exhaust the steam for one cylinder. Fig. 7 shows an external view of a compound engine of this type, coupled direct to a dynamo. The double-cylinder engine contains only five moving parts, all entirely closed against the inroads of dust, so that they may work in stokeholes or similar dust-laden atmospheres without injury and without special precautions.

In the compound engines the two sets of cylinders are dependent upon one another, and the high-pressure steam first expanded in the central trunk of the one engine passes to the next engine, and is further expanded before exhausting. In the simple engines the cylinders are independent of one another, and it is stated by the makers, Messrs. J. F. Blyth and Co., that they are well adapted to do the work of air compressers, pumps, or exhausters, and are noiseless in action, as the ordinary lift valves are dispensed with. Fig. 8 shows a plan of the cylindrical valves of the compound engine, and fig. 9 a similar plan of valve of the simple engine. We are informed that these engines have now been at work for over twelve months driving the works of the makers, and they may be seen in operation at any time by appointment.

ELECTRIC WELDING.

(Continued from page 331.)

Mr. C. J. H. Woodbury, of Boston, has made a series of tests with the Thomson electric welding apparatus described in our last article, at the United States Arsenal, Watertown, Massachusetts, with test pieces of different metals varying in diameter from 1·74in. to 0·25in. In the copper tests three unwelded specimens varied in strength from 32,390lb. to 32,840lb. per square inch. Out of four samples, in which the joint was not more than 4 per cent larger than the bar, three failed at the weld at strains varying from 29,450lb. to 31,830lb. per square inch; and the other failed ¾in. away from the weld, at 32,940lb. The remaining bars had enlarged joints, and broke away from the weld. Out of four welded brass bars, two were the same diameter at the joint as in the bar; and one gave way ¾in. from the weld at 47,730lb. per square inch—the full strength of the metal. In the remaining brass the joints were enlarged to about 80 per cent more than the bar; these broke through the shanks. A bar of German silver was welded to steel; the junction stood a test of 40,411lb. per square inch before it broke. Two pieces of brass were welded to wrought iron; the joints failed at 17,450lb. in one case and 33,500lb. in the other. In the octagonal steel experimented upon the breaking strain in the unwelded bar was 270,000lb. per square inch. Two pieces welded broke through the joint at 63,000lb. and 76,000lb. respectively. Other two broke close to the enlarged section at 90,000lb. and 105,000lb. per square inch respectively.

In cases where wrought iron was welded to octagonal steel, the wrought iron gave way at the shank, the joint remaining intact.

With the wrought iron tests a series of bars 1·02in by ·4in. sectional area were tested, having in their original state a strength varying from 53,500lb. to 55,830lb. per square inch of section. Out of seven samples five were distinctly larger in the weld than in the body; however, two of them gave way through the joint, where the section was increased by 25 per cent, the strain per square inch of the bar being 50,000lb. in one case, and 53,480lb. in the other. With bars of ½in. round iron, having an average strength of 58,000lb., one only broke at the weld, where it was 4 per cent less in section than the bar. All the others broke through, the welds being from 23 per cent to 70 per cent larger in cross sectional area. Two parallel bars gave way at the welds at an average of about 50,400lb., while in three cases in which the weld stood the trial its section was respectively 37 per cent, 47 per cent, and 36 per cent greater than the section of the bar. One sample had 40 per cent more sectional area in the weld than in the bar, and, as might be expected, it failed clean away from the joint. Another piece was 3 per cent smaller in the weld, and failed there at 49,500lb. per square inch. Another piece was parallel, and failed 3in. away from the weld, at 54,380lb. per square inch.

Another series of tests were carried out, and distinctly better results were obtained. The steel welds were poor, breaking at about 70 per cent of the strength of the bar in cases where the joint was not much upset. Two pieces out of four—octagonal steel—however, gave perfect results. Out of six samples of wrought iron, five were parallel. Three failed at the joints at the full strength of the metal, and two broke 2in. away from the joint at rather low strains. The value of these tests is much impaired by the increased size of the welds, which in many cases vitiates all comparison between the joint and the bar. It might also be necessary to know the amount of carbon in the steel experimented upon, for with hard carbon steel, say upwards from 0·14, the test pieces should be annealed after welding and before being tested, otherwise the material might be in a state of unnatural stress, the testing of which would not give a fair result. Enough is shown, however, to demonstrate that good electric welds can be made. The general results are very encouraging, and raise the hope that a new method of uniting metals is within our grasp, and that new forms of construction can be adopted which hitherto have been held to be practically impossible. In the above, comparison has been made with the full strength of the bar unwelded. Perhaps it would have been more just to have based comparison with hand-made welds, and with brazed and soldered joints, the latter having hitherto been the sole methods of uniting alloys of copper and brass.

The Thomson apparatus is now made in two forms. The diagrams and drawings in first paper illustrate the first or transformer system; the other form is called the direct system. In this machine the dynamo is situated below the clamps, and has its armature wound with two coils, one of fine wire to supply the current which excites the field magnets, while the other is a single copper bar, which supplies the current for welding purposes. The ends of this bar are connected to rings, from which the current is led by brushes to the clamps. Power is only absorbed (in both processes) during the time that the metal is heated; at other times the generator runs idly. Machines have already been made of sufficient power to deal with 3in. bars; and larger are still in prospect. The storage battery, properly arranged, constitutes another type. It is charged from a line or by a small dynamo, kept running constantly by power. Since the welding or heavy discharge currents are only needed at intervals, a comparatively small dynamo suffices for the charging. These storage cells are said to have been used successfully. Even primary batteries may, if of sufficiently low internal resistance, be used for the work, but are comparatively expensive to run. There are many variations in the clamping devices to suit the class of work to be done, and one very good example of this invention was shown in the Glasgow Exhibition, 1888. A process somewhat analogous to the one above described has been invented by Elias E. Ries, of Baltimore. This is shown diagrammatically on fig. 5.

This system seems but a variation of the older system, yet there are a few distinguishing points. A is the dynamo supplying alternating currents, C B are the brushes, E the primary circuit, V is the switch, U is the variable resistance. The transformer consists of an internal laminated ring core C, made of wrought iron; between the laminations are sheets of insulating material, the whole being secured together. G G are the primary coils, and I I the secondary coils. The primary coils are wound up in series, as shown, and the secondary coils in multiple arc, their electrodes K L being connected respectively with the segmental conducting wires or connections M N of the secondary circuit P R leading to the clamping and welding mechanism. It is claimed that this arrangement of the primary and secondary coils in a homogeneous magnetic field around the core C, made up of sections insulated from each other parallel to the lines of magnetic force, will cause the inductive action to be equal upon each particle of wire, the circulation of Foucault or "eddy" currents, which flow in planes perpendicular to the lines of magnetic force, will be prevented, and the magnetic force in turn can circulate without the production of free magnetic poles, the iron core *c* being a conductor for the lines of force, and not for the electric current.

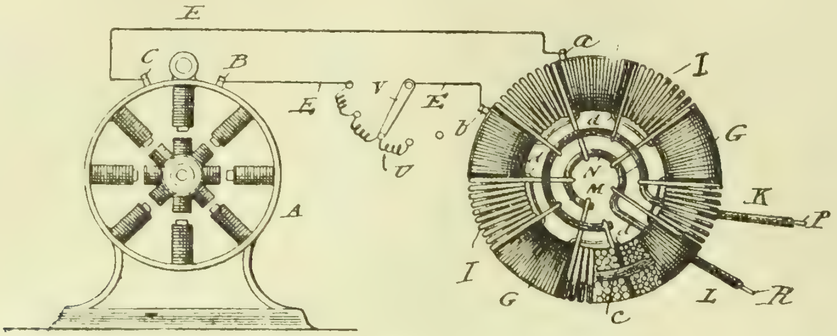


FIG. 5.

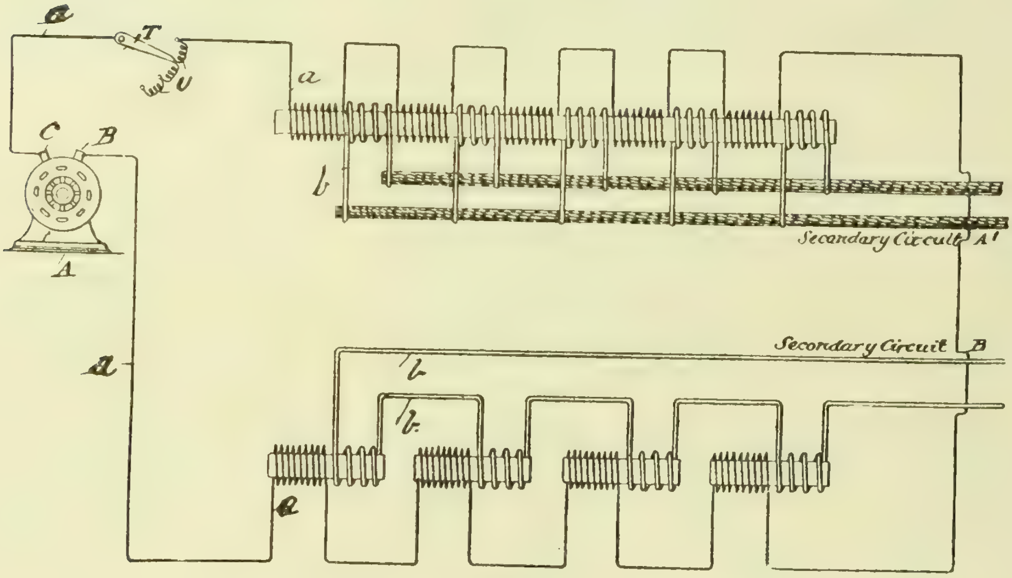


FIG. 6.

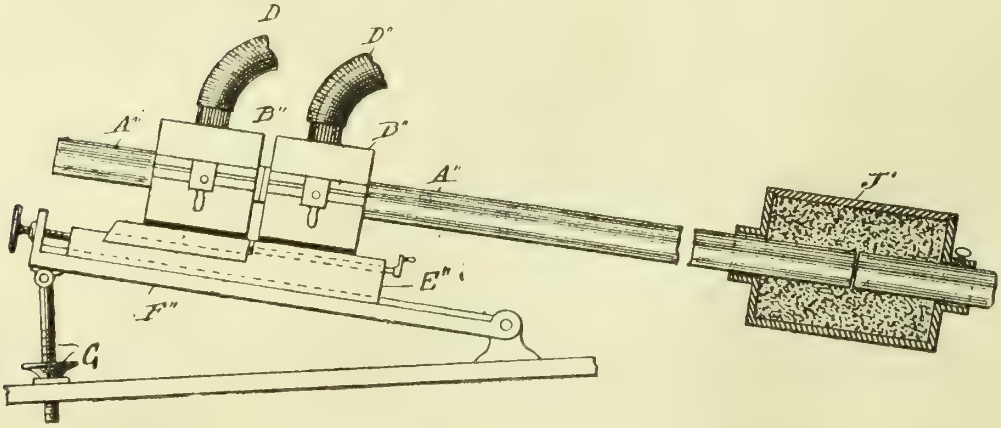


FIG. 7.

The same result, however, may be accomplished in many ways. Two arrangements or modifications are shown in fig. 6, in which the transformer connecting with secondary circuit A¹ consists of a core having its primary coils wound at intervals thereon, and connected with each other in series and with the switch levers in the primary circuit, and the secondary coils in the spaces or segments between, and corresponding in number and relative situation to the primary; the terminals from said secondary coils being connected in parallel with the secondary circuit A¹, *a* is the primary wire, *b* is the secondary wire, U the variable resistance, T switch, A alternating current dynamo, C B the terminals. Another arrangement of converter is connected with this dynamo circuit, fig. 6. It consists of a series of induction coils having dependent cores, and primary and secondary coils, the primary coils being connected in series with each other, and with the dynamo. The secondaries are connected in series, having their terminals communicating with the secondary circuit B. Fig. 7 is a sketch of the welding clamps. In this process $D^{11}D^{11}$ are the leads for conveying the current; A^{11}, A^{11} are the bars to be welded. The clutches $B^{11}B^{11}$ are brought together by means of a screw and nut of similar construction to that of a lathe E^{11}. In the diagram the slide rest is shown upon an inclined table F^{11}, designed with the object of assisting the screws by the extra weight of the higher slide block, and in cases where little pressure is required, as in lead pipes, small wires, and the like, the weight of the top block will be sufficient. The incline is regulated to suit different substances by means of the screw and nut G. In this process it is proposed to use a tempering box J^1, which is applied in the case of articles where the temper has to be retained. A freezing or cooling mixture is placed in the box and applied to the weld (fig. 7) while at a high temperature. This device does not seem to be a very practical one, owing to the time required for fixing, and the variation of material required for varying tempers. Carbon has been used. It would seem more practicable to cool with water while at the proper heat, in the old way. Sufficient experience does not seem to have been had to determine its practical value.

(To be continued.)

MARINE ENGINE TRIALS.

(Continued from page 366.)

The mean vacuum in the low-pressure cylinder (obtained by detailed measurement of all the diagrams) was 11·6lb. per square inch below the atmosphere. The absolute back pressure was therefore 2·73lb. in the condenser, assuming the gauge to be correct, and 3·3lb. in the cylinder.

Power.—The following are the mean effective pressures in the different cylinders in lbs. per square inch :—

Cylinder	Top	Bottom	Mean
High-pressure	60·10	56·82	58·46
Intermediate	20·47	18·54	19·50
Low-pressure	12·22	12·55	12·38

These pressures correspond with the following indicated horse powers :—

High-pressure cylinder	662
Intermediate cylinder	507
Low-pressure cylinder	825
Total indicated horse power	1,994

These figures are the average from thirty-four sets of diagrams, six diagrams in each set. The maximum indicated horse power given by any one set was 2,086, taken at 5-15 a.m. with 72·1 revolutions per minute and 147lb. boiler pressure. The minimum indicated horse power given by any one set of diagrams was 1,890, taken at 12-45 p.m. with 70·9 revolutions per minute and 140lb. boiler pressure. Each set of diagrams was worked out for the revolutions per minute corresponding with the counter readings for the half-hour in which that set was taken.

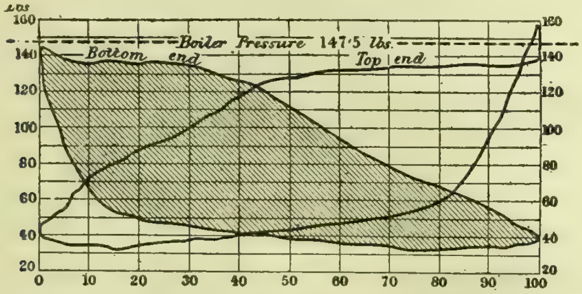


Fig. 1.

Boiler Efficiencies.—The rate of combustion in the furnaces was 19·25lb. of fuel per square foot of grate surface per hour, or 0·602lb. per square foot of total heating surface per hour. The evaporation was at the rate of 7·46lb. of water per lb. of fuel put on the fire, including clinker. This water, being supplied at a temperature of 163 deg. Fahr. and evaporated at a temperature of 363 deg., must have received heat at the rate of 1,062 thermal units per pound. Each pound of it was therefore equivalent to 1·10lb. evaporated from and at 212 deg. The actual evaporation reduced to this standard was therefore 8·21lb. of water per lb. of coal, or about 9·62lb. per lb. of carbon value in fuel, allowing for clinker. The equivalent amount of heat utilised per lb. of coal was 7,922 thermal units, or say 62 per cent of the whole calorific value of the coal, which percentage therefore represents the actual boiler efficiency. The total nominal calorific value of the fuel burnt per minute was 853,900 thermal units. Although it cannot be assumed that the analysis of furnace gas already given was a fair average, it has been thought worth while to work it out. It appears from it that the weight of air per pound of carbon was about 22·0lb., and per pound of coal about 15·5lb. The loss of heat in raising the temperature of the furnace gases works out to 21·9 per cent of the whole calorific value of the fuel, the loss by formation of carbonic oxide to 3·6 per cent, and that due to the evaporation of the moisture in the fuel to 1·2 per cent. The sample of coal analysed being free from clinker, the 4 per cent of clinker may roughly be said to correspond to a loss of about 3 per cent of the whole heat. These quantities add up to 91·7 per cent of the whole heat of combustion; and the balance must include, among other things, all losses by radiation. The amount of water evaporated per square foot of tube surface was 5·18lb. per hour, and per square foot of total heating surface 4·49lb. per hour. These quantities have to be multiplied by 1·1 to bring them to standard conditions. The average rate of transmission of heat through the material of the boiler was 5,244 thermal units per square foot of heating surface per hour.

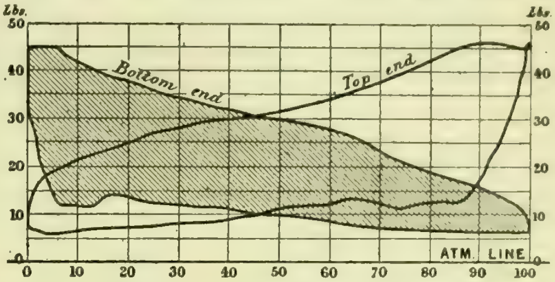


Fig. 2.

Engine Efficiencies.—The measurement of feed water shows that the quantity used per indicated horse power per hour was only 14·98lb., or within the limits of accuracy of measurement 15·0lb. The actual heat received by the feed water per minute was 528,700 thermal units, or 265·6 thermal units per indicated horse power per minute, which, as given in the last paragraph, is 62 per cent of the whole heat of combustion. For purposes of comparison with a perfect engine, it may be assumed that the higher limit of temperature is that of the boiler steam, 363 deg. Fahr., while the lower limit may be taken as 120 deg. Fahr. It was unfortunately impossible to measure the temperature of the condensed steam as it entered the hot well; but with the good vacuum given above, it is not probable that it differed much from 120 deg. Fahr. The temperature corresponding to the mean back pressure in the low-pressure cylinder is 146 deg. Fahr. If the engine had been "perfect," and had worked between 363 deg. and 120 deg. Fahr., it should have turned into work 0·295 of the heat received by it. The heat actually turned into work was 85,240 thermal units per minute, showing an efficiency of 54·6 per cent as compared with a "perfect" engine working between the same limits of temperature and receiving the same quantity of heat per minute.

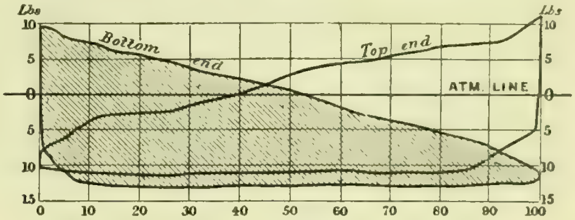


Fig. 3.

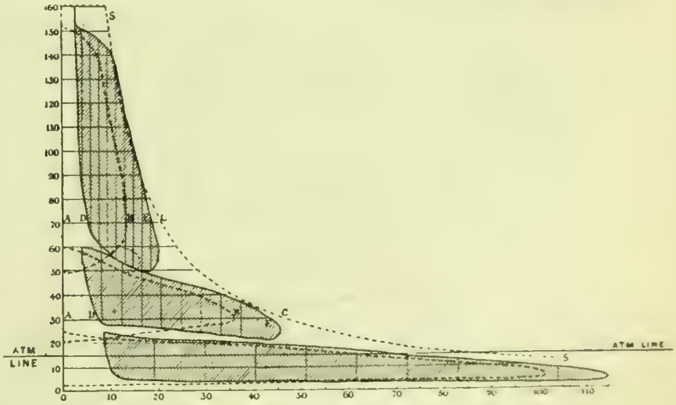


Fig. 4.

This is a high efficiency, but corresponds with the low feed-water consumption. The absolute engine efficiency, or ratio of the heat turned into work to the total heat received by the feed water, was 16·1 per cent.

Total Efficiency.—The combined efficiency of the boilers and engines, or ratio of the heat turned into work to the total heat of combustion of the fuel, was almost exactly 10·0 per cent.

Steam by Indicator Diagrams.—Careful measurements of all the diagrams taken have been made to ascertain the proportion of steam accounted for by them, and the following are the results, the actual weight of feed water used per revolution having been 6·93lb :—

Proportion of Steam accounted for by Indicator Diagrams.	Lbs. per Revolution.	Percentage of Total Feed.	Percentage in Jackets or present in Cylinder as water.
	Lbs.	Per cent.	Per cent.
Steam present in high-pressure cylinder after cut-off, when the pressure was 110lb. per square inch above the atmosphere	5·34	77·1	22·9
Steam present in intermediate cylinder, when the pressure was 22lb. per square inch above the atmosphere	5·56	80·2	19·8
Steam present in low-pressure cylinder near end of expansion, when the pressure was 4lb. per square inch below the atmosphere	5·22	75·3	24·7

It will thus be seen that even in these very economical engines, and with a liberal allowance for the steam used in jackets, which unfortunately could not be separately measured, there must have been a very considerable loss due to cylinder condensation.

In fig. 4 are shown expansions of the set of indicator diagrams given in figs. 1, 2, and 3, each expanded diagram being the mean of the two corresponding actual ones. The full lines in fig. 4 show these mean indicator diagrams themselves drawn to the same scale of pressure and of volume, and placed so that the space to the left of each diagram represents the clearance space in the corresponding cylinder. The dotted lines in fig. 4 show the same diagrams set back (in the manner described in Proceedings, 1887, page 70) in such a way that at any pressure the horizontal distance AB measures the actual volume of *working* steam in the cylinder at that pressure, as represented by the difference between the volume of steam of that pressure in the cylinder during expansion and during compression, or AE – AD, independently altogether of clearance steam. Each horizontal distance or abscissa of the dotted curves, such as AB, is therefore directly comparable with the corresponding abscissa AC of the saturation curve SS; and the ratio of the one to the other $\frac{AB}{AC}$ at any pressure gives the "dryness fraction," or ratio of steam to mixed steam and water, for the working steam at that pressure.

Coal Consumption.—The total coal put on the fires, 4,005lb. per hour, corresponds to 2·01lb. of coal per indicated horse power per hour, of the quality already stated. This corresponds to 1·76lb. of carbon value per indicated horse power per hour, or say 427 thermal units per indicated horse power per minute. As each indicated horse power per minute is equivalent to only 42·75 thermal units, this makes the combined efficiency of boilers and engines 10·0 per cent, as given above.

Speed of Vessel.—The following notes from the log book of the ship may be of interest :—

	Time.	Distance in nautical miles.
Left Pier Head	0-50 a.m	0
Bass Rock	2-20	20
St. Abbs Head................................	3-40	39½
Ferns	5-10	62
Flamborough Head	0-50 p.m.	175
Dudgeon	4-57	236
Cromer	6-25	257
Haseborough	7-0	265½
Cockle	7-46	275

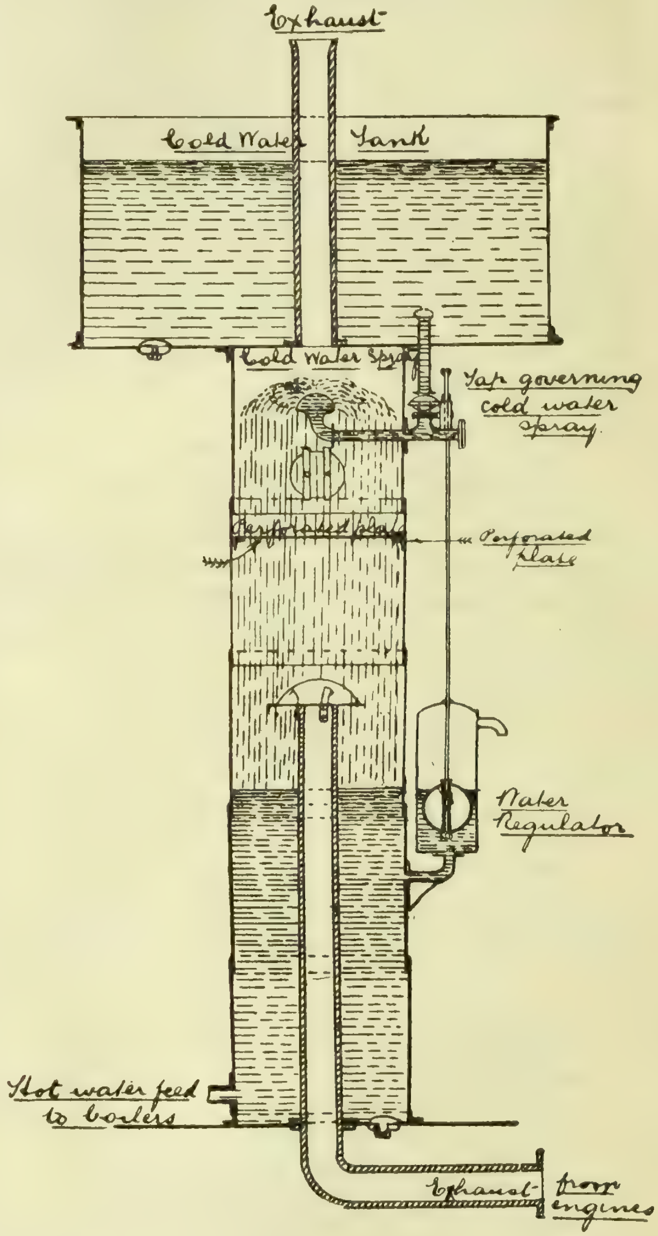
The mean speed between Leith and Cromer, which practically covers the trial, was therefore 14·6 knots.

(To be continued.)

THE LANCASTER CONDENSER AND FEED-WATER HEATER.

We illustrate here a new form of condenser and feed-water heater, Whittle's patent, manufactured by Messrs. Lancaster and Tonge, engineers, Pendleton, near Manchester, which is of very simple construction. The exhaust pipe from the engine is continued half way up a vertical wrought-iron case or tube, as shown, and a bonnet is placed above it, which spreads the steam throughout the chamber. Cold water enters in spray and falls over a perforated plate, which further subdivides the steam, and it is thereby in great part condensed, so that but little escapes at the open end of the pipe. The water tank may be arranged as shown in the engraving, or placed in some other position, or the feed valve may be supplied from town water.

The heat of the steam is thus utilised in heating the feed water, and back pressure is diminished by the rapid condensation. At the same time the exhaust is effectively silenced and prevented from blowing about to any inconvenient extent. The arrangement, further, is so simple that it may be trusted even in the most unskilled hands. As the illustration is almost self-explanatory, we need not enter into further details.



SERIOUS WAGES DISPUTE IN HULL.

During the last few weeks considerable friction has existed between the employers and those employed in all the large engineering works in Hull.

From what we have been able to learn, it appears that all the fitters, erectors, and machinemen, together with the engine smiths and pattern makers, sent in notice about seven weeks ago to their masters for an increase of 2s. per week in their wages. Up to Wednesday, the 8th inst., little or nothing had been done in the direction of an amicable arrangement between masters and men, so that then the whole of the men concerned gave their employers a week's notice to terminate their engagements in the event of the masters refusing them the increase asked for.

We understand that those at the head of the minor engineering establishments in Hull have conceded the advance, so that at the time of writing the matter stands between the remainder of the men and those masters who belong to the Hull Iron Trades Employers' Association. On Thursday, 9th inst., the Employers' Association requested a deputation of the men to wait upon them, and it was stated that the masters were prepared to offer 1s. per week advance upon the "standard" rate, and as the deputation were unable to accept this concession, a mass meeting of the men was held on the following night, when this offer was laid before them, but it was declined, and the original request of 2s. was insisted upon.

The men concerned in the dispute are at present receiving the "standard rate," viz., 31s. a week, and are asking for 33s., as they contend that the present state of trade warrants the increase, as business is now brisker than it has ever been previously, and similar advances have been made in the marine engineering establishments on the Tyne and Wear.

On the other hand, the masters assert that the present rate of wages has never been exceeded in Hull, and while admitting that the rates of wages may be less than in other towns on the north-east coast, they claim that the higher rates of carriage incurred in procuring the materials used in the engineering trade more than make up for this difference, and they also maintain that the cost of living and house rent is, comparatively speaking, very much cheaper than in the North of England.

Viewing the matter from a disinterested standpoint, it seems to us that something should be done to arrange matters by a method more peaceful than striking. If the matter were submitted for arbitration, something might be done to avert the misery which usually attends a strike of great proportions, and the men should remember that it is now a little over fifteen years since a strike so considerable as the present one threatens to be occurred in Hull, and at that time the men were, after being out some three months or more, obliged to go in on the old terms. The number of men affected by the dispute is about 1,500.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

Sir,—When I wrote the letter which appeared in your issue of October 5th last, my object was merely to contribute to the discussion, without aiming at anything like finality. At the same time, I believe that the complete solution of the question of the strength of plain furnace tubes lies in the direction which I have indicated. That the resistance to collapse abstractly is inversely as the square of the diameter of the tube may be made apparent by an example. Suppose two tubes of which the diameters are as 1 and 2, subjected to the same external pressure per square inch. The total collapsing pressures per lineal inch of the tubes are as 1 and 2, and the distances of the centres of pressure from the longitudinal section of the plate, when it would be folded in the event of collapse taking place, are also as 1 and 2. It follows that the collapsing powers are in the compound ratio of the total pressure and the leverage of pressure, or as (1 to 2) × (1 to 2), or 1 to 4, as the squares of the diameter.

I have had an opportunity of examining Mr. Michael Longridge's list of 2,000 plain unfortified iron furnace tubes of Lancashire and Cornish boilers, from which I made a random selection of 84 tubes of $\frac{3}{8}$in., $\frac{7}{16}$in., and $\frac{1}{2}$in. plates, of lengths varying from 7ft. to 32ft., together with the working steam pressures which they had supported for years without a failure. Particulars of the dimensions and working pressures of the 84 tubes are given in the following table :—

Thickness of Plates.	Number of Tubes.	Diameters	Average Diameter.	Lengths.	Average Length.	Working Pressure per Square Inch.	
						Pressures	Average.
In.	Tubes.	In.	In.	Ft.	Ft.	Lb.	Lb.
$\frac{3}{8}$	43	21 to 36	29·5	10·6 to 30	19·3	30 to 60	41
$\frac{7}{16}$	34	27 to 44	33	7 to 32	20	18 to 65	45·5
$\frac{1}{2}$	7	30 to 42	33	11 to 32	24·6	30 to 66	46

The several pressures for each thickness of plate do not seem to have any relation to the lengths of the tubes ; but in the above table there is a sensible relation between the diameters, lengths, and pressures, taken together, and the thickness of plates, as is clearly shown by the comparative products of these three elements, thus :—

$\frac{3}{8}$in. plates .... 29·5 × 19·3 × 41 = 23,343
$\frac{7}{16}$in. " .... 33 × 20 × 45·5 = 30,030
$\frac{1}{2}$in. " .... 33 × 24·6 × 46 = 37,342

These products are approximately as 3, 4, 5, or as the squares of the thicknesses of plates ; and they seem to indicate that, taking comprehensive averages, the minds of designers were influenced in some degree by the element of length of tubes in relation to thickness of plates.

Now, let us refer back to Table II. of collapsed furnace tubes, page 471, October 5, 1888. It is plain from the table that the mere length of furnace tubes did not influence the quantity of the resistance, which was simply the direct resistance to collapse, though the actual collapsing pressures were considerably in excess of the working pressures in current practice, above given ; yet the margin is, comparatively speaking, narrow. 30in. tubes, for example, $\frac{3}{8}$in. thick, worked daily with steam of 41lb. per square inch, collapsed under steam of 76lb. pressure. Let us not delude ourselves by assuming that we work plain flues at a factor of 4, or even 2.

I do not believe that hydrostatic tests are sufficient for proving what a boiler can do under the conditions of high temperature and unequal straining to which boilers are subject under steam ; and from what I have pointed out above, it behoves us to investigate the matter much more closely than has yet been done.—Yours, &c., D. K. Clark.

London, May 21, 1889.

To the Editor of "The Practical Engineer."

Sir,—Your correspondents, "Inquirer" and "C.T.," do not appear to have seen my letter on this subject in your issue of 6th July last, in which I gave a formula which experience justifies me, I believe, in saying gives fairly correct results. I may repeat that it is $P = \frac{16\ t^2}{D^2}$ for tubes seven or more diameters long, P being the collapsing pressure in pounds per square inch, t the thickness of plates in sixteenths of an inch, and D diameter in feet.

Fairbairn's formula was extremely valuable at the time it was published, as nothing previously existed but erroneous guesses and assumptions, none of which took into consideration the fact he discovered and announced, that length was a factor in the question. But his conclusions, it is now generally conceded, were not infallible, and in *Engineering* of 4th January last you may find another letter of mine, in which I gave a summary of his experiments, and showed that they did not agree with his statement that the strength of a flue or tube was proportional to the 2·19 power of the thickness. I stated that he had based his formula upon an experiment which gave an abnormal result, and upon another still more inapplicable, as it was a butt-jointed tube, and that by a manipulation of the figures he showed that the erroneous power of 2·19 was correct, and that the square was practically a near approximation, with the unfortunate result that his constant was more than twice as large as it should have been, consequently making it appear that tubes were more than twice as strong as the experiments, accurately interpreted, would have done.

I see that in Table II. in that letter I made an error in addition, making the average power of the thickness 2·08 by dividing 10·38 by 5. The correct addition would have been 9·38 ; this divided by 5 would make the average power 1·88, which is still further from Fairbairn's 2·19.—Yours, &c., W. I. Ellis.

Manchester.

HIGGINSON'S SPEED REGULATOR.

To the Editor of "The Practical Engineer."

Sir,—With reference to Higginson's speed regulator, illustrated in your issue of May 3rd, I wish to call your attention to the total diversity of principle and reasoning on which that governor acts as contrasted with the numerous forms of governor using a spring—some recently patented and illustrated.

Mr. Higginson reduces the weight as the speed increases, and *vice versa*. All the governors using springs increase the weight or resistance as speed increases, and *vice versa*. And yet we are told each of them gives better results in uniformity of speed. Can you explain ?—Yours, &c., Paradox.

MARKING OFF MANHOLES.

To the Editor of "The Practical Engineer."

Sir,—In common with no doubt many of your readers who have been struck with the novel and simple method of constructing an approximate ellipse given by your correspondent, "A. M.," on May 17th, I would feel much obliged if he would give the *geometrical* proof, which must be very ingenious.—Yours, &c.,

Portsmouth. Fantôme.

POWER OF LOCOMOTIVE ENGINES.

To the Editor of "The Practical Engineer."

Sir,—In my reply to "Locomotive Engine Driver," the rule for speed in feet per minute contained a mistake. It should read "speed in feet per minute equals miles per hour multiplied by 5,280, divided by 60." Yours, &c. Dreadnought.

QUERIES AND REPLIES.

36. **Nut Cast on Iron Screw.**—A phosphor bronze nut has been cast on an iron screw. What is the best method of getting it off? The screw is 3in. diameter and ⅜in. pitch.—Subscriber.

Answer.—Make hot and use oil freely, and loosen with hammering. If the threads are equal, you should then get the nut off. Sometimes it is impossible to move them without breaking.—C. T.

Answer.—Heat the nut over a sharp fire quickly, so as not to heat the iron screw, secure your nut from turning, and when heated try and work it loose, using fine emery powder and oil. If it is too tight, place it on an anvil and hammer it, so as to expand the nut, and when started, then use the emery powder as above stated. It is a good plan to paint the screw over with a thick solution of chalk and water before casting on the nut, and also to heat the screw well before the nut is cast on; this greatly prevents the seizing. Always cast nut on best part of screw where largest in diameter, if screw is worn at all.—T. M.

Answer.—Surely warming the nut and keeping the screw comparatively cool by a stream of cold water over the projecting part will enable "Subscriber" to remove it with a spanner. If, however, it is required to work freely on the screw, I would suggest repeated heating of the screw, which by its expansion would tend to stretch the nut, and in time probably loosen it. Hammering with quick strokes on the several faces of the nut is a method which, if persevered in, generally answers with even larger nuts which have set fast from roughly cooling an overheated bearing.—Fantôme.

38. **Duplex Mining Pump.**—Which is the best duplex action mining pump for use with compressed air, taking into account compactness and first cost as well as economy?—S.

Answer.—I can recommend the duplex pump constructed by the Pulsometer Engineering Co., Nine Elms Ironworks, London. It acts admirably.—C. D.

Answer.—In answer to "S," as to best duplex mining pump to work by compressed air, I would recommend Worthington's above all others.—W. A.

39. **Separate Condenser.**—Which is the best separate condenser for use with high-pressure engines, and state advantages?—H.

Answer.—The Messrs. Tangye constructed a separate condenser and air pump, Holman's patent, which I believe does good work.—C. D.

40. **Barffing Cast Iron.**—Can any of your readers inform me whether cast iron which has been subjected to the process known as "Barffing" will withstand the action of a boiling solution of weak sulphuric acid? Also, can you give me the name and address of any firm where this process is carried out?—Works Manager.

Answer.—Messrs. Bower, of St. Neots, subject iron to the Barffing process, but as the protecting film is composed of the magnetic oxide of iron $Fe_3 O_4$, it cannot be expected to withstand hot diluted sulphuric acid. I know that it does not do so.—Chemist.

44. **Resistance of Piping to Water.**—Will you kindly permit me through the medium of your paper to ask if any of your correspondents will answer the following question, viz.: In a rising main of 3in. per yard, 400 yards long, composed of 200 yards of 4in. and 200 yards of 2½in. pipes, a pump is required to force through those pipes 30 gallons of water per minute. Will the resistance offered to the pump vary, and, if so, how much in each case, if the pipes were laid in the following order—

1.—200 yards 4in. pipes next the pump.
200 „ 2½in. „ delivery end.
400

2.—200 yards 2½in. pipes next the pump.
200 „ 4in. „ delivery end.
400

3.—100 yards 4in. pipes next the pump.
100 „ 2½in. „ the above.
100 „ 4in. „ „
100 „ 2½in. „ „
400

4.—100 yards 2½in. pipes next the pump.
200 „ 4in. „ the above.
100 „ 2½in. „ „
400

5.—100 yards 4in. pipes next the pump.
200 „ 2½in. „ the above.
100 „ 4in. „ „
400

6.—If the pipes were laid alternately—one 4in. pipe and one 2½in. pipe—throughout the entire range?—Medium.

Answer.—"Medium" should state what size pumps, &c., he is going to use to force the water (30 gallons per minute) through; then one might state what pipes would be sufficient.—T. M.

45. **Boiler Solution.**—Would some practical reader inform me as to the advantage or disadvantage of using paraffin as a boiler solution? My employer has been recommended to use one pint per week. Size of boiler, 15ft. by 4ft., fired externally; no ventilation except through manhole on top of boiler. Would any explosive gases be left behind after emptying boiler for cleaning, thereby causing danger on entering with an exposed light? I should be glad of someone's opinion of the above.—Coventry.

Answer.—"Coventry" evidently means paraffin oil, not paraffin, which is a solid substance, like wax. Both paraffin oil and petroleum have been found very useful for loosening lime scale. Economiser pipes, when heavily incrusted, if filled with either of these oils, and allowed to stand a few days, may be thoroughly cleared. The oil is very insinuating, and the scale seems to absorb it with avidity, and by hammering the pipes nearly the whole of the scale will fall out. It should be used, however, with great caution as a "boiler solution." The same objection applies to the use of these oils inside boilers as to the introduction of any greasy matter. With some kinds of water, particularly when the fine flour-like deposit of carbonate of lime is present, the introduction of any kind of grease is apt to cause serious trouble by overheating in the furnaces. Hence the introduction of paraffin oil into boilers, if the water is not very good, may be followed by fusion of fusible plugs, distorted furnace plates, &c. There is much more risk from this than from the formation of any gases likely to explode on entering the boiler with a light after emptying. If "Coventry" has much scale in his boilers, probably the most effective way of using paraffin oil would be to paint it over the scale when the boiler is laid off for cleaning.—Azim.

46. **Lining Shafting.**—Will some reader inform me the best way to put up some shafting in line with some already up; also some at right angles to it? I want to know how to line it up, and how to get the position of the plummer-blocks; they will be bolted against upright pillars.—R. D.

Answer.—Suspend the new shafting, with plummer-blocks on, in its place, by ropes or chains; keep the couplings ⅛in. apart; then, with an iron wedge, filed smooth, test the distance all round the couplings, starting at end next to old shafting; then, after one coupling is right—top, bottom, and two sides being equidistant—start with next coupling, &c., till all are done; then mark off holes for securing plummer-blocks to upright pillars. Of course this operation can only be carried out when couplings are faced and turned true on the outsides. The outside of coupling gives the height of shafting. Otherwise, drop a twine, with weight attached, at every coupling, and sight them in line; and, for fairing shafting, use spirit-level. For the right-angled shafting, place shaft in position, and try a straightedge on top and bottom with the other shaft, suspending the shafting as before mentioned; set it level with a spirit-level. To get the angle, either use a large square, or erect a perpendicular with large pair of trammels; fix your plummer-blocks, and then key the bevel wheels on after the setting is done and the shaft secure in the bearings.—T. M.

Answer.—Fix a string parallel to the existing shaft at a certain fixed and convenient distance from it—say one, two, three, or four feet—and at the same level. Continue this line of string as far as you intend to carry your new shafting, keeping it straight from end to end, with support at intervals, if needed, to prevent it sagging. Then place your plummer-blocks on the brackets attached to the pillars, with their centres at the same level as the string line, and at the same distance—say one, two, three, or four feet from it—as the centre of the existing shaft is distant from it. The position of the new plummer-blocks will then be in one continuous straight line with the old ones. While this line is up and in position, others may be fixed at any required point or points on it at right angles to it.—W. A.

35. **Locomotive Driving Wheels.**—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

41. **Hot-water Pipes.**—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft.? What book may I get on arrangement of greenhouse?—Water-heater.

47. **Hardening Malleable Iron.**—Will any reader kindly inform me how to make malleable iron flint hard, as I have some cast cups to harden, and I do not know what powder or liquid to use?—Cycling.

48. **Steam Discharge by Free Expansion.**—How many gallons of water must I evaporate to supply the steam discharged from a ½in. diameter pipe, 6ft. in length, at 60lb. per square inch of boiler pressure. The steam is for blowing purposes, and is discharged freely into the atmosphere at atmospheric pressure?—Subscriber.

49. **Proportions of Pipes to Hydraulic Ram.**—We have a 10in. ram, with 1¼in. inlet and outlet pipes, pressure 700lb. per square inch. Is this a correct or good proportion? if not, how is the correct proportion calculated? Steam Crane.

50. **Small Air Pump.**—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

TO CORRESPONDENTS.

D. H. S., Wallsend-on-Tyne.—You will find full information on the subject of Whitworth Scholarships in the Calendar of the Science and Art Department, which you can obtain from the Science and Art Department, South Kensington, London, or through any bookseller. The publishers are Messrs. P. S. King and Co., King Street, Westminster. You can obtain full information as to terms of admission to the Royal Navy as engineer by writing to the Secretary, Admiralty, Whitehall, London.

Subscriber, Liverpool.—The Otto gas engine, as made by Messrs. Crossley, is covered by numerous patents, but the cycle of operations giving an impulse every second revolution is covered by Otto's Patent, No. 2,081, of 1876, which expires in May, 1890 You can refer to the specification at the Free Patent Library, Liverpool.

J. J. L., Coventry.—Thanks for your letter and your appreciation of our paper. We have pleasure in duly inserting your query.

A. T., Blackburn.—You can get full information by writing to the Secretary, Admiralty, Whitehall, London.

Foreman, Bickershaw.—A patented article cannot be legally made for personal use. If used by you royalty could be claimed upon it; indeed the patentee could apply for an injunction to prevent you from further using it, and ask for the surrender or destruction of the article. If a patented machine is constructed solely for scientific or experimental purposes, and not for use or profit, it is very unusual for patentees to attempt interference, but still the right exists, although not put in force.

Steam Crane, Coatbridge.—We shall reply in our query column. There is no comprehensive work on cranes and hoisting machinery. We intend to publish a series of articles on the subject. Thanks for your appreciative letter; we are very much pleased that our articles have proved useful to you in designing.

Water, Bradford.—Your first letter has not reached us. Kindly write again and repeat your question. Please remember that we expect correspondents to give their addresses as well as their names, which, of course, we do not publish, and letters without full address do not receive the same attention from us as those properly dated and addressed. We expect our correspondents to have confidence in us when they ask for information.

A project for a "sub-marine bridge" under the Sound has been put forward by a Swedish engineer. At a cost of over £600,000 a bridge, carrying a line of railway, but submerged to a depth sufficient to allow vessels to pass over it, would be built. The bridge would be a tube resting on piers.

MISCELLANEA.

The deepest artesian well in Russia is now in working order. An Odessa correspondent telegraphs that its depth is 2,090ft., and that the sinking operations have taken two years. The well is at Kharkoff.

There are now 32½ miles of cable tramway in Melbourne. The number of persons carried during the last half of 1888 was over 19,750,000, being an increase of 9,400,000 as compared with the returns for the same period of the previous year.

The Blackpool Corporation have decided to extend the electric lighting on the beach from the South Pier almost to the bottom of South Shore. Mr. Thomas Barton, electrical engineer, Ainsworth Street, Blackburn, has obtained the contract, and the work is to be finished by Whitweek.

SHIPBUILDING.—The screw steamer Glencairn was successfully launched from the yard of Messrs. T. Priestman and Co. on Tuesday, May 21st. She has been built to the order of Messrs. Robert Livingston and Co., West Hartlepool, for the general trade and the highest class at Lloyd's. The principal dimensions are: Length over all, 240ft.; breadth, 32ft.; depth moulded, 16ft. 4in. The engines are triple-expansion, with cylinders 17in., 28in., and 46in. respectively, with a stroke of 33in., and have been built by Messrs. Hutson Corbett, Kelvinhaugh Works, Glasgow. Steam is supplied from an exceptionally large boiler, working at a pressure of 160lb. The deck machinery consists of windlass by Messrs. Harfield and Co., four horizontal steam winches, patent worm steering by Messrs. Davis, and steering gear aft by Messrs. Hastie and Co., Greenock.

STEAMING IN WEAVING SHEDS.—Mr. T. Birtwistle, secretary to the United Textile Factory Workers, has forwarded the following to each member of the Government: At a meeting of the United Factory Workers of the Northern Counties, held at Manchester on Saturday, the 18th May, the following resolution was unanimously adopted—"That this meeting, representing over 80,000 factory workers, strongly condemn the action of the cotton manufacturers in asking for a further inquiry into the system of oversizing and the infusion of steam into weaving sheds, after neglecting to take part in the previous inquiries that have taken place, and also declining the offer made to allow them to take part with the Joint Committee in framing a bill. And we therefore urge upon her Majesty's Government, through the Home Secretary, not to accede to their request, but to proceed at once to deal with the question in a practical way in a short bill."

THE FIRST SLUICES ON THE MANCHESTER SHIP CANAL. The Works Committee of the Manchester Ship Canal Company have recently inspected the first sluices which have been constructed on the works. The sluices are situated at Old Randles, on the Cheshire side of the river Mersey, about three miles past Runcorn. They are of exceptionally large dimensions, and afford a 30ft. clear opening. A remarkable feature about the sluices is that, notwithstanding their gigantic size and weight, they are so designed and executed that one man can lift them with one hand; indeed, Mr. S. Platt, the chairman of the Works Committee, has performed this feat with the utmost facility. The sluices have been constructed on Stoney's patent principle, the friction on face being broken by free rollers, and the whole construction thoroughly counterbalanced. The success of the sluices was fully proved. This is very satisfactory, because many others of a similar type will be required on the works.

THE LATEST PACIFIC LINER.—The largest and quickest passenger steamer built for the trade between this country and South America and the Pacific left Barrow for Liverpool on Saturday, having been constructed for the Pacific Steam Navigation Company by the Naval Construction and Armaments Company. The vessel, which is named the Oruba, is 450ft. long, 49ft. beam, 10,000 gross registered tonnage, and engines on the triple-expansion type, indicating 6,500 H.P. She is a magnificent vessel, and has been fitted up in sumptuous manner, and is lighted throughout by electricity. She has accommodation for 150 first-class passengers, 90 second, and 650 steerage. Her speed is expected to average sixteen knots. The Oruba is built entirely of steel supplied by the Barrow Hematite Steel Company. She has no less than 500 incandescent lights. The Naval Construction and Armaments Company are building a sister ship to the Oruba, which will be launched shortly. They have also orders for two large cargo steamers for the same company. These, when completed, will make six that have been built at Barrow for the Pacific Company.

THE STRAWSONISER.—On Saturday, May 18th, a public trial of Strawson's air-power distributor, now commonly known as the "Strawsoniser," took place at one of the Queen's farms near Windsor, in the presence of a number of agriculturists and representatives of the press. The machine is worked by means of a powerful fan, driven from the travelling wheels. The distribution is performed by a spreader when the material is a powder, and by nozzles when it is a liquid. As the material falls from the hopper it is caught by the blast of air from the fan, and distributed over the ground to a width and in a quantity regulated at pleasure. The machine is used as a broadcast sower of corn, seeds, manure, or sand in the streets, and as a distributor of insecticide powder or liquid. Two machines were worked at Windsor on Saturday, one with solids and the other with liquids. Each was drawn by one horse. The first trial was with paraffin as an insecticide. As the machine travelled it spread a fine spray over 18ft. to 20ft. of ground so regularly that every leaf and blade of grass in the track was found to be sprinkled over with the liquid. The quantity used was two gallons an acre, but one gallon can be spread over the same area if desired. Next the nozzles were fixed for sprinkling hops, the assumption being that the crop was on the poles several feet high. In this case a fine spray was sent from the ground level to a height of 20ft. on each side of the machine as it travelled along. Barley was sown broadcast in the next trial, a width of 18ft. being covered with perfect regularity on each journey of the machine. Salt was sown in the same way. Lastly, powdered lime was distributed over a field in a perfect cloud, falling lightly all over the surface. The idea was that of covering young turnip plants attacked by the fly. All who were present appeared to be perfectly satisfied with the work done.

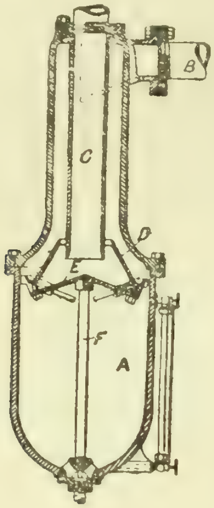
AN IMMENSE DRY DOCK.—A New York correspondent says that the great dry dock, lately built by the Chesapeake Dry Dock and Construction Company was opened for business on the 24th of April, at Norfolk, Virginia. A large company of distinguished personages, engineers, and Government officials were present. The dock is built on the well-known plan patented by J. E. Simpson, of Brooklyn. It consists of an immense caisson, with an end gate, something like a canal lock. In docking a ship the gate is opened, the caisson is allowed to fill with water, which sinks the caisson to the required depth. The ship then passes in over the floor of the caisson, and is held in the desired position; meantime, the water is pumped out of the caisson, which rises and lifts the vessel out of the water. These docks are now in all parts of the world. The present dock is one of the largest of its kind ever constructed. It is 630ft. long from head to outer sill, 130ft. wide at top and 50ft. at the bottom, and 33ft. deep. The approach to the dock is piling 250ft. long and 150ft. wide, while on each side piers 80ft. wide afford ample wharf room. The caisson is an iron structure 96ft. long on top, 50ft. at bottom, and 33ft. deep. The dock is supplied with two centrifugal pumps of a capacity of 40,000 gallons per minute, each of which empties it in one hour and 36 minutes. The combined power of the two engines is 500 horse power. There is in course of construction a shipbuilding plant alongside of the dry dock, which will, when completed, enable the company to do the finest work of construction and repair in the country. The vessel selected for the first trial of the new dock was the great ironclad warship Puritan. The dock was lowered and the Puritan was hauled in and placed in position. The gates were closed and the powerful pumps put to work to clear the dock of water, which was done in about two hours. The Puritan is 300ft. long and 60ft. wide, but she looked small in comparison with the great dock.

THE EXHIBITS OF MESSRS. GALLOWAY, LIMITED, AT THE PARIS EXHIBITION.—Messrs. Galloway, Limited, of the Knott Mill Ironworks, Manchester, exhibit at the Paris Exhibition—in addition to the illuminated fountains—an internal Galloway flue, suitable for a boiler 30ft. long by 8ft. diameter, capable of working at 100lb. pressure. This flue is constructed of best selected mild steel plates, and consists of two furnaces joining into one flue of special shape. The two furnaces are in solid welded rings 3ft. 3in. diameter, flanged by machine and securely riveted together with a strengthening ring between the two flanges; the holes in these flanges are drilled by specially constructed machinery so as to ensure freedom from strain and perfect accuracy in putting together. The flue formed by the junction of these furnaces is made according to the most improved patents, giving ample room for cleaning and examination, increased strength, and avoiding objectionally thick plates. This flue is supported by 38 patent Galloway cone tubes, all interchangeable, and with their flanges square with the centre line of tube, thus putting less strain upon the material during manufacture. Four patent pockets are fixed in the flue to direct the flame amongst the cone tubes; also two expansion pockets at the back end to prevent the undue escape of the heated gases, and to give the necessary space in the end plate for expansion and contraction. The flue is provided with two boiler ends, each in one piece, of the best selected mild steel; the front plate is prepared for attachment to shell by angle ring, is turned on its outer edge, and the openings for flue ends are bored out by special machinery. The back end plate is flanged for connection to shell. A few rings of the shell are placed in position to show the connection of the flue ends and shell, which are strongly attached together by gusset plates, fastened by double angle both to shell and flue, care being taken that these gussets are not brought too near the furnace crowns, but sufficient space allowed for expansion. Messrs. Galloway also exhibit a trophy of their patent Galloway machine-made cone tubes, suitable for insertion into Galloway boilers, Lancashire, or two-flued boilers. These tubes vary in dimensions from 5ft. long, 10½in. diameter at the large end, and 5½in. diameter at the small end, to 1ft. 6in. long, by 6in. and 3in. diameter respectively. Also a selection of mountings for steam boilers, consisting of boiler blocks, stand pipes, and manholes, of which the firm construct large numbers for other boiler-makers in all parts of the British Isles, as well as the Continent of Europe. A highly-finished model of the Galloway boiler is placed in the exhibit, with the upper portion of the shell raised in order that the entire construction may be seen.

ILLUSTRATED PATENTS.

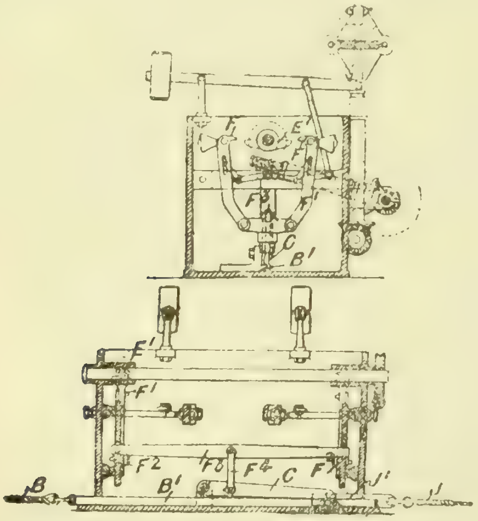
17,808. Steam Separator, E. P. Strasson, College Point, Queen's County, New York, U.S A.

A section of one is shown. The steam enters the vessel A by the branch B and leaves by C. The mouth of the outlet pipe is surrounded by a cone D formed with a gutter or channel round its lower edge, in which a portion of the water collects and from which it is removed by small drain pipes, as shown. The bottom of the cone is closed by a plate E secured on the end of a rod F, by which the whole is supported. The steam in passiug round this cone on its way to the outlet pipe deposits all its suspended water, which falls to the bottom of the vessel A and is removed by a drain pipe.—December 27, 1887. [8½d.]



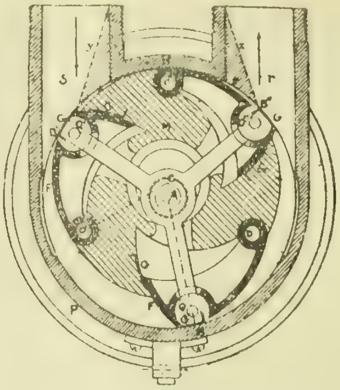
17,875. Preventing Overwinding in Mines, &c. A. Bertram, Ince, Wigan.

The steam is automatically shut off and a steam brake applied, if, when the cage is passing a particular point, its speed is greater than a predetermined limit, and also by contact if it rises too high. The first is accomplished by connecting with the governor gear levers F^1, which are pivoted to a crosshead F^2. This, when raised, lifts the pawl C by means of the bar F^3 and link F^4, and so frees the drawbar B^1, which is connected by the rope B to mechanism tending to close the throttle valve and open the steam brake valve. The action of the governor is to swing inward the levers F^1 as the speed increases, and so put their hooks F in the way of cam arms E^1 on the shaft E, which is connected by reducing gear with the engine shaft. These arms then raise the levers F^1 and with them the crosshead F^2 and pawl C, and so free the bar B^1. Instead of a rotating shaft E, a reciprocating carriage may be employed having levers upon it, which are drawn aside by catches put into their way by connection with the governor. When thus drawn aside they operate, liberating mechanism as above. The rope J attached to a drawbar J^1 is connected to a tappet projecting within the well, which is struck by the cage if this rises too high, thereby freeing the pawl C. The mechanism may be employed in combination with the previously described or separately.—December 29, 1887. [8½d.]



17,841. Rotary Engines and Pumps, L. and C. Taverdon, Bruxelles.

Arms A, B, A, B^1, A, B^{11} revolve concentrically in the casing P and pass through slots in the eccentric disc M. Vanes F are hinged to this disc at the points D, D^1, D^{11}, while their opposite ends are pivoted by knuckle joints O, O^1, O^{11} to the arms aforesaid. Packing strips G, G^1 preserve their tightness against the disc and casing respectively. The shaft A, about which the arms rotate, is formed as a fixed crank-pin within the disc, the centre of which is hollow. *s*, *r* are the inlet and outlet, as indicated by the arrows; they may be partially filled up by blocks *y*, *z*, as shown. In order to balance the pressure of the disc M against the abutment H, two similar engines are mounted on the same shaft with these abutments opposite to one another, or the pressure may be partially balanced by forming the disc |-shaped and admitting steam behind the flange. Steam may be admitted and exhausted through the disc M if desired. In a modification an abutment F is hinged to the outer casing while the disc M oscillates about it, giving motion to the shaft by a crank. A dynamometric governor may be applied to the driving shaft, which is then hollow, and works in a sleeve, having part controlled by the governor.—December 28, 1887. [11½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

May 13th.

7924 Ventilating Sewers, G. Smith, Hammersmith.
7929 Stop Valves, J. Sturgeon, Birmingham.
7930 Weighing Machines, W. H. Hand, Bristol.
7932 Ball Taps, R. Howarth, Wolverhampton.
7937 Rotary Engine, H. Igel, Newcastle-on-Tyne.
7938 Multiplying Power, F. H. I. Lèques, London.*
7940 Making Wells, F. Bonnett, London.
7951 Shafts or Axles, J. Idiens, London.
7952 Steam Boilers, J. Rawlinson and S. C. Rawlinson, London.
7956 Smokeless Fuels, W. Boggett, London.
7965 Valve Gear, A. Walden, London.
7969 Ratchet Drill, P. R. Erickson, London.*
7970 Rivet Set and Header, W. Lowe, London.*

May 14th.

7980 Ore-concentrating Machinery, S. H. Stephens, Cornwall.*
7982 Scaling Sheet Metal, G. Clark, Sheffield.
7999 Gripping Jaws, T. W. Barber, Leonard's-on-Sea.
8005 Mechanical Stokers, J. Procter, Manchester.
8007 Furnaces, J. Cunliffe, Manchester.
8011 Smoke Consumer, E. Metcalf, Accrington.
8013 Petroleum Engines, G. W. Weatherhogg, London.
8022 Coupling Railway Cars, A. J. Boult, Middlesex. (D. H. Freeman, United States.)*
8028 Raising Water, H. H. Lake, London. (A. B. Merrill, United States.)*
8029 Steam Engine, W. D. Hooker, London.
8035 Brakes, W. W. Popplewell, Middlesex. (The Laurence Railway Brake Company, United States.)*
8040 Artificial Fuel, A. Mayall, London. (J. H. Lancaster, United States.)
8041 Rotary Pump, J. A. Wade, London.
8044 Tube Expander, H. E. Newton, London. (W. Walker and W. M. Newton, New South Wales.)
8050 Air Pumps, H. W. Nield, London.
8058 Metallic Packing, R. H. N. Lindley, London.

May 15th.

8071 Ventilator, F. A. Moore, London.
8072 Governors, H. W. B. Waygood, Liverpool. (J. E. Waygood, New Zealand.)
8089 Steam-pumping Engines, W. Holker, Liverpool.
8100 Riveting Machines, W. Skaife, London.
8110 Sifting Machines, H. J. Haddan, London. (W. Hahn, Germany.)
8112 Type-writers, G. A. Wilkins, London.
8118 Liquid Fuel, G. R. Young, London.

May 16th.

8125 Taps and Valves, T. Fletcher and A. Clare, Manchester.*
8127 Carding Engines, J. Thompson and T. Barker, Manchester.
8133 Bricks, T. H. D. May and H. A. Brown, Bristol.*
8136 Safety Lamps, T. Thomas, Pontypridd, Glamorganshire.
8154 Lubricator, E. J. Oates, A. D. Oates, and W. Earnshaw, London.
8155 Asbestos, W. Walker, London.
8163 Gas Lamps, W. Stern and J. Mücke, London.*
8164 Couplings, B. Key, London.
8168 Axle-box Lids, J. Donnelly, W. McLaren, and A. Trask, London.
8171 Propellers, L. Sellier, Liverpool.
8175 Motor, H. J. Haddan, London. (— Bailhache, Foucart-Alvimare.)
8179 Gas Retorts, A. Runge, London.*
8181 Explosive Shells, E. Davies, London.
8192 Water Gas, Josef von Langer and L. Cooper, London.*

May 17th.

8200 Tubes, W. P Thompson, Liverpool. (C. Pognon, France.)
8214 Flanged Joints, J. MacIlwraith Gorrie, Glasgow.
8215 Brake Gear, J. Cleminson, London.
8218 Propulsion for Boats, W. S. Baikie, Stromness, Orkney Islands.
8242 Hydrocarbon Engines, J. W. Hartley, Stoke-on-Trent.
8246 Self-closing Tap, R. Ellis, Tiverton, Devonshire.
8259 Lubricator, R. H. N. Lindley, London.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

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We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE
PRACTICAL ENGINEER,
JUNE 7TH, 1889.

SPIRIT VAPOUR ENGINES.

THE beautiful little engines adopted by Mr. Yarrow for propelling his Zephyr launches have aroused considerable interest among engineers in the use of vapours other than steam in prime movers. In these engines the boiler is simply a copper coil enclosed within a containing case, heated by a petroleum flame, and instead of water a light petroleum, intermediate in density between gasoline and benzoline, is pumped into the coil; it there boils and generates pressure, which is utilised by the pistons in the usual way, and after use the vapour is condensed by a surface condenser, and then pumped back to the coil boiler. The engines thus act precisely as do ordinary surface condensing steam engines, and if there were no leakages whatever, the same liquid would last for ever. There is a very slight leakage, of course, which requires to be made up from time to time, and a portion of the same hydrocarbon is used to burn to produce the heat necessary for the boiler. The boiling point of the liquid is considerably lower than that of water. At atmospheric pressure it boils at 130 deg. Fah., as against 212 deg. Fah., and at a temperature of 300 deg. Fah. the pressure is about 125lb. per square inch above atmosphere, against about 53lb. for steam. The latent heat, too, is very much less than that of steam, so that as the result of the combined lower temperature, evaporation, and less latent heat, a very much greater volume can be evaporated by the same source of heat at a given pressure and in a given time. Thus, using the same apparatus and the same source of heat, 50 cubic centimetres were evaporated in about 4½ minutes, while it took 36 minutes to evaporate the same quantity of water. The data we have given have been carefully determined by Mr. Yarrow, and we consider it most creditable to him that he should have undertaken what is really a most laborious and complete scientific investigation in order to prove the advantage or disadvantage to be expected from the use of a light hydrocarbon. He has conclusively proved that for small engines the spirit vapour offers great and distinct advantages, giving with identical fuel consumption in the steam engine no less than double the power as measured by the brake.

We had the pleasure of a run in one of these launches at the Glasgow Exhibition last year, and we were much impressed with the extremely small and handy engine and boiler. The launch was very swift, and the complete absence of the usual steam boiler was most noticeable. The little light generator at the stern looked almost too insignificant to give sufficient power for a good-sized craft; but it proved itself thoroughly able for its task, and the engines were if anything more easily and rapidly handled than those used in steam launches. Apart altogether from the economy, the clear space in the central part of the hull, and the entire absence of heat and dirt, were great and obvious advantages in a pleasure vessel.

The economy obtained seems to have surprised some, to judge from the comments we have heard, and an exaggerated idea seems not uncommon as to its possible application in large engines. It seems to us that the matter is after all a very plain one, easily understood with a little care.

The demonstrated fact that in a perfect heat engine the economy depends not on the working fluid used, but solely on the limits of temperature, has produced an impression among some scientists that there can be no advantage in using fluids more volatile and of less latent heat than water and steam. But it is forgotten that steam engines are not perfect heat engines, and that the loss in small engines with little expansion is due to two causes—first, discharge of all the heat of the steam at full boiler pressure; and second, cylinder condensation. It is quite obvious that the vapour of a volatile liquid of low latent heat, when discharged into a condenser at full boiler pressure, will carry away much less heat per stroke, and also that the less the elevation of the temperature above that of the cylinder walls the less will be the cylinder condensation. Accordingly we would expect to find, what is really the case, that in an engine of small size, and using little or no expansion, there is considerable economy in using a light hydrocarbon instead of water. But if large engines and considerable expansions are adopted, then the lower temperature of evaporation becomes a positive disadvantage, and the reduction in cylinder condensation due to cooling by the walls would not sufficiently compensate for the limited range of fall of temperature due to work performed upon the piston. We cannot, therefore, expect large compound or triple-expansion engines to be operated more economically than with steam.

Many attempts have been made to introduce engines known as binary vapour engines, in which the heat still remaining in the exhaust steam is utilised to evaporate a volatile liquid, and create pressure at a low temperature. The experiments of M. Du Trembley, in France, which resulted in the propulsion of two large steamers, the Du Trembley and the Bresil, running between Marseilles and Algiers, were perhaps the most extended and important. Ether was used and evaporated by the steam on its way from the cylinder to the condenser. Considerable economy was thus obtained, but by no means so good as with the compound engine, while great difficulties and annoyances were experienced. It was impossible to prevent leakage, and the engineers had to use safety lamps to prevent explosions in the engine-room. The expense, too, was considerable, as the leakage had constantly to be made up. From accounts published in 1856, we find that the whole vessels were so impregnated with ether vapour that they could be detected by their odour at quite a distance. After a time the experiment was abandoned because of continually recurring accidents and the great expense of renewing the ether. Some time later carbon bisulphide was proposed as a liquid, but to those familiar with the abominable odour of this compound, and its dangerous properties when inhaled, it is needless to say that it also failed completely.

It is in our opinion exceedingly improbable that any hydrocarbon spirit could be used instead of water in really large engines, and it is impossible that greater economy could be attained in such engines than is at present to be had with the best construction of steam engine and boiler. Still, for small powers, where great power in a small space and with but little weight is absolutely necessary, we believe that great development is possible.

In a letter to the *Society of Arts Journal*, last week, Mr. J. E. Dowson points out that the consumption of one-third of a gallon of light hydrocarbon, or 3lb. per horse power per hour—as given by Mr. Yarrow for his system—is considerably in excess of that used in petroleum engines proper—that is, engines where the petroleum is either burned or exploded within the cylinder, such as the Otto or Priestman's; one using gasoline to the extent of 1·2 pints or 1lb. per I.H.P. per hour, and the other using 1·71 pints of heavy oil or 1·69lb. per effective horse power per hour. It is quite true that it is much more economical to consume petroleum by burning direct within the cylinder of an engine, as with gas engines; but Mr. Dowson seems to forget entirely that petroleum engines are exceedingly heavy for the power produced, and are very difficult to handle when compared with vapour engines. Petroleum engines, too, cannot be reversed, and once started they must continue running in one direction, so that clutches or other gear must be used between engine and propeller shaft to change the revolutions of the screw when required. Altogether, notwithstanding attempts by Otto, Priestman, and others, the internal combustion is not yet in a position to compete for launch or marine work. We do not for a moment assert that it cannot be adapted to the purpose, but at present it certainly is not capable of effective action on board of any vessel. Indeed, as yet petroleum engines have made little or no progress even for land purposes; there seem to be difficulties in application of which the general public are unaware, otherwise we are much at a loss to understand the small number of such engines in actual work.

The spirit vapour engine occupies a position midway between gas and steam engines, and, although capable of considerable development, cannot be expected to compete with either, but it can find many uses peculiar to itself, especially for small powers.

THE ESCAPE OF HER MAJESTY'S SHIP CALLIOPE.

The narrative of the escape of the Calliope from Apia Harbour, Samoa, on the 16th of March last, against the full force of a hurricane, as given by Captain Kane in a letter to Rear-Admiral Henry Fairfax, Commander-in-Chief, Australia, and published in a parliamentary paper last week, is most exciting reading, and proves that much more than mere good luck was concerned in her preservation. When it was known that a terrible hurricane in Samoa had wrecked six out of seven war vessels, it will still be fresh in the minds of our readers that the British man-of-war was mentioned as the only one which succeeded in getting out to sea and weathering the storm. Although deeply sympathising with the loss of life and vessels of American and German nationality, yet we could not repress some natural self-gratulation on the fact of our vessel's escape, but it was felt that after all it might be a mere chance, and not the result of superior seamanship. Captain Kane's report shows that first-class engines, steady engineers and firemen, together with daring seamanship, combined to form the necessities of safety. The chief engineer of the vessel, Staff-engineer Bourke, and his staff, are specially commended both by the captain and Admiral Fairfax. "Thanks to the admirable order in which the engines and boilers have been kept, all went well," steaming with the extreme power to be got from the machinery from 9-30 a.m. to 8 p.m., without a hitch, although racing with every plunge in a very heavy sea.

The captain says: "I called on the staff-engineer for every pound of steam he could give us, and slipped the one remaining cable. I had slipped the sheet some time before, finding it did no good and hampered my movements. The engines worked admirably, and little by little we gathered way and went out, flooding the upper deck with green seas which came in over the bows, and which would have sunk many a ship. My fear was that she would not steer, and would go on the reef in the passage out, especially as the Trenton was right in the fairway. But we went under her stern, putting our foreyard over her quarter boat, and came up head to wind most beautifully. Once outside her, it was nothing but hard steaming; if the engines held out, we were safe; if anything went wrong with them, we were done for." The wind and sea were so terrible, that even at full power only one knot an hour was made, enough to give steerage way, and this with the Calliope, which steamed in smooth water fifteen knots an hour. The importance of powerful engines of the very best workmanship cannot be overrated when so small a margin means safety. The officers, seamen, and engineers are to be congratulated on their happy escape unhurt by the exercise of their skill and daring, while other vessels were lost beyond recall.

THE OTIS LIFT IN THE EIFFEL TOWER.

On the morning of the 29th May an experiment was made with the Otis lift, to prove the action of the safety-braking device intended to come into operation in the improbable event of the hoisting ropes breaking. The lift cage consists of two compartments, one above the other, and weighs some

11,000 kilogrammes. It was loaded with 3,000 kilogrammes of lead, and raised to a considerable height in the tower, and then sustained by ordinary ropes. The ropes were then cut at one blow by two men armed with hatchets. The cage at once fell, but almost at once began to move slowly; it swayed for a moment, and the brake seized firmly and stopped it. Not a pane of glass was broken, or even cracked. A powerful arm seemed to have caught the cage in its descent, and to have stopped it without shock at a height of over 30ft. from the ground.

The Messrs. Otis, of New York, have made a specialty of the construction of passenger lifts, which are so commonly used in America, for ready access to the high buildings prevailing there. In their construction expense has been entirely subordinated to safety, and every possible provision which experience could suggest and ingenuity devise has been adopted. The details of their machines are exceedingly interesting, and we hope in an early issue to discuss and illustrate them with some completeness.

SERIOUS EXPLOSION IN HULL.

On Wednesday morning, the 15th ult., a serious air explosion occurred at the Holderness Foundry, Williamson Street, Hull, owned by Messrs. Priestman Brothers, the makers of the well-known petroleum engine.

From information which we have received, it appears that one of the partners of the firm, Mr. W. D. Priestman, was conducting some experiments in charging a cast-iron cistern with compressed air, with a view to supplying machinery to the Trinity House for the blowing of fog horns, when from some defect in the gauge, which failed to register the correct pressure of the air contained in the vessel, the cistern suddenly burst.

Mr. Priestman, it seems, was at the time of the explosion superintending the tests, and was standing close to the receiver, inspecting the gauge at the top of the cistern (which is a cast-iron receptacle about 5ft. 9in. long, 2ft. 9in. deep, and 2ft. 6in. wide), when he was suddenly hurled backwards with great force against a box which stood near, resulting in a fracture of both of his legs and severe injury to one of his arms.

It is stated that the pieces of the tank were not blown to any great distance, but fell more or less in a heap on the scene of the accident, but in view of the serious nature of the injuries received by Mr. Priestman, it is presumed that the several pieces, which were of great weight, were driven forcibly against him, thereby causing him to come into contact with the box behind him, which was, by the way, smashed to matchwood.

The most marvellous feature of the case is, that only one of the many workmen standing near sustained any injury, and that not sufficiently severe to warrant his removal to the infirmary.

A considerable amount of public sympathy with Mr. W. D. Priestman has been expressed, the news of the accident being received with audible manifestations of deep regret at the occurrence, as the Priestman family have, by their kindly acts, won the esteem and respect of all who know them.

COMMON-SENSE ENGINEERING AS APPLIED TO STEAM MACHINERY.

By W. H. Booth.

In selecting steam generators, there is frequently seen a lamentable want of that every-day common sense which ought to be visible in such an undertaking. Too frequently the selection of a steam boiler is in the hands of a chairman of directors, whose technical knowledge does not extend to steam boilers, and who is led by the specious arguments of a travelling salesman to select something wholly unsuitable for the purpose, whereas had he obtained the advice of an expert he would at once have rejected the article offered. Often the whole arrangement of the steam boilers of some large institution, such as a workhouse, a hospital, or even a technical college, is left entirely in the hands of an architect, who, however competent in his profession, is utterly unfitted to deal with a problem of mechanical engineering; and public institutions could be pointed out where the steam engineering is simply disgraceful. Steam boilers are sold in districts of the country where smoke-producing bituminous coals are certain to be burnt, which are only fit to be used for coke or other smokeless fuel. Tubular boilers of the locomotive type are put down in positions where, in the absence of a forced draught, smoke must be produced, in utter disregard of the fact that locomotive boilers are the outcome of a condition of things which is favourable to perfect combustion in the smoke box. Where smoke-producing coals are to be burned, furnaces must be specially adapted for them. The essentials of combustion are a thorough admixture of the gases evolved from the fuel with air supplied above the fuel, a temperature of about 1,000 deg. Fah. as a minimum, and a sufficient unimpeded space for combustion to become complete. In the Lancashire boiler these conditions may be secured. The grate is usually of considerable length, and serves to raise to the necessary temperature the gases from the fuel and the air which enters above the fuel by openings usually provided in the furnace doors. At the bridge wall there is usually a contraction of area, and this seems to be favourable to ignition. Thus far the conditions are favourable to smoke preventing. The final requisite is very frequently absent., viz., the unimpeded expansion space. In a plain Lancashire or Cornish boiler—that is, one without tubes—the conditions are favourable, but too usually it is the custom to fix cross water pipes in the flue tubes, which, in the writer's opinion, are often worse than useless. Personal experience, and the knowledge acquired by inquiry from inspectors, firemen, and flue cleaners, have all pointed to the bad effects of water pipes. The obstruction which they offer to the burning gases pouring over the bridge wall seems to have the effect of extinguishing the combustion by shock, and the result is soot, the hydrogen burning and leaving the carbon unconsumed. Advocates of water pipes forget that the gases from a coal furnace are an impure mixture of hydro-carbons and the oxides of carbon, and are, therefore, very "tickle," and only ignite and continue to burn under favouring conditions. Seeing that water pipes have no effect in stiffening flues against collapse, they ought not to be placed near the bridge, and if used at all should, in my opinion, be at least 12ft. from the bridge. Similarly, in boilers of the Galloway type, it would be a good practice to remove the first pocket, which usually comes so soon after the bridge. When this is removed there is a semi-cylindrical space between the pipes and the side of the flue, down which the burning gases may pass as they rush over the bridge. The insertion of the side pockets is, of course, done for the purpose of compelling the products of combustion to pass amongst and between the water pipes, not intentionally to prevent an inspector from passing, which they, however, most effectually do. The intention is good, and perfectly justifiable and proper if coke fuel be used, or the boiler is intended to burn American anthracite, but for bituminous coal it is incorrect.

Boilers have been tried of the sectional type, built up of many small pipes, from 3in. to 7in. diameter, and placed in a more or less inclined position above the furnace. In these boilers the products of combustion rise vertically from the furnace, and pass amongst the water tubes. There can be no passage of air from the door along the furnace and over the fuel to mix and become heated with the gases, and there is no point of concentration, as a bridge wall. Boilers so constructed are sure to be smoky, for even if it were possible to effect ignition of the gases, they would at once be extinguished between the small pipes. Any furnace from which the gases rise vertically is a smoke producer, as witness the common small vertical boiler, as supplied with derrick cranes, &c. These boilers are notoriously dirty, simply because no means are taken to compel the gases to pass close in front of the fire door, to mix with a supply of air admitted at that point.

As a rule the working and management of steam boilers is better understood in the manufacturing districts of Lancashire and Yorkshire than in the South and London districts, where boilers of a temporary character seem to be frequently employed. Of late years temporary engineering has come largely to the front, chiefly because of the introduction of the electric light. To some extent this has been the fault of electricians, who, however competent as electricians, are often not steam engineers. In other cases, installations of light have been made on the trial principle, and the necessary semi-portable character of the steam plant has been followed by younger electricians, whose only excuse or reason for the use of temporary plant is that they are following the example of some noted man who had a reason for employing temporary plant not perceived by his servile imitator. In other cases, again, the exigencies of position, such as the installation of electric light in a building where no provision has been made for steam power, has compelled a design of boiler not of the best, but which is unfortunately followed as a precedent by others whose surroundings would allow of better things. It is largely due to the temporary character of so much electrical engineering, which has been fostered by so many temporary installations as ephemeral exhibitions, that lighting and motive power by the new agent have been retarded and thrown into disrepute. Fa too much electrical work has partaken of the work of the plumber or tinsmith. Now, however, that it is coming more into the province of mechanical engineering, a great improvement may be expected.

The very ease with which a wire carrying a large power may be taken round a corner or through a hole bored by a gimlet has helped to keep down that solidity and excellence of work which is as much requisite to success as in any other branch of engineering. The moral effect has been bad, for it has tended to the belief amongst the ignorant that electricity is of a mysterious nature, and can do anything, whereas it is but a manifestation of energy which hitherto it has not seemed necessary to employ, but which now appears to be most desirable for many purposes. Popular ignorance magnifies the visible difference between a small wire and the ponderous revolving shaft which it displaces into something marvellous, and the moral effect of the use of such comparatively small means for great ends has infected the electricians themselves, and rendered them incapable of appreciating the true condition of the steam plant which they employ. No mechanical engineer can enter a room of dynamos, as usually fitted up, without experiencing a sense of the unseemly bustle and confusion which characterises the place, and the undesirable mixture of boilers, coals, ashes, engines, belts, and delicate high-speed machinery, in a badly-ventilated, overheated building.

Common sense in engineering demands separation between boiler-room and engine-room, and for dynamos the seclusion of the boiler is still more desirable, owing to the care necessary for high rates of rotation. Common sense also calls for very much more liberal bearings in electric machinery than are often employed. Given plain, substantial boilers, engine of cotton-mill type, and substantial, well-made dynamos and motors, and there is no good reason to fear the breakdown of electric installations of a size sufficient to pay. Modern cotton mills, with engines of 1,000 to 2,000 horse power, run indefinitely without breakdown, failure, or even stoppage from heated bearings, simply because of substantial, plain, and rational design.

PRACTICAL NOTES ON MARINE ENGINEERING.—XIX.

Screw Propellers.

In three previous articles on this subject we have treated of the diameter, pitch, and surface of the propeller, and we now proceed to deal with the form, strength, number, and material of the blades.

In dealing with the former of these, the usual method is to construct a diagram from which the angles of the blades are taken, and from which the pattern-maker or moulder may take templets for thicknesses and also the shape of the blades. An outline of this diagram may prove interesting to many of our readers, and we therefore give a short explanation. Take the circumference of the propeller, and lay it off as in fig. 2, line AB. Next lay off the circumference of the boss from A to C parallel to AB; from A draw AD equal to pitch; join BD and CD; then CD is angle of blade at boss, and BD angle of blade at periphery. Divide CB into a convenient number of equal parts, say five or six, or every 9in. or 12in. in length of blades; join each of these with D, to get angle of blade at the various intervening places.

If it is intended to construct an uneven pitch, say one increasing from loss to periphery, lay off each pitch as shown—A_1 being the reduced pitch at boss C_1, the circumference; join C_1 and B; the pitch then increases along this line.

A templet is made for each division in the blade from boss to tip (fig. 1), and with these in position, and at the angles for each as already found, the moulder sweeps up the blade with a board radiating from the centre of boss as a pivot. The position of the blade at the boss is often the distinguishing feature between a good and inefficient propeller. Instead of placing the blade right in the centre of boss, it should be kept aft a distance about equal to its own thickness, as shown in fig. 2. With loose blades this allows a greater space on the driving side for the studs where they are in tension. We may here mention that many interesting experiments have been carried out regarding the angles of the blades, which experiments have in all cases been more or less successful:—

(1) Straight blades have been set at an angle of 45 deg.

(2) The pitch has been made twice as much at the boss as at the tip.

(3) The pitch has been variable across the blade to an amount equal to one-fourth of true pitch.

(4) A true screw—that is, as true as can be cast.

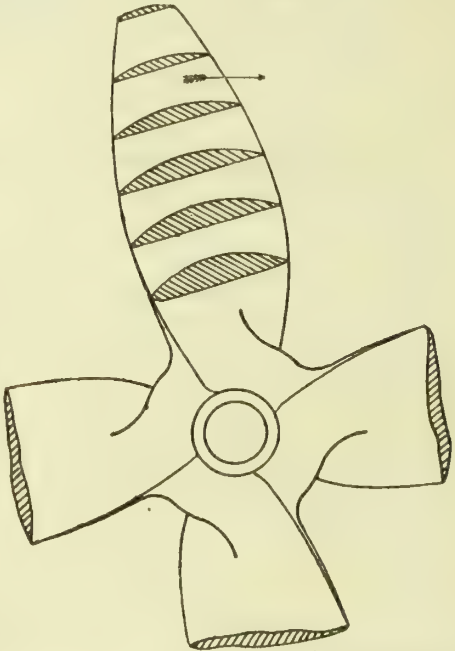
(5) A true screw cast, and the face of the blade afterwards accurately measured and chipped up by hand, and the back polished.

Roughly speaking, these appear to be about the extremes in the ideas of setting of blades, but there is little doubt that the true screw is the best under all conditions.

The thickness of the blade at the root—that is, about two diameters of the shaft out from the central line—to give the requisite strength is calculated in various ways, though from the thickness of some propellers it would appear that no calculation had been made; indeed, the thinness of blades and general lightness of some propellers would give the impression that they were not intended to stand any of the severe strains to which they are continually subjected, but rather that it was intended that they should act as a safety piece for the engines, should the blades come in contact with a quay wall, or similar projection.

In order to reduce the resistance to a minimum, it is a good practice to make the blades as thin as is consistent with safety.

Fig. 1.



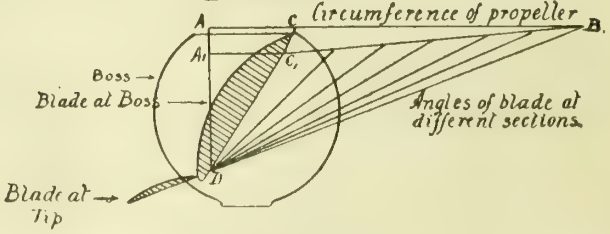

A
C
Circumference of propeller
B.
A₁
C₁
Boss
Blade at Boss
Angles of blade at different sections.
Blade at Tip
D

Fig. 2.

Perhaps the formula most used, and the best, is that proposed by Rankine, thus:—

$$\sqrt[2]{\frac{D^3C}{LN}} = \text{thickness of blades}$$

(here measured at two diameters of shaft out from centre) where D = diameter of shaft;

„ L = length of blade at boss;

„ N = number of blades;

„ C = a constant, according to the quality of the material, say 3 for the best cast iron for propellers over 16ft. diameter, where the length of blade at boss is not less than three times the diameter of the shaft. In large propellers it is necessary to limit the thickness within practical limits, so as to obtain sound metal: 3·5 to 4 for all other diameters less than 16ft. where the best cast iron is used; 3 for all diameters less than 16ft. where a good steel mixture is used (that is, about one-quarter to one-fifth scrap steel melted with the cast iron); 2·5 for all diameters in cast steel, manganese, bronze, or other equally tough metal.

Another method adopted to obtain this dimension is to allow from ⅜in. to ½in. per foot diameter for the thickness at root of blade—that is, 0·375D to 0·5D = thickness in inches. Average practice may be taken as being 0·5D for cast iron of good quality when length equals 2½ times diameter of shaft; 0·4D for cast iron of good quality when length equals 3 times diameter of shaft; 0·3 for cast steel, manganese, bronze, &c.

Again, one-half of the diameter of shaft, with a slight addition or deduction, as the case may be, is a rule of thumb way of getting at the thickness. For cast iron an addition of about 10 per cent is not uncommon, and a reduction of about $\frac{1}{3}$ per cent for cast steel, bronze, &c. The width of the blade, where measured for this thickness, should be quite equal to that already mentioned. The lip of blade is for small diameters made as thin as practicable from $\frac{1}{2}$in. upwards, say to $\frac{5}{8}$in. for 10ft. diameter to 1$\frac{1}{2}$in. for 20ft. Referring to the illustrations, fig. 3 shows a boss for loose blades. With this kind of boss the metal round shaft should always be continuous for the full length, except the small recess at about half-way, so that in case of leakage at a blade or through the stud holes the water cannot come in contact with the shaft. When the boss is cored out any leakage soon finds its way to the bearing surface by way of the key seat, corrosion commences, and makes the propeller slack. Fig. 4 is a spherical boss with blades cast on. Fig. 5 is an oval boss with blades cast on. Figs. 6 to 9 give an idea of the various shapes of blades for different sizes of propellers. No. 6 is generally adopted for large diameters, where the largest diameter has been adopted and where the surface is easily obtained. In these the blade is narrowed towards the tip where the speed is greatest and the resultant thrust the least. No. 7 is a good shape for the larger sizes, but where the largest diameter has not been adopted. This form answers for three blades as well as four. The surface is kept up towards the tips. These blades are often thrown back, as in figs. 4 and 5. It is supposed that by this means the blades work in more solid water and get clear of the eddies consequent on the forward motion of the vessel. Fig. 8 has been successfully applied where there are only two blades and for medium diameters. Three blades also of this shape have done well in twin screw-steamers. Fig. 9 is for the small diameters where the engines do not run at a very high number of revolutions. Either two or three blades of this shape answer well for barges and towing purposes.

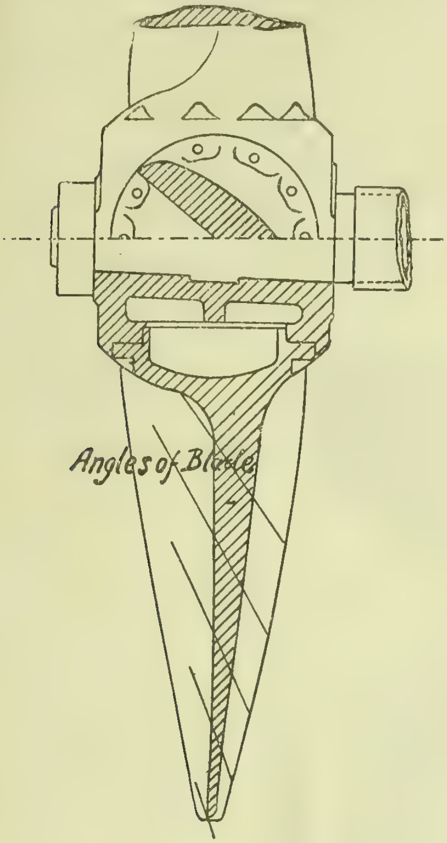


Fig. 3.

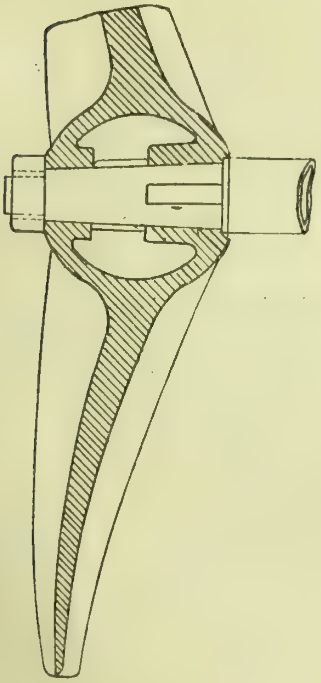


Fig. 4.

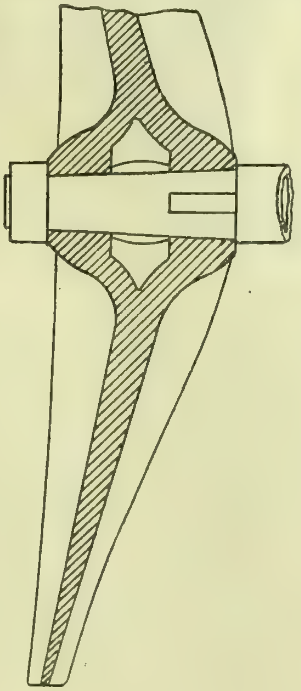


Fig. 5.

Kunstadter's patent screw-steering apparatus was introduced with a view to the better handling and easier steering of ships in channels and harbours, and, when applied to vessels of warfare, to their better control in time of action. It is illustrated at fig. 10, and the main feature consists in the application of the well-known Hooke's joint, which is fitted to the shaft immediately aft of the large propeller. The outer portion of the shaft is continued through the rudder, and the smaller or steering propeller is fixed on the end, as clearly shown in the illustration. The rudder, when moved over in the ordinary way from the deck, takes the outer propeller with it, which latter, revolving at an angle to the keel, exerts itself in turning the vessel round. The rudder post is riveted to allow of the shaft joint passing through it, and the weight of the outer part is taken by a bearing in the rudder.

This arrangement answered its purpose admirably when applied to the steamship Stratheden, to which our illustration refers. The dimensions of the vessel are 284ft. by 38ft. by 16ft., having compound engines indicating about 1,200 horse power.

It cannot be denied that, while there are many good features in connection with the design, there are some points open to objection, the principal ones being extra first cost, excessive wear of the joint and consequent upkeep, and the likelihood of damage to

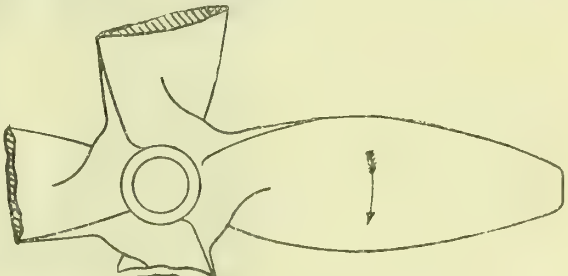


Fig. 6.

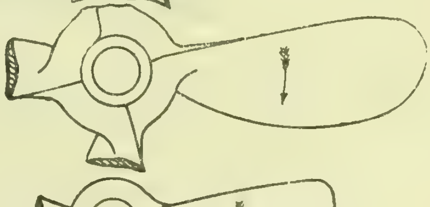


Fig. 7.

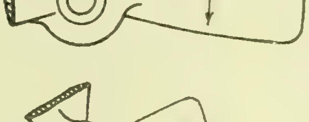


Fig. 8.

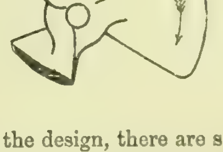


Fig. 9

the small screw when hard over in channel or harbour; but these are difficulties which can be overcome through care and attention.

This illustration also shows an example of a propeller having straight blades, set at an angle of 45 deg., without any attempt at forming a true screw.

The application of Hooke's joint to screw shafting may also be found in the case of the lowering screw, where the aft portion of the vessel is divided, to allow of the tail shaft and propeller being moved up and down as required. An example of this may be seen in the steamship Camel, a vessel built by Messrs. Harland and Wolff, in 1870; dimensions, 170ft. by 22ft. by 12ft.

For securing the bosses of all kinds to the shaft a fore and aft key sunk into the shaft is invariably used, and a wrought-iron nut with a fine thread, in depth about ⅔ the diameter, is fitted hard up against a turned face on the outside, and secured by means of a set pin and check. If there is only one fore and aft key, it should be not less than ¼ diameter of shaft in width, and in length equal to 1¼ times the diameter. Sometimes these keys are made the whole length of boss, but the disadvantage with this arrangement is that it cannot be taken out and renewed without drawing in the shaft, removing the propeller, and then putting the shaft out again, unless a clearance equal to the length of boss has been allowed in the width of stern post.

The taper of the bearing surface varies from ½in. to ⅞in. per foot. A very fine taper does not, however, answer well, for in driving on the boss to ensure a good fit there is a liability of splitting it, and again, if the boss has been successfully put on in the first instance, there is more difficulty in getting it off again for examination of the shaft when the vessel is in dock, just at the very time when everything has to be done expeditiously.

The material used for propellers is usually cast iron or a "steel mixture," though of late years cast steel has become quite common, both for blades and boss. Wrought-iron forged blades have been used for torpedo boats with fair success. Other alloys, such as brass, phosphor, and manganese bronze, have also been adopted, but their great cost is much against their general use. As regards cast steel, the advantage to be had over cast iron is in the increased strength, allowing of a consequent reduction in thickness. In some instances they have not lasted so well, the steel corroding at the tips of the blades at the back much faster than those of cast iron. It would appear that the form of the vessel and run aft, or the proportions of propeller relatively to that of the hull, must have something to do with the corrosion of blades. The admission of air and its contact with the revolving screw is the generally accepted theory of the cause of this corrosion taking place. In some vessels the blades are never affected, and in one instance the original steel blades are yet doing work, after fourteen years of good and constant service. In other cases both steel and cast-iron blades have been tried on the same vessel, with the result in each instance that they were reduced in thickness at the tips after a comparatively short period.

To prevent this corrosion taking place many methods have been adopted, such as tinning the blades or covering them thinly with some metal not subject to the corrosive action; but these thin plates have been found to get slack—no doubt through the vibration of the vessel—and then a galvanic action is set up between the covering plate and the blade, which soon makes it necessary to have new ones fitted.

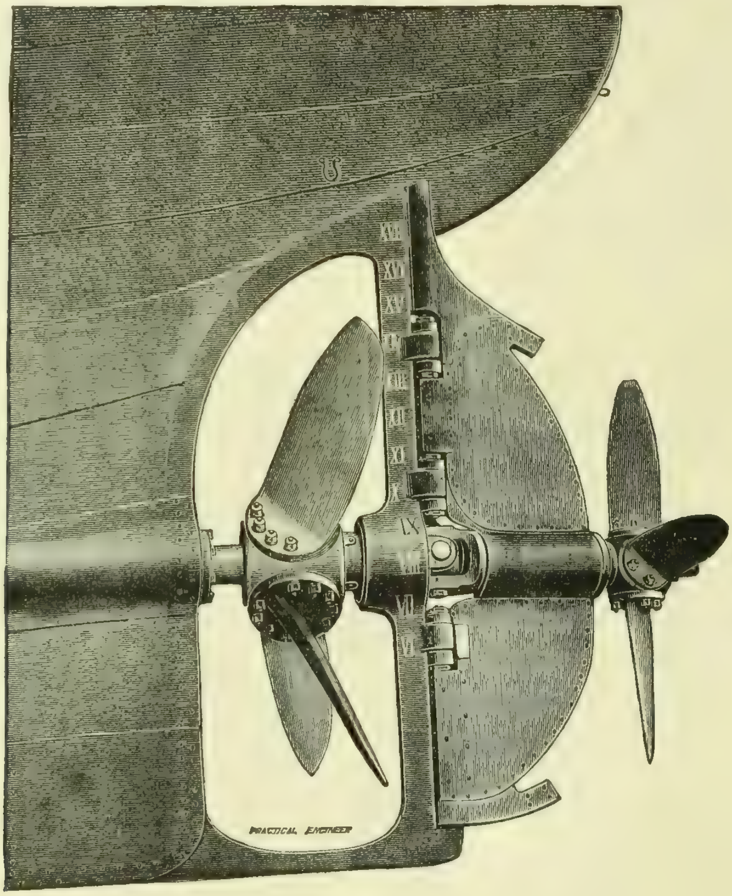


Fig. 10.

The best process is perhaps that known as Johnson's patent, where the blades are ground smooth—then heated and covered with tin to a thickness of about ⅜in. By this method actual metallic contact is ensured, and there is no effect from vibration.

The air theory was the subject of a very costly experiment on the Clyde a few years ago. The imaginative engineer whose inventive genius had taken a turn in this direction was successful in persuading an eminent firm to give a trial to his idea of overcoming the evil effects of a vacuum being formed towards the tips of the blades on the backing or go-astern side. The accepted theory of air always being in contact with the blade had no reference in this instance, as the blades were of bronze, and therefore not subject to corrosion. The object appears to have been to destroy the vacuum or partial vacuum which there is every reason to suppose does exist thereabout, but unfortunately the mechanical application of the theory in the shape of a projected web or pin at about right angles to the surface of the blade was the cause of such great resistance to the revolving of the propeller, without any apparent gain in the form of increased speed of vessel, that it was deemed advisable, after a short trial, to place the vessel in dry dock and remove the webs, which were cast solid with the blades, and which were expected to have added considerably to the speed. Considering this vessel was one of large size, with a propeller of somewhere about 20ft. diameter, the experiment was not only a costly but a very bold one.

This question of the best material of the propeller blades is one of the greatest importance to the shipowner. On it depends in a large measure the continuous and successful and economical running of the steamer. Delay and demurrage, consequent on the breakage of blades, differences in speed, with the result only too clearly shown in the coal bill, are amongst the not least important considerations.

Some very interesting experiments have been made to determine the relative values of the materials already mentioned, and it has been determined that steel blades are the strongest, and can therefore be made the thinnest, but do not last unless properly protected at the tips. This is, however, a matter which can be guarded against, as already mentioned. Manganese bronze of good quality, where special care has been taken in the remelting, has proved to be well suited for this purpose; in one notable instance in a large mail vessel there was a decided gain in favour of bronze—increased speed, less horse power, and a greater reduction in coal on a round voyage.

In conclusion, we may mention that for high speeds a cone-shaped cap should be placed over the nut aft to destroy the vacuum in wake of propeller boss. The aft side of brackets for twin screws should also be tapered so as to give an easy run. A perceptible decrease in the resistance of the vessel through the water has been found to be due to attention to these apparently small matters.

THE WENSTRÖM MAGNETIC SEPARATOR.*

As the margin of profit in the manufacture of iron continues to decrease, attention is called more and more to economies in every department. Beginning at the bottom, in the preparation of the ore at the mine, we notice a general tendency is towards the shipment of richer ores, securing to the mine-owner a better price per ton, which the purchaser is glad to pay by reason of the saving in freight of iron, and in the cost of reduction, which depends so largely upon the amount of fuel and flux, and the productive capacity of the plant. In other words, the difference in value between rich and poor ores is much greater than their relative percentages of iron indicates; because the barren material in a lean ore is not merely worthless, it is a positive source of expense, requiring transportation, handling, fluxing, smelting, and its due share of general expenses; in return for which it yields nothing and decreases the available capacity of a given plant and capital for profitable work.

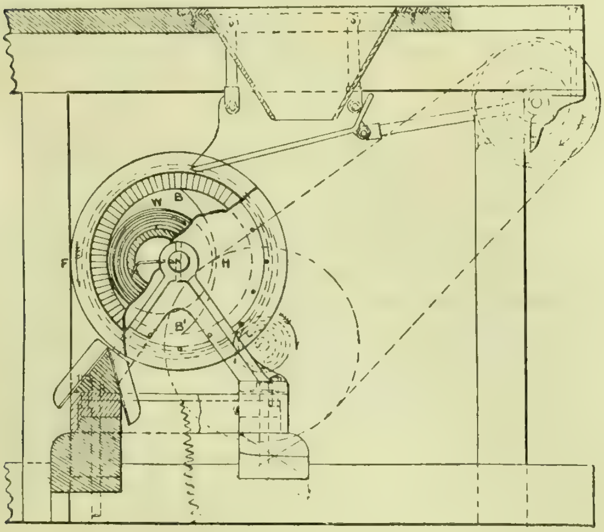


Fig. 1.

The enriching of the ore is done in most places by hand-picking, and in a few by wet concentration; but the managers of several magnetite mines in Sweden have been practically successful in doing it by machinery. The only magnetic separating machine which has actually taken the place of hand-picking was designed and patented by Mr. Jonas Wenström, of Örebrö, Sweden.

In this machine, which is illustrated in figs. 1 and 2, Mr. Wenström has taken advantage of the property of soft iron to become magnetised by induction. The machine consists of a barrel made up of soft iron bars and some non-conducting material (usually wood), which is rotated around a stationary shaft by means of a cog-wheel. Inside of this barrel, on the shaft, is placed eccentrically a cylindrical electro-magnet, provided with a number of flanges, between which wire is wound in such a manner that the flanges are of negative and positive polarity, being energised by a current passing through the wire coils from a small dynamo. As will be understood, the flanges are circular, and follow the internal contour of the barrel on the front side, while on the opposite side they are cut down to the line B, B^1 in fig. 1. Hence the bars of the revolving barrel on the front side of the machine are magnetic only while passing from B to B^1; and after they pass the point B^1 in the lower part of the machine, they cease to be so, and remain entirely without magnetism in passing through the space from B^1 to B, at the back of the machine. The bars have alternately two and three projections coming close to the polar flanges, so that each bar becomes virtually a prolongation of the magnetic poles.

The ore and rock are fed on top of the revolving barrel, coarse and fine together, and the ore adheres to the barrel during half a revolution, being only released after it has passed out of the magnetic field at B^1; the non-magnetic material rolls off the barrel and falls in front of the dividing-board, while the magnetic material drops off behind it.

Two sizes of this separator have been introduced. The largest size treats from six to seven tons of material per hour, and the magnetism is strong enough to support pieces of ore up to seven pounds in weight, and separate them from the rock. The smaller size treats from two to three tons per hour of finer material, below three-quarters of a pound in weight of single pieces.

In Sweden these separators are used at the iron-mines for extracting from old and new dumps of waste material the good ore which has been missed in the hand-picking, or was to fine to be picked out in that way. They are also applied to the ore now being mined, which in former time were selected by hand. Three of the Swedish mines use the larger size of the machine, and four the smaller.

During a recent journey in Sweden (unfortunately in the winter, when the dumps were frozen and the machines idle), the writer visited five of the mines where these machines are used, and obtained the records of their working results. It is deemed sufficient to give in this paper, as a typical example, the data thus collected at the Dannemora mine. Practice elsewhere is essentually similar, the cost varying at each mine in proportion to the handling necessarily given the ore before it comes to the separator.

The Dannemora plant consists of a separator (fig. 2), 24in. on face and 27in. in diameter, a small dynamo, and a portable engine, which runs not only the separator but also a bucket-elevator and a hoist capable of raising a car loaded with half-a-ton of ore. The material, which is anything below a 4in. mesh, is dumped from a trestle at the elevator, which conveys the material to the feed of the separator, and the separated rock falls into a chute, and is thence delivered into a car and run off to the waste dump. The ore runs down into a barrel-screen of perforated steel, the holes being one inch in diameter. The pieces which pass through fall into one car, while the coarser portion fall into another. These cars are then hoisted on the elevator and run off to the point of shipment. The fine stuff, below one-inch mesh, is kept by itself for reasons connected with the subsequent roasting. All the ore is roasted, and there is some difficulty in roasting the fine ore. Consequently, not more than 5 or 10 per cent of the charge in the roasting-kilns is permitted to be fine. The fuel used in the kiln is the tunnel-head gas from the blast-furnace.

Four labourers and an engineer are required to run the machine to its full capacity, with a boy to pick out from the rock any pieces of ore which may have been mechanically knocked off by larger pieces of rock. The men's work consists of shovelling the ore into the elevator, and taking the rock and ore in the cars to the dumps. The amount of the material handled averages six and a half tons per hour.

The separator was introduced in 1866, during which year no permanent plant was erected, but the machine was moved around from one small waste-heap to another. The present plant was erected in 1887, and during that year, as also in 1888, the separator was run intermittently through a season of five months.

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* Paper read by Mr. Robt. Anderson Cook before the Am. Inst. of Mining Engineers.

The work of the three years was as follows :—

Year.	Total material treated. Tons.	Ore obtained. Tons.	Percentage of total material obtained as ore.	Rock. Tons.
1886	2000	No data	—	——
1887	5720	3609	63	2111
1889	5169	2923	76	1214

The cost of hand picking at Dannemora, previous to the introduction of this machine, was 32·6 cents per ton. It now costs 9·8 cents per ton,* and 30 per cent more ore is obtained from the same material. Analyses of these ores are not frequently made, but it is known that the separated ore averages 59 per cent iron for the coarse, and 45 per cent for the fine. If the fine ore can be fed by itself in a somewhat different way, the results, as to that part, would be much better.

Any invention adopted from a foreign country, where the plans of working, as well as the ore treated, are different from our own, must necessarily be changed to some extent to do the work required in America. Apart from this consideration, each ore must be treated in a different way. But that this invention is of practical value to us in America is demonstrated by the fact that it is used profitably in Sweden, where labour is not worth more than 50 cents per day.

There are three different cases to which this machine can be successfully applied, with only one change in the feed (namely, when the ore is below a half-inch mesh). First, where there are waste-dumps, and the run of mine has to be hand-picked. Second, where only what might be called preliminary crushing is necessary to break the greater part of the ore free from the rock, that is, by passing it through an ordinary crusher to a half-inch mesh—which ought not to cost more than fifteen cents per ton. Third, where the ore must be pulverised by further machinery to a one-quarter-inch mesh or some smaller size.

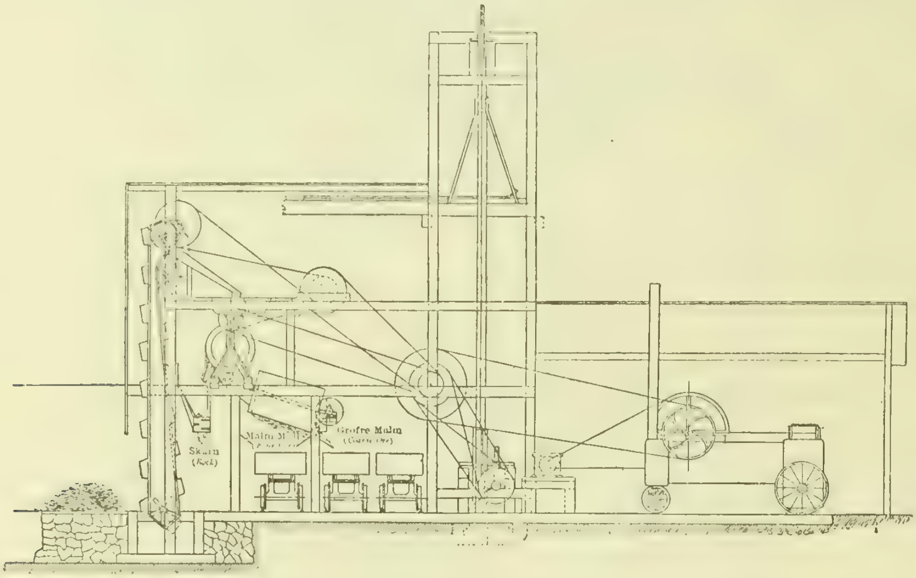

Fig. 2.

The first two of these cases are very simple, but the third is a problem by itself, in which the cost of mining, the number of tons which must be crushed to obtain one ton of concentrate, and the cost of crushing, are items of far more importance financially than the mere separation of the ore from the rock. Each mine-owner must decide for himself whether it will pay. The cost of separating ore per ton of finished product by any machine, it is impossible to give, since it varies with the richness of the ore. A Wenström machine requiring one and a half horse-power to run the dynamo, and half a horse-power, or less, to run the separator, has a capacity of fifty tons of fine (or a larger amount of coarse) material in ten hours. The feeding should be automatic, and the ore and rock should fall by their own weight into cars, so that there need be no hand labour, except that of feeding the crusher or screen, if coarse material is to be used.

Some interesting questions arise in connection with the concentrated fine ore.

One, which the Swedish Government settled to the satisfaction of its furnace-manager, is that of the use of fine ore in the furnace. It had always been supposed to be a detriment to the furnace to charge a large proportion of fine ore. Experiments were made at the expense of the Government, under the charge of Mr. Granstrom, of Norberg, an eminent Swedish engineer, in the preparation of briquettes of a mixture of fine hematites crushed and concentrated to 65 per cent of iron, with slacked lime, in a powerful brick machine. These briquettes were very nice-looking ; but, when put in the furnace, they all went to pieces. Mr. Granstrom then resolved to see exactly how much fine ore a furnace would stand. Taking one of the charcoal furnaces in his charge, he began by using a mixture of 10 per cent fine ore, and gradually worked it up to a maximum of 75 per cent. The only change he found with the latter mixture was that the gases were a little hotter, and he was able to carry a little heavier burden on the furnace. The pressure was the same and the conclusion reached was that the manufacture of briquettes was entirely unnecessary.

Another question concerns the effect of fine concentration in reducing such impurities of the ore as enter the pig-iron made from it. This has never yet been carried so far in practice as to convert a non-Bessemer ore into a Bessemer ore, by eliminating, through the process of concentration, the phosphorus contained in the gangue ; but in all the concentrations of ores, wet or dry, the impurities have been materially reduced ; and it seems not unreasonable to expect that many ores, which are but little outside the "Bessemer limit," will be brought within the limit, and thus made more valuable.

There are other uses to which this magnetic separator has been profitably applied in Sweden. One is that of separating the pieces of iron from the dirt, in yards where pig-iron has been stored, or from any old heaps of waste material—for instance, where the dumpings from cupolas have been piled.

A machine was sent a short time ago to the Lackawanna Iron and Coal Company, at Scranton, Pa., U.S.A. At these works the waste from the cupolas, and from around the runners at the converter, has been for a long time treated by putting it in a "rumbler," such as is used for cleaning castings at foundries, only of a larger size. The fine pieces of slag and iron being thus broken up and fall through the rumbler, and these have always been sent to the waste-dump, while the coarser pieces are taken from the rumbler and sent to the cupola to be melted over again. At present, the fine waste, before it goes to the dump, is put over the Wenström separator.

The following is the result of eleven days' running (from March 3 to 13, 1889), four and a half hours per day, 198½ tons of waste being put over the machine. From this quantity there was obtained 35 tons 3cwt of iron. Two men were added to the force at the rumbler to handle the material to and from the separator. The engineer was the same who ran the rumbler, and the steam for running the separator was obtained from the same boiler ; so that the total expense was only two dollars and a half per day for coal, labour, and oil.

The handling of converter-cinder on a large scale has not been undertaken as yet by the Lackawanna Company, the crusher required not being ready.

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*This includes interest on plant and depreciation. The cost for repairs has been nothing, and the machine shows no wear.

ON OIL-CARRYING STEAMERS.

(Continued from page 314.)

I WILL only briefly advert to the case in which the oil does not extend to the bottom plating, but is separated from it by a cellular bottom, as in some vessels built in Sweden on the East coast, or by a tank having a section like an inverted V, as in a number of vessels built specially for this trade. Here if the oil leaks through the flat on which it rests into the space below in any quantity, it will be free to move from side to side as well as the oil in the compartment above. The effect will be to further reduce the effective metacentric height. On the other hand, the transference of some oil from the free surface in the compartment to the cellular bottom has the effect of lowering the centre of gravity, and thus adding to the vessel's stiffness. If there be no oil-tight middle line bulkhead, the loss of effective metacentric height is

$$\frac{I_1 + I_2}{35\ W} \cdot \frac{8}{10} - \frac{w\,x}{W},$$

where I_1 has the value as before, I_2 is the moment of inertia of the plane of the oil surface in the cellular bottom about the middle line, w the weight of the oil collected in the cellular bottom, and x the distance between its centre of gravity and that of the same quantity of oil lost in the compartment above.

If the middle-line bulkhead be oil-tight under the above condition, the oil in the cellular bottom being free to move from side to side, the loss of effective metacentric height is

$$\frac{1}{4} \cdot \frac{8}{10} \cdot \frac{I_1}{35\ W} + \frac{8}{10}\,\frac{I_2}{35\ W} - \frac{w\,x}{W}.$$

In this case the vessel is permanently inclined, too, owing to the movement transversely of the centre of gravity of the oil which has passed into the cellular bottom.

We have seen that if G m be greater than G M, the vessel will not remain upright, but will incline away from that position, reaching a position of equilibrium at a greater or less inclination according to the circumstances of the case, and it will perhaps appear obvious to those who have followed me thus far that it is of very great importance in loading or unloading, if the greatest number of tanks are to be filled or discharged simultaneously, that care be taken to maintain the common centre of gravity of hull, coal, and fittings in the middle-line plane. If this be not done, the vessel will incline sometimes through a large angle even though m be below M. To show that such is the case, let us suppose the vessel to be upright and at rest, and to have a definite effective metacentric height M m, one or more of the tanks being only partially filled. Let now a small weight, as for instance some bunker coal, be moved from the middle line to one side, or from one side to the other. We should find in the case of a vessel having cargo that could not shift, that she would assume a position of equilibrium of a definite inclination as in the inclining experiment. But in an oil steamer having tanks only partially filled, the inclination of the vessel due to the moving of the weight causes a wedge of oil to pass from one side to the other. This has the effect of further inclining her; more oil consequently passes from one side to the other, she becomes still more inclined, this leads to the transference of still more oil, and so on until finally a position of rest is attained. It is not difficult in cases where the ultimate inclination is not great to determine the precise inclination at which the vessel is brought to rest under such circumstances.

Suppose the vessel to be at first upright and at rest, and let a small weight w be moved transversely through a distance a. This will cause the common centre of gravity of hull and cargo to move transversely through a distance $\frac{wa}{W}$. Let θ be the inclination at which the vessel is finally brought to rest. The weight of the wedge of oil transferred from the one side to the other is $\frac{\frac{1}{2}y^2\,\theta \cdot l}{35} \cdot \frac{8}{10}$, and the shift of the common centre of gravity due to this cause is $\frac{8}{10} \cdot \frac{I_1 \cdot \theta}{35\ W}$, as before.

Hence the total shift of the centre of gravity is

$$\frac{w\,a}{W} + \frac{8}{10}\,\frac{I_1 \cdot \theta}{35\ W}.$$

But since the vessel is brought to rest at the inclination θ, which is assumed not to be great, the centre of gravity must be finally in the vertical through the metacentre, and hence the shift of G may be written as G M $\cdot\ \theta$. Equating these two values, we get

$$\text{G M} \cdot \theta = \frac{w\,a}{W} + \frac{8}{10}\,\frac{I_1 \cdot \theta}{35\ W},$$

from which

$$\theta = \frac{35\ w\,a}{35\ W \cdot \text{G M} - \frac{8}{10}\,I_1}.$$

As an example, suppose the displacement of the vessel to be 3,000 tons, G M = 1·25 feet, and the compartment 24 feet long as before in a vessel 40 feet broad. Let the small weight, w, be 5 tons, and the distance through which it is moved transversely 30 feet. Ordinarily the transference of this weight of 5 tons would incline the vessel through about 2¼ deg., whereas from the above equation it is found that with free oil in one compartment the inclination is raised to as much as 10½ deg.

For the similar case, in which the same compartment is divided by an oil-tight, middle-line bulkhead, the corresponding equation giving the inclination will be—

$$\text{GM} \cdot \theta = \frac{w\,a}{W} + \frac{1}{4} \cdot \frac{8}{10}\ \frac{I_1\ \theta}{25\ W},$$

from which

$$= \frac{140\ w\,a}{140\ W \cdot \text{G M} - \frac{8}{10}\,I_1}.$$

If this equation be applied to the above axample, it is found that the ultimate inclinaticn of the vessel having an oil-tight, middle-line bulkhead is about 3 deg.

The above formulæ give the inclinations at which the vessel comes to rest under the several conditions with great closeness in all cases in which the inclination is not large, and especially when the free surface of the oil is not very near the crown of the tank. In those cases in which the free surface of the oil is very near the top of the tank, or where the inclination becomes great, its actual value can only be determined by the calculation of the vessel's stability as affected by the movement of the oil, the inclination at which the curve of stability cuts the base line being that at which the vessel comes to rest.

The above examples show the great importance of providing in the design of an oil vessel that the common centre of gravity of the hull, coal supply, stores, &c., shall be in the middle-line plane. Further, before loading or unloading cargo, if the ability of the vessel to load or discharge simultaneously from the greatest number of tanks without danger or inconvenient inclination is to be regarded, care should be taken by properly trimming the coal to bring the vessel upright before loading or unloading is begun.

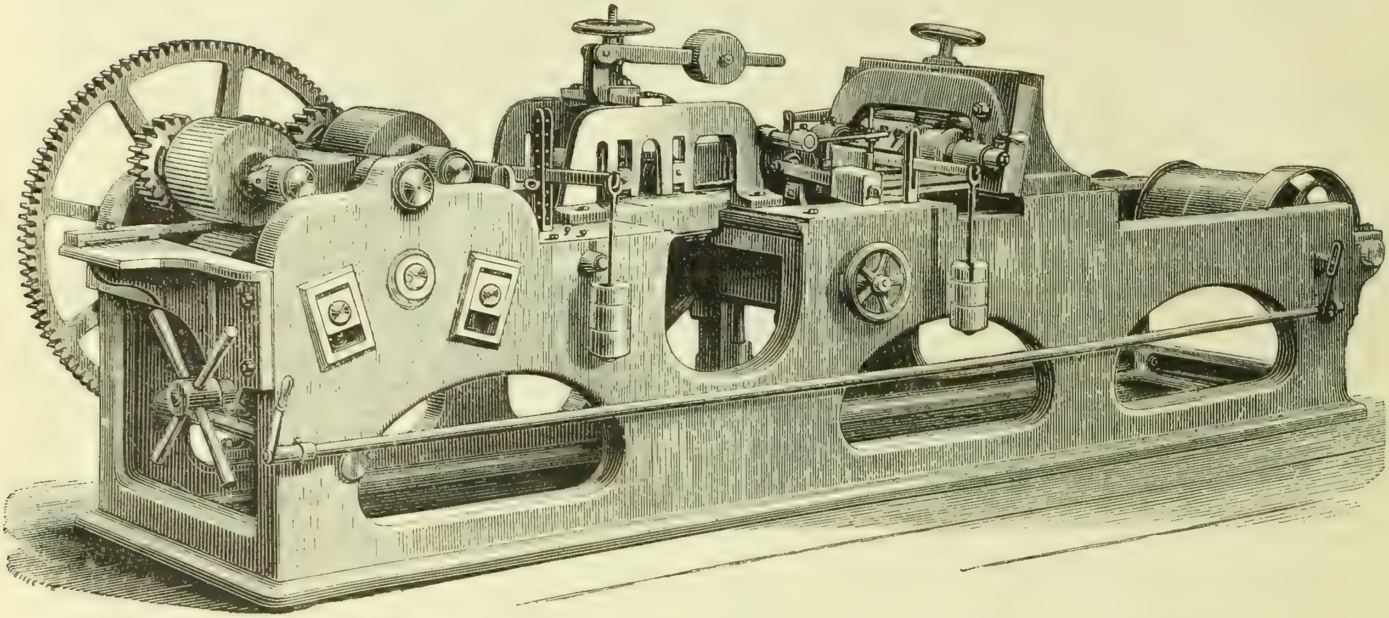
I have dealt up to the present with the initial stability of vessels containing oil having a free surface, or with moderate inclinations only from the upright position: it will be proper now to consider its inclining effect at larger inclinations. Although so long as G m is less than G M the vessel will continue to remain upright, she is not so capable of resisting inclination due to external forces—such as wind pressure or the heave of the sea—as if the cargo were not free to shift. In the latter case for moderate inclinations the righting moment may be expressed by the product of W $\cdot$ G M sin θ, whereas in the former it is but W $\cdot$ m M sin θ, as I have already shown. For large inclinations the above expressions cease to be correct, and the loss of righting arm caused by the shifting of the cargo can then be best represented by means of a diagram.

(To be continued.)

PROGRESS IN COALMINING.—Mr. Ralph Moore, inspector of mines for the Eastern District of Scotland, on his retirement from that post, which he has held for 27 years, received a few days ago a farewell present from a number of gentlemen connected with the Scottish coal and iron trades. In thanking the donors, Mr. Moore gave some interesting details of the improvement in mining appliances since he first was a colliery manager, 48 years ago. At that date, he said, there were cages at two or three collieries in the county of Edinburgh, but there were none in Lanarkshire. The coals were all drawn in corbes. A few years after there was not a single colliery without them. Pug engines were first introduced about 1845. Ventilating furnaces were of the most primitive description. Fans were unknown. The first fan in Scotland was put up in 1868; now there were hundreds, and scarcely anyone thought of doing without a fan. The amount of ventilation in a colliery was from 8,000 to 10,000 down to as low as 1,000 cubic feet per minute, and now there were some collieries in the district with 250,000 cubic feet per minute. Last year he made the calculation that eight tons of air were sent into the mines for every ton of coals extracted. Wire ropes were not in use at the time of which he spoke; now there was nothing else. Underground mechanical haulage was practically unknown; now it was universal. Many large collieries had only one shaft, now all had two. A coalowner putting out 100,000 tons a year was a large coalowner. There were coalowners now putting out over 600,000 tons annually. As a consequence of all these improvements, the output of minerals in the district, which in 1856 was 4,500,000 tons, was now 17,000,000 tons, and the death-rate, which in 1853 was one for every 250 persons employed, is now about one in 800.

COMBINED PLANING AND MOULDING MACHINE.

CONSTRUCTED BY MESSRS. THOMAS ROBINSON AND SON, LIMITED, ENGINEERS, ROCHDALE.



We illustrate above a combined planing and moulding machine, as manufactured by Messrs. Thomas Robinson and Son, Limited, Rochdale, of an exceedingly useful type, with fixed and rotary cutters for working on sides and edges at one operation. It can be used not only for working all kinds of mouldings and spoutings, but is also specially adapted for planing and matching floor boards at a high rate of speed.

When large mouldings are required to be worked, Messrs. Robinson recommend that the top cutter-block should be made to cant at an angle, so that the cutters, which work the thin part of the mould, need not project further from the block than the others.

To facilitate sharpening and setting the cutters, the bottom cutter-block can be made to draw out of the machine like the fixed irons.

The machine is specially designed to suit joiners and builders, and is capable of performing a great variety of work very rapidly.

INSTITUTE OF MARINE ENGINEERS.

A meeting was held in the Langthorne Rooms, Broadway, Stratford, on Tuesday evening, the 14th ult., in connection with the Institute of Marine Engineers, presided over by the honorary secretary, Mr. James Adamson.

Mr. J. McFarlane Gray, chief examiner to the Board of Trade, read a paper on Pressure, and gave a highly interesting and instructive address, which was listened to with evident pleasure by an appreciative audience. Mr. Gray re-called a few reminiscences of his early life, and told several anecdotes of more recent date, illustrative of the power of littles, and the weighty consequences which frequently follow directly in the line laid down by apparent trifles; pointing out also that the duty of each and all is to find pleasure and a happy contentment in doing faithfully and well the various details of work which fall to our several lots in life, without undue hankering after what lies beyond. The subject matter of the paper was of a more scientific character, dealing with some of the properties of molecules in motion, of Newton's laws of motion and of energy, interspersed with some valuable hints as to retaining rudimentary facts in the memory, and adding bit by bit to the store of knowledge.

The Chairman, after commenting on the kindness manifested by Mr. Gray in coming forward to give his counsel and help, expressed himself highly indebted for the pleasure he had obtained in listening to the paper and address.

Messrs. A. Gibb and J. Hawthorn made a few remarks, the latter gentleman describing and illustrating on the black board a new system he had discovered of squaring numbers and combinations of numbers mentally and quickly.

Mr. J. Hawthorn proposed, and Mr. J. R. Ruthven seconded, a vote of thanks to Mr. Gray, which was heartily applauded.

Mr. Gray, in acknowledgment, referred to an interview he had had many years before with Mr. Ruthven's grandfather, of "Waterwitch" fame, which was full of interest to him—then on the threshold of life—and fruitful of much thought, research, and discovery.

Mr. Shorey proposed, and Mr. Gray seconded, a vote of thanks to the chairman, referring specially to his other post as honorary secretary of the Institute.

The vote was warmly accorded, and, in closing, the Hon. Secretary announced he was pleased to report that the membership is steadily increasing, the registration of the association had been sanctioned by the Board of Trade, and that, further, the library is receiving frequent additions, and now consists of about 200 volumes, some 30 of which had been presented by Mr. Gray, and a cheque for £10 towards the library had been received the previous day from Mr. A. Beldam.

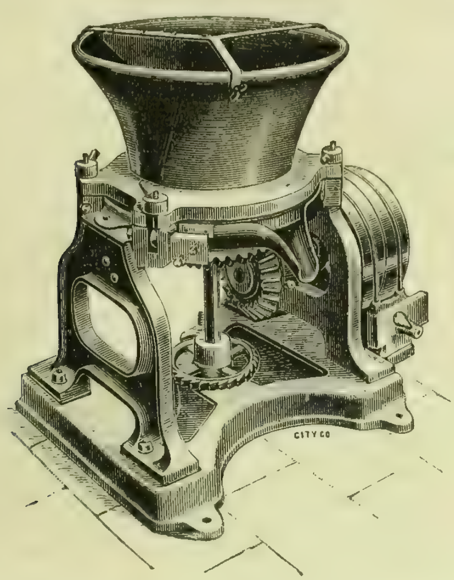
It was urged upon members present at the meeting to encourage as much as possible the junior engineers to come forward and join the institute, as the greatest benefit would be derived by them from the association, and by apprentices also, who are eligible as graduates. It was intimated that the next paper would be read by Mr. G. W. Manuel, on "Shafting of the Mercantile Marine."

AN IMPROVED PAINT MILL.

Messrs. Follows and Bate, Manchester, have just introduced a new form of paint mill, which we illustrate here. It has several special features, and has been designed to turn out large quantities of material.

The principal feature in the mill is the cone, so constructed that paints can be ground either in thick pastes or thin liquids. In one size it is 20in. in diameter, and a mixer is arranged in the hopper used for dealing with thick pastes. This consists of two beaters, of which the top one is fixed, and the bottom rotates with the cone, by which arrangement all the material in the mill is thoroughly mixed.

A further improvement has been added in the shape of an annular trough, which is fitted with four scrapers for grinding thin material. Thus the machine, as now made, can be used for grinding thin or thick material at pleasure. By means of a tooth wheel and rachet, the position of the cone can be altered, as shown in the drawing. This is a great improvement on the old method of using a thumb screw, and is especially valuable for regulating the position of the cone and hopper for exceedingly fine grinding.



The whole machine is mounted on a cast-iron base, with driving gear complete, and forms a compact and serviceable mill, both for paint grinding and enamels.

MARINE ENGINE TRIALS.

(Concluded from page 382.)

Supplementary Trial.—Some hours after the main trial was finished, and after all the fires had been cleaned, the stoke hole was closed, the fans set to work, and the engine driven for a few hours at full power with forced draught. The particulars of the work done under these circumstances are given in Table I. As to diagrams C, E, and F, which were taken with live steam admitted to the first receiver, it may be explained that the engine has an auxiliary starting valve of 2½in. diameter, which enables this to be done. This valve is occasionally used when there is any fear of the boiler blowing off, so as to avoid waste of steam and fresh water. This occurs generally for only a minute or two at a time. The engines run from 2 to 3 and sometimes as much as 4 revolutions per minute faster, and it is found that the diagrams are much distorted, and the pressure on the intermediate piston much increased.

TABLE I.—Supplementary Trial at Full Power with Forced Draught.

Indicator Diagrams.	Boiler Pressure per sq. inch above atm.	Revolutions per minute.	Mean pressure per square inch.			Indicated Horse Power.			
			High-pressure cylinder.	Intermediate cylinder.	Low-pressure cylinder.	High-pressure cylinder.	Intermediate cylinder.	Low-pressure cylinder.	Total.
Set.	Lbs.	Revs.	Lbs.	Lbs.	Lbs.	I.H.P.	I.H.P.	I.H.P.	I.H.P.
A	146	81·0	60·9	28 4	18·5	778	832	1393	3003
B	151	81·0	63·2	28·8	19·0	808	844	1426	3078
C	150	83·1	30·2	33·7	24·1	397	1013	1863	3273
D	145	78·7	64·1	25·5	16·7	796	727	1222	2745
E	136	80·0	32·9	33·0	21·8	415	957	1617	2989
F	130	80·0	31·2	32·9	21·6	394	952	1608	2954

Diagrams A and B are believed to represent the average full-power working of the engines going north from London to Leith, when the steamer always runs with forced draught. Diagrams C correspond to the conditions of A and B, but with live steam admitted to the first receiver.

Diagrams D are believed to represent the average working of the engines later on in the same full-power run when the tubes are getting dirty, the high-pressure motion being drawn up about 1in. Diagrams E and F correspond to the conditions of D, but with live steam admitted to the first receiver.

When the vessel got into port and was being berthed, it was endeavoured to get a set of indicator diagrams while the engines were going astern. One complete set only was secured, of which the following are the particulars, all the links being in full gear:—

Boiler pressure, lb. per sq. in. above atm.	lb.	147
Revolutions per minute	rev.	76
Vacuum in inches of mercury	in.	27
Mean pressure, high-pressure cylinder	lb.	48·8
" " intermediate cylinder	lb.	31·5
" " low-pressure cylinder	lb.	17·1
Indicated horse-power, high-pressure cylinder ..	I.H.P.	585
" " intermediate cylinder....	I.H.P.	867
" " low-pressure cylinder....	I.H.P.	1,208
Total	I.H.P.	2,660

It is interesting to compare the results thus obtained with those when running in forward gear, as showing the effect of altering the sequence of the cranks, which under these circumstances follow in the order—high, low, intermediate.

Observers.—As this trial was perhaps the first marine engine trial carried out on any large scale at sea in which the feed water was measured and the coal weighed throughout for such a length of time, it may be interesting to mention the staff which was found necessary for the experiments. The work was carried on by two relays of observers, five in each relay, keeping alternate four-hour watches. Mr. Frederick Edwards took charge of one watch, consisting of Mr. Bryan Donkin, jun., Mr. A. G. Ashcroft, Professor Beare, Mr. Beck, and himself. Professor Kennedy took charge of the other watch, on which were also Mr. C. L. Simpson, Mr. R. H. Willis, Mr. B. Bramwell, and Mr. N. Burnett. One man in each watch took the feed-water measurements continuously; with him was an engineer, specially engaged for the purpose, to stop and start the feed pump as the tanks were changed in the manner above described. Two observers in each watch took the indicator diagrams and other observations in the engine-room; and two others attended to the coal measurements, one in each stokehole; these four interchanged places after two hours' work. As it was necessary that the ordinary work of the ship should not be interfered with, or the time of the engineer's staff encroached upon, an extra stoker was carried in each stokehole for the purpose of filling the coal baskets to be weighed. An extra man was also carried to look after the donkey boiler, which for reasons already mentioned had to be kept going during the whole trip. Besides the ten observers already mentioned, there were seven others employed, allowing for change of watch. The whole trial, although requiring very close and continuous attention on the part of those engaged on it, went off without the least hitch of any kind, a fact which was no doubt due in a great extent to the very cordial help received throughout from everybody connected with the ship, but especially from Mr. Clephane, the chief engineer; his cooperation throughout was invaluable, and the committee have much pleasure in taking this opportunity of acknowledging it. They are also indebted to Messrs. J. and G. Thomson, who have kindly furnished them with detail drawings of the cylinders and other parts of the engines; to Mr. C. J. Wilson, F.C.S., for analysing the furnace gases and the coal; and of course in the highest degree to Mr. Aitkin, of the London and Edinburgh Shipping Company, for his kindness in allowing the trial to be made, and for the trouble which he took in connection therewith.

MECHANICAL STONE CUTTING.

Among the exhibits at the Paris Exposition is the stone-cutting machinery of M. Paulus Gray, of Marseilles. The so-called saw is an endless wire cord, or a single wire twisted upon itself. This wire merely serves to draw along the wet sand, which really does the work. This method is used exclusively in two marble quarries in Belgium, and is at work in other parts of Europe on various kinds of stone, including granite.

In practice, a cord about a quarter inch in diameter is used, travelling at a speed of about 13ft. per second, a smaller cord and increased speed being used for a simple subdivision of blocks. The twist in the cord causes it to turn as it cuts, thus wearing the whole surface evenly, until it is smooth. Before being worn out a cord 450ft. long is capable of cutting to a depth of 70ft. in 15ft. blocks, or of producing about 500 square feet of sawn surface in marble. In a marble block 15ft long the cut is at the rate of 4in. in depth in one hour; in granite it is 1in. in the same time.

One endless wire, guided by grooved pulleys, may be made to cut at several different places not too near together. The tension is maintained by a loaded truck on an incline, and the driving power required is slight, as there is so little surface in contact. The feed is controlled by an automatically operated screw in stone of even texture, or by hand in other cases. In the Traigneaux quarries 14,000 cubic feet of marble are produced annually by 30 men and five boys, who feed the machines. The patents are held by the Société Anonyme Internationale du Fil Helicoidal, Brussels, Belgium.

THE DUTIES OF A TOWN SURVEYOR.*

The duties of a town surveyor are very numerous. He must not only be an engineer of undoubted ability and integrity, but he must have at the same time great organising capabilities. The following was hardly an exaggerated view of the manifold duties he has to fulfil: Sanitary engineer, architect, accountant, waterworks manager, quantity surveyor, land surveyor, landscape gardener, and engineer for the construction of roads and bridges, besides other minor duties.

The author dealt at some length with the first and most important of these duties, viz., that of sanitary engineer, and pointed out the great importance attached to the proper construction and ventilation of sewers, and referred to the question of flushing. He said that if sewers were laid at good gradients, they should be self-cleansing, and there would be no necessity for flushing except at upper ends, which, owing to the smaller volume of sewage had not the same cleansing properties.

The question of dealing with sewage when it arrived at the outfall works also came within the province of the town surveyor, for whatever process was used he was supposed to be equally competent to deal with all of them.

In the capacity of architect the engineer must be equally at home. He has to superintend the erection of all classes of dwelling houses, buildings, &c.; for not only had he to see that the sanitary matters were carried out properly, and that the structural arrangements were as they should be, but he must be on the look out for the insertion of timber in party walls, &c., so as to prevent the spreading of fire.

One individual against whom the town surveyor had to guard was the "jerry builder," and the greatest vigilance in detecting the number of dodges practised by him was required.

The town surveyor's duties as accountant were next alluded to, and to his duties in the capacity of manager of waterworks. Unless he had a competent foreman, he would find it impossible to work satisfactorily this important department. If, on the report of the foreman of the water department, more water was found to be passing through the meter that registered the supply to the town than seemed consistent, he might well conclude that there was a waste of water somewhere, and this place had to be found, and the defect remedied as soon as possible.

As quantity surveyor the town surveyor was expected to know sufficient to enable him to give estimates of intended work, and had to prepare specifications, &c. Great care was needed in selecting from the many tenders that were offered the right one.

His duties as landscape gardener chiefly consisted in the laying out of parks and public gardens, &c., and though this was not so difficult, yet great artistic skill was necessary to produce good effects.

A more important duty was that in connection with the construction and maintenance of roads and bridges. Economy in road repair was not an advisable proceeding, but much discretion had to be exercised. It was said that wherever a road had a traffic exceeding 1,000 vehicles per day macadamised roads were not economical. There was no doubt that hammer-dressed stones, laid on concrete, was the most enduring roadway that could be made, and one that the town surveyor should have some knowledge of, as well as wood paving, asphalt, &c.

A great deal more might be written on "The Duties of a Town Surveyor," but the author thought he had perhaps already conveyed some slight idea of the onerous and multifarious duties of this most important public office.

STRIKE OF ENGINEERS IN HULL.

On Monday, 13th ult., the men concerned in the above dispute came out on strike, and at the time of writing this no progress has been made to a satisfactory settlement of the question between themselves and their employers.

The men have organised a strike committee, and seem determined to remain out at all hazards, unless their claims are satisfied. We learn that a number of the men have already obtained employment in other districts, but it should be mentioned that the executive of the local branches have objected to this wholesale migration from the town, as they fear that, should the masters concede the advance, there would not be a sufficient number of men to fill the vacant posts. It is reported that travelling cards have been refused the men, but this has not prevented many of them from leaving the town and accepting work at Stockton and other shipbuilding centres.

From later reports it seems that the Employers' Association, desiring to arrive at a speedy settlement, have resolved to accept the offer made by Mr. Charles H. Wilson, M.P. (of the firm of Messrs. Thomas Wilson, Sons, and Co.), to act as arbitrator in the dispute, but we believe that the men are not inclined to allow the matter to be submitted for arbitration, but would be pleased to accept the kind services of Mr. Wilson as "mediator" between masters and men.

THE USE OF SPIRIT AS AN AGENT IN PRIME MOVERS.

(Concluded from page 376.)

We adopted two sets of pipes, condensing coils, &c., so as to avoid, as far as practicable, any mixture of water and spirit, which would tend to vitiate the experiments. To make the system of pipes clear I have had those in connection with steam or water painted dark blue, and those in connection with the spirit and spirit vapour painted red.

It will be evident that when we raise steam in the boiler we have the means of working our little engine either by steam or by spirit vapour. When steam is used, the stop valve on the pipe leading direct from the steam space in the boiler is opened, and the gear on the right-hand side of the apparatus brought into operation. In this case the internal copper coil in the boiler plays no part. On the other hand, when the spirit vapour is used, the stop valve on the end of the internal coil is opened, and the gear on the left hand side of the apparatus is set to work. How to start the apparatus when steam is used is self-evident. To start it when spirit is adopted it is necessary to run some spirit into the hot well and turn the engine a few times by hand, so as to force a small quantity of spirit into the coil in the boiler. The heat from the gas flame is first taken up by the water in the boiler, and is then passed on to the copper coil and evaporates the spirit; the water only acting as a convenient means of transmitting the heat from the flame to the spirit. By these means we are enabled to try steam and spirit vapour under precisely similar circumstances with regard to boiler efficiency. Had we adopted for the spirit another boiler, instead of a coil inside the same boiler, some question might arise as to the comparative efficiency of the two boilers, a doubt which is thus obviated. It will be seen that the boiler is fitted with a pressure gauge for steam, a pressure gauge for vapour, a thermometer, and the necessary appendages, so as to get a complete record of all that was taking place.

Our experiments consisted of several continuous trials, each of three hours duration, alternately with steam and with spirit vapour. The wall diagrams 2 and 3 illustrate the results representing average examples; and in order to condense their size I have taken the record of the middle or second hour of the three hours trial. Each vertical line represents an interval of time of five minutes, during which period five observations were made, the mean of these five being the spot through which the lines pass. It will be seen that the diagrams show the variations of pressure, revolutions, gas consumption, and stress on brake respectively. The upshot of these experiments is seen in the summary, which points to the fact that although the amount of gas consumed during the three hours was practically the same, being at the rate of 82 and 83 cubic feet, the power obtained, as tested on the brakes was, in the case of spirit, nearly twice that recorded in the place of water, the powers being as 4722 to 2524.

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* Paper read before the Birmingham Students of the Inst. Civil Engineers, by Mr. J. S. Pickering.

SUMMARY.

Expansion agent used	Steam.	Spirit.
Duration of trial	3 hours	3 hours
Cubic feet of gas burnt per hour including the amount required to raise pressure at end of trial to what it was at the commencement	82·20	83·48
Mean pressure of spirit in coil	—	55·80
Ditto steam in boiler	37·99	30·07
Mean revolutions per minute	312·6	552·2
Tension on brake	1·154lb.	1·222lb.
Foot-pounds per minute obtained on brake.	2,524	4,722

At equal intervals during these trials diagrams were taken with an ordinary indicator, and I show on the walls six of each, which form fair average specimens. The working out of these diagrams gives a power, in the case of spirit, of 11,975 foot-pounds per minute, and, in the case of water, of 5,199 foot-pounds per minute, which more than confirms the results obtained by the brake.

It is familiar to us all that spirit evaporates much more readily than water, and the wall diagram 4 illustrates the comparative heat absorbed in evaporating equal quantities of water and spirit at atmospheric pressure. The horizontal distance on the diagram represents time, and the height represents quantity, from which it will be seen that it takes nearly nine times as long to evaporate equal quantities of water as it does spirit; or, in other words, a given amount of heat will evaporate nine times as much spirit as it will water. Water being a uniform body the line is straight. The spirit line is curved because the spirit is not uniform, being really a mixture of various hydro-carbons, the more volatile passing off first.

Touching the class of spirit which we used for our experiments, I would mention that it is a hydrocarbon distilled from petroleum, having a specific gravity of about ·680, water being 1·. The reason this spirit has been adopted is because it is low in price and can be easily procured, and also, being obtained from petroleum, it is of an oily nature. A spirit which is not oily in its character would be deficient in lubricating power, and therefore not so suitable for working the machinery.

As I thought it would be of interest to show the position occupied by the spirit adopted by us throughout in these trials, with reference to other products of petroleum, I here give the names and respective specific gravities of a few.

Gasoline	·650
Launch spirit	·680
Benzoline	·700
Benzine	·725
Refined petroleum of commerce	·800

The wall diagram 4 shows the relative quantity of spirit and water evaporated by the same amount of heat, but it will not show the comparative advantages of using the one or the other, except taken in conjunction with the volume of vapour or steam respectively obtained from the same quantity of spirit or water, because in the production of power it is the difference between the volume in the production of power it is the difference between the volume in its liquid and vapour state at a common pressure that determines the results obtained.

With a view to experimentally ascertain the density of spirit vapour as compared with steam, Mr. Boverton Redwood kindly undertook this investigation, the result of which is that petroleum spirit gives about one-fifth the volume of vapour that water yields. Taking this in conjunction with the results shown on the wall diagram 4, it would appear that a given amount of heat will produce one and four-fifths the bulk of spirit vapour at atmospheric vapour that it would if used to convert water into steam. This result therefore tends, as far as it goes, to further confirm the gain in favour of spirit.

With a view to illustrate the difference of pressure between steam and the spirit we use at common temperatures, I may refer to the wall diagram No. 6. The upper line represents the pressure of spirit vapour, and the lower line the pressure of steam. It will be seen, for example, that 240 deg. temperature corresponds to steam at a pressure of 10lb., and spirit vapour at a pressure of 65lb. It also shows that water at boiling point, or steam 212 deg., can convert spirit into vapour at 45lb.

Touching the evaporation of spirit to produce power in actual practice, at present the only application which has been successfully developed is for the propulsion of launches. It is termed the "Zephyr" system. I may mention that of this type of launch we have already built a large number, and they are finding great favour. For small sizes certainly there would seem to be no question that, where the spirit is obtainable, this system is destined to take the place of steam, not so much on account of the probable increased efficiency, as the general convenience of the arrangement.

The diagram on the wall represents a launch propelled on this plan. It is 36ft. long by 6ft. beam, and is built of steel. Its total weight, including machinery, is only one ton; and I need scarcely say, that had it been propelled by steam the weight would have been considerably greater.

The propelling machinery, being light, can be placed at the stern; it consists of an engine which is so enclosed as to avoid leakage of vapour. The generator is placed aft of the engine, and consists of a copper coil enclosed within a double sheet-iron casing, the intermediate space being filled with asbestos or other non-conducting materials. Below the coil is an iron pipe, bent into the form of a ring, perforated with holes and arranged as an ordinary ring gas-burner.

An eight horse-power evaporator is shown on the table, from which it will be seen how small an apparatus it is.

In the bow is an air-tight copper tank of a capacity of 40 gallons, for containing the spirit; this serves in a measure to balance the engine at the stern. The tank is placed in communication with the feed pump by means of a pipe passing outside the boat close to the keel. The feed pump delivers into the bottom of the vapour generator, and the exhaust from the engine passes into the two condensing pipes, placed longitudinally, one on each side of the keel. The vapour is condensed in these pipes, and is forced back into the tank by the action of the engine.

There is a spirit hand pump, having its suction connected with the tank, and its delivery joining the bottom of the evaporating coil, so that by working it spirit can be drawn from the tank and forced into the coil. Now, in order to start the launch, a little heat is first applied to the evaporating coil, and then a small quantity of spirit pumped into it by hand, which is immediately converted into vapour, and the pressure begins to rise. By opening a valve a small portion of this vapour is arranged to pass into the ring burner, and is ignited, together with a suitable proportion of air; and from this moment the heating process is self-acting; so long as there is vapour in the evaporator a portion of it will go to heat up the incoming liquid. The engine can now be started, the feed-pump on the engine providing a continuous supply of spirit to the coil; from this moment the action throughout will be automatic, and when once started neither the engine nor the evaporator requires any further attention.

After the vapour has left the engine, it passes through the exhaust pipes under the boat, is condensed and forced into the tank in the bow, to be used over and over again. A boat of this type will run eight miles an hour easily, and carry fuel for 200 miles.

Owing to the rapidity with which spirit evaporates, as a matter of fact, from the time of lighting up it does not require more than five minutes on an average to start the boat.

It will be seen that the entire central portion of the hull is available for passenger accommodation, and is not hampered by a boiler, as in a steam launch, which usually is a source of considerable inconvenience, and occupies the best part of the space. The small weight of the machinery is also a point of importance, as it tends to reduce the draught. The whole arrangement is so exceedingly simple that a fairly intelligent stranger can learn how to work it in an hour's run.

Although the spirit indicated in the summary on page 600, having a specific gravity of ·680, is what we use for our launches, grades lighter and heavier may be adopted within certain limits, gasoline on the one hand, and benzoline on the other, the lighter giving a better and the heavier an inferior result.

I will not venture to assign any reason for the apparent gain in the use of spirit over water, but I would point out that in a condensing engine the two great losses of heat are due, firstly, to the waste gases which pass up the funnel, and simply go to raise the temperature of the surrounding air; and, secondly, to the loss arising through raising the temperature of the condensing water, which goes to warm the sea.

As regards the first loss, it is self-evident that owing to the low temperature at which the spirit evaporates, the products of combustion are available to produce evaporation down to a much lower temperature than in the case of water. As an illustration of the low temperature at which the waste gases pass away in the "Zephyr" launches, when going at full speed it is quite possible to hold one's hand immediately over the funnel.

I have now explained the results of the experiments we have made to test the value of spirit as an evaporating agent to produce power; I have also described one successful practical application of it; and I submit if these results are further confirmed by experience, there is reasonable ground for believing that this system in some form is capable of further and possible extensive development.

ON THE TREATMENT OF STEEL BY HYDRAULIC PRESSURE.

At the twenty-fourth ordinary meeting of the session of the Institution of Civil Engineers, on Tuesday, the 7th of May, Sir George B. Bruce (the president) being in the chair, the paper read was on "The Treatment of Steel by Hydraulic Pressure, and the Plant Employed for the Purpose," by Mr. William Henry Greenwood, M.Inst.C.E.

Attention was directed in the paper to the presence of blow-holes in steel ingots, also to their origin, and to the various methods proposed for the production of sound ingots; but the author treated more especially of the method, the effect, the advantages, and the development of fluid compression, as typified in the plant and 10,000-ton press erected by him at the Abouchoff Works, St. Petersburg. It was assumed that molten Bessemer, open-hearth, or crucible steel possessed the quality of occluding a considerable volume of gases, especially of hydrogen and nitrogen, derived all or in part from the products of combustion in the furnace, or from other sources; and that, under ordinary conditions as to pressure, such occluded gases were, more or less, completely evolved at the moment when the particles of metal changed from the liquid to the solid state, and were thus imprisoned within the ingot in the form of bubbles of various forms and dimensions. A second source of unsoundness arose from the contraction of the metal within the ingot after its outer skin had solidified, producing contraction cavities; and, lastly, the metal from ingots as usually cast was weak along the surface, owing to the development of a radial acicular structure in the cast metal. The combined effect of these three causes was that ingots of mild steel, such as were used in the construction of ordnance, large engine shafts, or other heavy forgings, for cylinder liners, torpedoes, and war material, contained cavities necessitating the rejection of about 30 per cent from the head or top end of each ingot; while, to get rid of the surface honeycombs and weak acicular structure, which caused unclean, seamy, and roaky forgings, an additional 10 per cent to 20 per cent of metal had to be left for turning and machining to waste. Even after these losses of material, the remaining metal was inferior to the same metal after fluid compression. The method of fluid compression claimed, then, to save the whole of the rejected head or top of the ingot, to reduce to a minimum the amount of metal to be left for turning or machining from the surface of forgings, and to produce from any temper of metal a greater amount of ductility, homogeneity, and reliability than was obtainable under the best conditions of casting in open moulds without pressure. The additions of increased proportions of manganese and of silicon did not commend themselves to the author for the classes of steel under consideration; for, although promoting solidity of the ingot, they hardened, raised the elastic limit and ultimate tensile strength, but lowered the ductility and general reliability of the metal. Of the mechanical devices for increasing the solidity of steel ingots, the author noted the proposals for the cooling of the outside of the moulds, for agitating the metal during solidification, casting the metal in a vacuum, and the direct application of pressure, by the use of high-pressure steam, injection of water, of explosives, of solid carbon dioxide, &c., upon the surface of fluid steel in closed moulds. These methods of fluid compression had all failed from mechanical, physical, and practical difficulties in their conduct; and the plan suggested by Sir Henry Bessemer in 1856, but quite independently developed and carried to a successful issue at the works of Sir Joseph Whitworth and Co., and now known as the method for the fluid compression of steel, remained the only one before the public which yielded ingots of mild steel of practically uniform molecular structure, strength, and ductility throughout their whole length. The ordinary cast-iron moulds, or wrought-iron casings, lined with brick or moulding cement, could not be used when aggregate pressures of thousands of tons were to be exerted upon the surface of the fluid metal; but such moulds were replaced, in the fluid-compression process, by built-up steel moulds, lined with suitably grooved cast-iron lags, protected by a coating of refractory silicious material. A loose plate of the diameter of the ingot fitted in the bottom of the mould, and was protected by an upper covering of burnt fireclay segments, and a similar plate was carried upon the top plunger of the press for closing the top of the mould. The paper traced the development of the hydraulic press for the fluid compression of steel, commencing with the erection, in 1866, in the works of Sir Joseph Whitworth and Co., of a 250-ton press, with a 12in. cylinder, designed more especially for the compression of the metal for steel shells. In this the mould, which was partially filled with metal, was carried in a middle head of the press, whereupon a core, carried upon the top head of the press, was forced into the fluid metal, at the same time closing the mouth of the mould. After this the pressure was applied from below, as in all the subsequent presses. Following this came a much more useful 2,000-ton press, with two columns, and a 30in. hydraulic cylinder. Its columns were secured by nuts to the base or foundation, and upon the upper ends of the columns was carried a fixed head, upon which rested a vertical hydraulic cylinder, whose piston rod was connected to the intermediate or movable head. The intermediate head could thus be raised to any point, and then locked, so as to resist the application of pressure from below. The locking arrangement consisted of a pair of nuts, each made in halves, and so disposed that by the movement of a lever and a system of links the halves of the nuts could be either brought together or separated. When separated the head was free to move, but when closed the nuts embraced the columns and fitted into a series of parallel, slightly undercut, V grooves, which were cut as a thread along the upper halves of the length of the columns. In this manner the head was locked or secured against vertical movement under the action of the bottom or pressing cylinder. The metal was cast in the steel mould already described, and the further movements and actions of this press were similar to those of the larger Abouchoff press already referred to. The next press, also erected in Manchester, had four steel columns, 12in. in diameter, and was fitted with five pressing cylinders, namely, four of 28in. diameter, and one of 13in. diameter, capable of producing together a pressure of 8,000 tons. Except for the locking arrangement, which was complicated but more nearly automatic than that last described, the principle was the same as in the last. Its columns were, however, screwed with a square screw thread, and the locking nuts were not split, but could be made to revolve automatically as the head was raised or lowered. The five pressing cylinders were placed on the base of the press, with the small one in the centre. The cylinder for lifting and lowering the movable head was carried upon the upper fixed head or table of the press, while the locking of the movable head at any desired height, according to the length of ingot under operation, was effected by four locking nuts, which could be revolved either just clear of the head or into firm contact with the same. In the latter case the head was locked fast to the columns, and was immovable under the full pressure of the press acting from below; and in the former condition the head could be freely lifted to any desired point. This 8,000-ton press was placed second by the author's erection, in Russia, of the press upon the lines of the Whitworth patent of 1874. This press had four screwed columns of 16in. diameter, and one hydraulic pressing cylinder of 50in. diameter, capable of exerting a gross pressure of 10,000 tons. For working the press an accumulator, giving a pressure of 2 tons to the square inch, was employed to effect the rapid movements of the head of the press, of the lifts, cranes, &c., during the manipulation and transference of the fluid metal from the furnaces to the mould, and of the mould under the press.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

BALANCE OF LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—Although the locomotive has been in constant use daily for the last sixty years, and in that time has been brought to the position it now holds, as being perhaps the most wonderful combination known to mechanical engineering, it is somewhat surprising that, after all these years, there are some who, while being daily connected with locomotives either in the office, the workshop, or on the road, are still making mistakes regarding them, and on points that were thought to be settled at least fifty years ago.

The mistakes particularly referred to at present are those made in connection with the balancing, both in practical work, as far as their application to the machine itself is concerned, and in education as noticed on the part of the younger members of the profession, who, reading the different papers that are being brought every now and then before one or other of our institutes or associations, and confiding in them through the prestige thus given, naturally conclude that the matter they contain is sterling, and of course adopt it for their future guidance. Now, this would be perfectly correct on the part of the young readers mentioned if the papers themselves were always to be trusted, but unfortunately such is not the case, as the following extract from a paper read before one of our associations, and the comments following thereon, will show. Although not dealing exclusively with the balance of locomotives, still there were some statements thereanent contained in it which perhaps, to those well acquainted with the subject, appear unworthy of notice; still the younger members might adopt them as being correct when such in reality is not the case, and so perhaps in turn disseminate their knowledge with effects not bargained for.

The extract: "The internal disturbing forces which tend to unsteadiness of running *can only be partially balanced,* as we may only truly balance the revolving parts, *and they but for one speed, with the usual weights placed inside the rim of the wheel.*" Then, a little further on, it says: "Weights are placed in the wheel to compensate to some extent for these disturbing forces. In this manner we introduce an equivalent vertical unbalanced force, which tends to set up the *hammering action* on the rail noticed in engines on which the balance weights have been calculated, *taking too much of the horizontal forces into account.*"

The parts in italics are those that are greatly in need of explanation; in fact, the explanation amounts to proving them wrong entirely. In the first place, however, an examination of the method used for balancing locomotives will help greatly in the consideration of the above extracts. The method accepted as the correct one is as follows:

Let H = distance between centres of cylinders in inches
h = distance between centres of gravity of wheels in inches
W = weight in pounds of piston, rod, crosshead, connecting rod, crank-pin, and boss
W_1 = weight in pounds to be placed opposite the crank at the same radius on the wheel, on the same side of engine as the cylinder, the gear of which is to be balanced
W_2 = weight in pounds to be placed on the same centre as the crank-pin, but in the far wheel

NOTE.—The two resultant weights in each wheel to be combined by moving them towards each other in the inverse ratio of their weights, and then placed on the rim on a line drawn radially through the newly-found centre; the weight being reduced in the direct ratio of their distance from the centre of revolution.

Then for outside cylinder engines

$$W_1 \quad \frac{\left(\frac{H+h}{2}\right)}{h \times \left(\frac{h-H}{2}\right)} W = W \qquad (1)$$

$$W_2 = \frac{\left(\frac{H-h}{2}\right)}{h} W \qquad (2)$$

For inside cylinder engines

$$W_1 = \frac{\left(\frac{h+H}{2}\right)}{h} W \qquad (3)$$

$$W_2 = \frac{\left(\frac{h-H}{2}\right)}{h} W \qquad (4)$$

In the above rules the principles involved will be clearly seen; also it will be seen they take into account the whole of the moving weights. To fix the mind, however, let me take as an example an inside cylinder engine with 7ft. driving wheel, 12in. crank. H = 24in., h = 60in., W = 231lb. Then

$$W_1 = \frac{\frac{60+24}{2}}{60} \times 231 = 161{\cdot}7\text{lb.}$$

$$W_2 = \frac{\frac{60-24}{2}}{60}\, 231 = 69{\cdot}3\text{lb.} \qquad \begin{array}{r} 161{\cdot}7 \\ 69{\cdot}3 \\ \hline 231{\cdot}0\text{lb.} \end{array}$$

As shown by my example, the balance weights for an inside engine are exactly equal to the moving weights; but if we had taken an outside engine, it would be found that the balance weight exceeded the moving weights, the result of the moving weights being wholly without the wheels.

Using the example, I will now show where the paper was wrong in stating that the revolving weights could only be balanced for one speed by the weights in the rim. To do so, I will suppose the whole of the moving weights to revolve at the crank pin radius, the balance weight being placed at a radius of 36in. and weighing 77lb.; speed 30 miles per hour. $\frac{\text{Ft. per minute}}{\text{Circum. of wheel}}$ = revolutions per minute = $\frac{2640}{22} = 120$.

Centrifugal force = ·00034 WRN^2 where
W = weight in pounds
R = radius in feet
N = number of revolutions per minute

The centrifugal force of moving weights
= ·00034 × 231 × 1 × 14400 = 1130·9lb.

The centrifugal force of balance weight
= ·00034 × 77 × 3 × 14400 = 1130·9lb.

As the above shows no difference at 30 miles an hour, let me try 60 miles an hour. $\frac{5280}{22} = 240$.

Centrifugal force of moving weights
= ·00034 × 231 × 1 × 57600 = 4523·9lb.

Centrifugal force of balance weight
= ·00034 × 77 × 3 × 57600 = 4523·9lb.

As I find there is no difference at this speed either, I may safely say there will be no difference at any other speed, especially as it will be seen that the two factors, ·00034 and N^2, cancel in all cases, and this proves that the rules are correct so far as the revolving weights are concerned, and the paper in that case is wrong. As, however, the rules take into account the whole of the moving weights, and also as the greater part of these weights have a horizontal motion only, it will easily be seen that the engine will only be balanced in that direction, but at all speeds. It will also be seen on consideration that the unbalanced force in the vertical direction can have no effect on the steadiness of the engine, as, instead of there being any hammering action on the rail, as stated in the extract under discussion, it only causes a gradual imposition and relief of pressure on the rail equal to the centrifugal force of the balance weight, minus the proportion necessary to balance the revolving part of the moving weights, while in the upward direction its action is restricted by the weight of the engine itself, and, as the action is only a small part of that weight, it is very evident there can be no effect produced on the steadiness whatever. This being so, the first portion of the extract, which says, "the internal disturbing forces which tend to unsteadiness of running can only be partially balanced," must be wrong, as we have wholly balanced them; and the last part, which says, "on which the balance weights have been calculated, taking too much of the horizontal forces into account," must also be wrong, as that is impossible, seeing we require the whole of them.—Yours, &c., DREADNOUGHT.

THE STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

SIR,—Of the many pleasing practical questions started in your welcome weekly, none has for me so much interest as the one raised by "Inquirer" and by "C. T." in yours of the 10th and 17th ult., on the strength of furnace tubes, or, to put it in its broadest sense, on the collapsing strength of boiler flues.

What a commentary upon our boasted pedigree as a "practical people" is shown by the widely divergent results given in the two letters named, and, had they been inclined, they might have added many other data and formula, and further confused the confounded question.

Just fancy the thousands of steam magazines distributed throughout our populous manufacturing centres, ready in an instant to deal death and destruction to an innocent and confiding public, who are lulled to a false sense of security under the impression that such structures are adapted by precise mechanical and mathematical knowledge to bear safely the pressure intended.

I have always held we are nationally culpable for the loss of life through the collapse of boiler flues, and that the question ought to have been taken in hand by the Board of Trade, and by a long series of carefully conducted tests found the law which governs such tubes in all their variations of length, diameter, and thickness of plates; the effect of laps, angle-iron hoops, cross tubes, pockets, bowling hoops, and Adamson's seams, &c., &c., and not have left it to the private enterprise of such worthies as Fairbairn and many others, who have done their best (but which of necessity must fall short of completeness) to throw some light upon this dark subject.

To take a retrospect from the introduction of the Cornish and Lancashire boilers of such calamities as one has seen or heard of, or as we may learn from the yearly reports of our boiler insurance companies, is indeed a sorry compliment to our boiler engineering.

Just turn back to the days of five and ten pounds, and of our slowly advancing pressures, and observe the many attempts to strengthen these flues to meet the ever-increasing demand for higher pressures; the variety of methods, and the greater variety of ideas in their application, is the best evidence we were groping.

It is time some national or international effort was made to settle this very important point.

Had the question been one affecting the stability of a man-of-war, the elongation of a gun tube, or the bursting of a gun, millions of pounds would be voted to arrive at some knowledge as to the cause; but it is only a steam boiler, which a few pounds can replace, while the loss of life is even cheaper.

My position, as a responsible agent for a large firm having many boilers in various parts of the country, has often caused me great anxiety when buying boilers—especially second-hand ones—to determine the strength of the flues under all the conditions in which we meet them.

A good deal could be said of such troubles, but it might hardly be worth the space, as I am of opinion you can be better engaged if "Inquirer" and "C. T." would give us the benefit of their knowledge on the matter, which, from the tone of their letters, I am sure they are able to do.

I shall be highly pleased if this correspondence leads to the adoption of some correct but simple formula, which can be applied by a PRACTICAL MAN.

HIGGINSON'S SPEED REGULATOR.

To the Editor of "The Practical Engineer."

SIR,—Your correspondent "Paradox" seems to understand the *modus operandi* of my regulator, but I scarcely think that he is correct in saying that claims are made for any new governor because the spring which it employs increases in tension as the governor rises. If this increase of tension were an advantage, all spring governors would share it, for I believe it would be difficult to make a spring act otherwise. If any such claims are made, they are obviously absurd, as no rise of the governor can take place without a permanent increase of speed to balance the extra tension of the spring. The advantages of springs are that they give great power in a small space, and obviate the inertia inseparable from the use of a large dead weight. If a spring were substituted in an ordinary Porter governor for the central weight, without any other change, the increasing resistance of the spring would require a far greater increase of speed to fully open the balls than when the dead weight was used.

To prevent this extra variation of speed occurring, spring governors are generally made by construction, such as crossing the arms, &c., to approach nearer isochronism, and in every case the increasing tension of the spring is an element which has to be allowed for and corrected, if good governing is to result.

If it were not for the "hunting" which invariably results when governors are made isochronous, my regulator would be at a discount; as, however, "hunting" cannot be prevented except by giving stability to the governor, which in turn requires compensation when changes of load take place, there will always be a wide field for speed regulators. Trusting that I have made clear the apparent paradox, I am yours, &c.,

Manchester. J. Higginson, Jun.

QUERIES AND REPLIES.

47. **Hardening Malleable Iron.**—Will any reader kindly inform me how to make malleable iron flint hard, as I have some cast cups to harden, and I do not know what powder or liquid to use?—Cycling.

Answer.—Malleable iron may be hardened by the process known as case-hardening, which consists of packing the article in an air-tight box with any substance containing animal carbon, such as charred leather, horn, or bone dust; the box and contents are then heated to redness, and maintained at that temperature, the length of time depending on the depth to which the carburisation is desired to extend, an hour's duration giving a depth of about 1/16in. in thickness. The box is then allowed to cool gradually before opening. If, however, the friction is not great, a very hard coating, though only thin, may be obtained by first polishing, then heating, and rubbing with prussiate of potash, afterwards plunging in cold water.—Orion.

48. **Steam Discharge by Free Expansion.**—How many gallons of water must I evaporate to supply the steam discharged from a ½in. diameter pipe, 6ft. in length, at 60lb. per square inch of boiler pressure. The steam is for blowing purposes, and is discharged freely into the atmosphere at atmospheric pressure?—Subscriber.

Answer.—When the absolute pressure of the steam in pounds per square inch $= p$, which in this case is $60 + 15 = 75$lb., the following formula represents the weight of steam discharged through such pipe per hour:—

$$(\tfrac{1}{2})^2 \times {\cdot}7854 \times 60 \times (1{\cdot}05686 \times 75)^{\cdot 96} = \text{lbs. per hour};$$
$$11{\cdot}778 \times (79{\cdot}2645)^{\cdot 96} = \text{lbs. per hour};$$

or, $\log. 11{,}778 + {\cdot}96 \times \log. 79{\cdot}2645 = \log.$ of lbs. per hour;

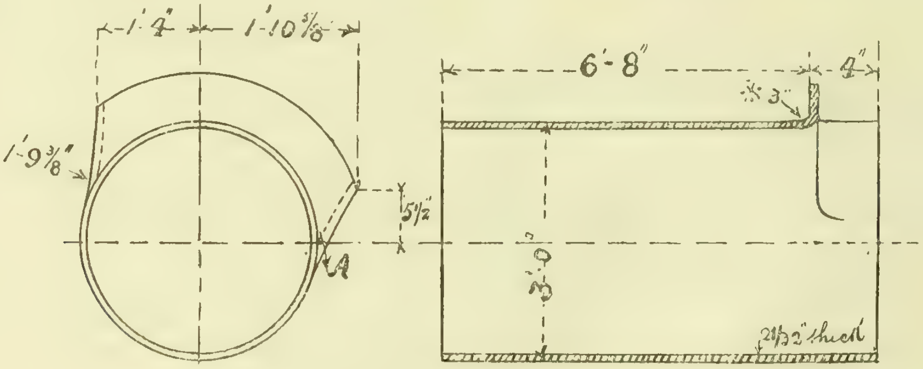
but $\cdot 96 \times \log. 79 \times 2645 = 1{\cdot}8990788 \times {\cdot}96 = 1{\cdot}8231156$;

$$\log. 11{\cdot}778 = 1{\cdot}0710715$$

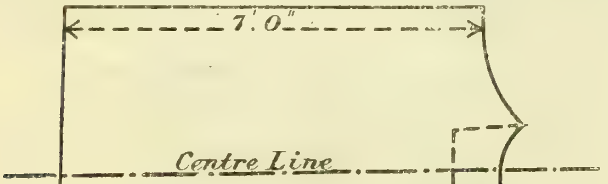
(as above) $\cdot 96 \times \log. 79 \times 2654 = 1{\cdot}8231156$

Log. of lbs. per hour.... $2{\cdot}8941871 = 783{\cdot}76$lb., or 78·376 gallons of water per hour required to replace that gone in steam.—W. A.

53. **Marine Boiler Furnace.**—Will you kindly give me the correct method for working out the dimensions of a plate required for a marine boiler furnace such as this?—R. H. H.



Answer.—The only way to make these furnaces is to set the full side, and measure off in lines parallel with the axis of the furnace, the fillet and corner to be formed by beating out and stretching the material, which must be thickened by jumping. The size of plate you require for the furnace shown will be 9ft. 5in. by 7ft. 6in., and when set out it will be similar to this stretch. The corners are formed where the dotted lines are shown.—Chalk Line.



35. **Locomotive Driving Wheels.**—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

41. **Hot-water Pipes.**—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft.? What book may I get on arrangement of greenhouse?—Water-heater.

49. **Proportions of Pipes to Hydraulic Ram.**—We have a 10in. ram, with 1¼in. inlet and outlet pipes, pressure 700lb. per square inch. Is this a correct or good proportion? if not, how is the correct proportion calculated? Steam Crane.

50. **Small Air Pump.**—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

51. **Straightening and Bending Angle-iron Bars.**—Will any practical man kindly give me a ready method of straightening and bending angle-iron bars about 5in. by 5in. by ¾in.? A sketch or description of suitable machine will much oblige.—Outsider.

52. **Details of Oliver.**—Can any reader oblige me with details of an "Oliver," to work by foot, for making bolts from ⅜in. to 1in., with dimensions?—H. C., Egypt.

TO CORRESPONDENTS.

Water, Bradford.—If you have trouble in getting the junk ring off to examine the high-pressure piston springs, your best plan is to drill and tap three holes in it, and use a box key and starting screws. We have always found it easy to deal with troublesome pistons in that way.

Caleb, Chesterfield.—At 60lb. per square inch above atmosphere the temperature of steam in a boiler is 307·5 deg. Fah. The temperature, of course, can be raised by superheating, but that is the temperature when saturated as in a boiler.

R. B., North Shields.—Messrs. Yarrow and Co., engineers, London, construct launches with naphtha or light hydrocarbon engines. Their well-known Zephyr spirit launches are so driven. Messrs. J. Donald and Son, Cadogan Street, Glasgow, are agents for an American steam engine suitable for launches fired by light oil.

D. H., Taff's Well.—"Machine Drawing and Design," by W. Ripper, Handsworth, Sheffield, is one of the best books upon mechanical drawing within our knowledge.

J. S., Birmingham.—We do not know of any book specially devoted to lining out and erecting machinery.

Gas Apparatus.—Gas engines cost less to run than steam engines, as compared with steam engines up to about 12 H.P., especially for intermittent work, even with gas at ordinary prices. In really large steam engines, however, steam at present costs about one farthing per I.H.P. per hour, against one halfpenny for gas engines. Dowson gas, however, requires to be used for the gas engine, and it must be fairly large to give this result. There is little doubt but that gas engines will ultimately be more economical than steam engines from a financial standpoint, as they are at present considered as heat engines. Gas produced by the vaporising of gasoline by air costs much more for a given power than ordinary coal gas. Water gas has not yet been extensively applied to gas engines. Dowson gas works admirably, and, with a 12 H.P. engine, costs about one halfpenny per H.P. per hour, as we have said. You should always give your name and address when writing for information.

J. H., Steamship Minerva.—Many attempts have been made to obtain motive power by permanent magnets, which were and are necessarily failures, as they are really attempts at perpetual motion. Electro motors driven by the electric current act by recurring attractions between wires, which practically become magnets for the time being.

Water, Newton Heath.—It is impossible to syphon water from a lower to a higher level. You cannot therefore syphon water from the canal to your boiler at 12ft. higher level.

T. J. M., Bedford.—We fear that if you have no interest in engineering it is impossible to advise you on the relative advantages of the various branches. Both electrical and locomotive engineering are good. Your best plan is to become apprentice first, and study while serving your time. Do not go to a technical college first; it is a great mistake. The amounts asked as premiums by firms vary much, but we prefer men who enter the shops as ordinary apprentices, without paying premiums. They always seem to work better and learn more.

Subscriber.—Thanks for your letter on water gas. We shall go into the subject more fully at an early date. It will be impossible to answer your questions in detail, however, because no water-gas plant has yet been constructed sufficient to supply a city, and consequently reliable data are wanting. There are still grave difficulties in applying gas engines to spinning mills, because of their irregular running, as compared with the standard types of mill engine.

MISCELLANEA.

The South Australian Government have made an arrangement by which an engine driver who runs his trains for two years without accident will receive a bonus of £10.

A Board of Trade half-yearly return shows continued progress in the use of continuous brakes on railways. In 1881 there were only 39 per cent of engines running, and 48 per cent of carriages fitted with such brakes; but at the end of last half year these numbers had risen to 94 and 91·5 per cent respectively.

Wood Gas.—It is reported that Mr. George Walker is now making gas for lighting purposes at Desoronto, Ontario, from the shavings and chips of resinous wood, at the rate of from 560 to 850 cubic metres per ton. The illuminating power of the gas is described as considerable, and so, we may be sure, is the value of the bye-products—the wood carbon, the tar, the wood vinegar, and the methyl alcohol.

The screw-steamship Eastgate, a vessel which was recently built by Messrs. Thomas Turnbull and Co., of Whitby, for Messrs. Turnbull, Scott, and Co., of London, ran a very satisfactory trip from the Tees lately, attaining a speed of about 10 knots. Her triple-expansion engines of 140 horse power nominal, having cylinders 20in., 33in., and 54in., by 35in. stroke, and working at 150lb. pressure of steam, have been supplied by Messrs. Blair and Co., Stockton.

Glycerine Cement.—According to the *Monde de la Science*, there is coming into use a new mastic harder and more resisting than Portland or any other cement of the kind. It is a mixture of glycerine and litharge or massicot (lead oxide). The journal in question makes it appear that the manufacture of the substance is very simple. After drying the finely-powdered litharge in a stove at a high temperature, the glycerine is added to it in quantity sufficient to make a thick mortar.

A Lad Killed by Molten Slag.—On Saturday, June 1st, a horrible accident occurred at Tudhoe Ironworks. An engine was engaged tipping slag over a heap, when the men in charge of the work suddenly discovered that one ball of partly molten slag had fallen on to three small boys, who were playing at the end of the tip. One of the boys was dead, his body being horribly mangled, and the clothing burnt from his body. The other two were very much hurt, and the affair created an intense sensation in the district.

Petroleum Tar for Boilers.—According to the German paper *Dampf*, the tar obtained in the distillation of petroleum serves a good purpose as an interior coating for steam boilers, loosening the scale so that after emptying and cooling them it either drops off the surfaces of its own accord, or may be easily removed by light hammer taps. Scale which has adhered for a long time also gives way to the action of the tar. It is recommended that the boiler surfaces be supplied with one or two coats before filling the boilers.

Government Engineering Orders for the Tyne.—The Admiralty has, we understand, placed an order with Messrs. R. and W. Hawthorn, Leslie, and Co., Limited, of St. Peter's Works, for the machinery of H.M.S. Pallas, a twin screw cruiser of 7,500 indicated horse power. The Pallas, which will be built at Portsmouth Dockyard, is a duplicate of H.M.S. Pandora, Pelorus, and Persian, at present being built at the Elswick Shipyard by Messrs. Sir W. G. Armstrong, Mitchell, and Co., Limited, for which vessels also Messrs. Hawthorn, Leslie, and Co. are supplying the machinery.

Ship Railway.—General Andrews tells the New York Academy of Sciences that a ship, in order to propel herself through the water of a canal, requires to burn twice as much coal as would be consumed by a locomotive employed to haul the same ship over a ship railway. Such haulage, he contends, would not rack the ship, because the distribution of weight among the numerous supports would be such as to make the weight sustained by each singly insignificant. In that case, we might expect to see the proposed Tehuantepee ship railway across the isthmus soon under way.

At Crarae Granite Quarry, Loch Fyneside, another monster blast has been fired. The total length of the mine bored through the solid rock was 84ft.; the powder chamber measured 4ft. by 3ft., and contained 11,000lb., or nearly five tons, of gunpowder; and the height of the rock resting over the mine was 163ft. The fuse was lighted at 1 p.m., and 25 minutes afterwards between 70,000 and 80,000 tons of fairly good granite were displaced. This is the first gigantic blast at this quarry since the fatal occurrence which resulted in the loss of several lives through suffocation some two years ago.

The Floods.—America—or, to speak more definitely, Pennsylvania—is suffering once more from one of those calamities which, in one form or another, seem to periodically devastate the country. Tidings have come of terrific freshets, caused by the recent copious falls of rain; and of whole towns and villages submerged. It is stated that at Johnstown about 10,000 persons have perished; while in other places many have also been drowned, the survivors flying for dear life to the mountains. Allowing even for the exaggeration of early telegrams, the disaster has evidently been terrible—one that appeals to all our sympathies for those who have been so suddenly overwhelmed.

New Mode of Electric Illumination.—A French electrician has submitted a proposal to the municipality of Paris with a view to supplying the electric light in a novel manner, which would tend to conciliate interests which at present enter into the question, namely, by obviating the necessity for laying down conducting wires. The originator of the idea has, it appears, invented a miniature gas motor, which he proposes to fix in the lamp standard, and above or below, the same as a dynamo would be placed to actuate an arc lamp on the top of the column.

Four locomotives, representing different types of motive power, are now in Philadelphia. The Strong locomotive, which recently made such a wonderful record on the Erie road, took out the 7-30 New York express on the Bound Brook route lately. The English locomotive Dreadnought, which has been tested with freight trains on the Mountain division of the Pennsylvania, takes a passenger train to Paoli. The Reading Railroad has just received the first one of a recent order of ten locomotives of the Wootten design, but heavier than any heretofore made, and supposed to be more powerful. It made its first trip on the Atlantic City road recently. The Shaw "balanced" locomotive is being pushed into shape for a trial run on the Reading road. American engineers are greatly interested in the appearance of so many locomotives of different types at once, and are watching for reports of their respective performances.

New Process of Making Copper Castings.—Messrs. Schneider and Co., Creusot, France, have patented a process, which consists in making, in a blast furnace, a cupola or a reverberatory furnace, castings having a variable proportion of copper, with a proportion, likewise variable, of the ordinary constituents of cast iron. These copper castings are used for the manufacture of the copper steels which serve for the preparation of articles such as sheathing and armour for vessels, cannons, projectiles, bed-plates, steam cylinders, rolls, &c., the articles when desired being case-hardened or hardened in oil. Copper ore is mixed with the charge in the blast furnace, or copper alloys with the charge in the cupola. Also copper filings can be mixed with coal to form a copper coke, which is used for heating the blast furnace or cupola; or copper compounds can be melted in a reverberatory furnace, with a mixture of steel or iron, under a layer of anthracite to prevent oxidation.

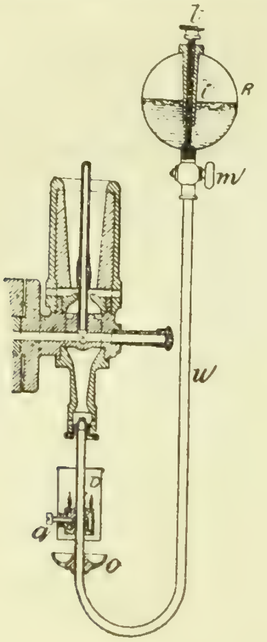
Owens College Engineering Society.—The last of the summer excursions arranged by this society took place on Saturday last, when a number of the members proceeded to Horwich by the 1.20 train from Manchester, and visited the Liverpool Waterworks at Rivington. Owing apparently to some misunderstanding respecting the train, the party was not so numerous as was anticipated, but the members who went were shown over the works, in the absence of Mr. Parry, C.E., by Mr. Chorlton, who fully explained the various points of interest in connection with the works. The whole of the water sent from these works to Liverpool is passed through large filtering ponds, about 13,000,000 gallons per day being treated, and the new machinery recently put down for washing the sand was examined, and the construction and arrangement of the filters, mode of measuring the water, &c., inspected. The day being fine, a most enjoyable afternoon was spent, the breezy walk round the various reservoirs and works putting the members in good trim for the substantial tea provided by Mrs. Gerrard at the Blackamoor's Head Hotel, Rivington, which, it need scarcely be added, was done ample justice to.

The Institution of Civil Engineers.—At the last ordinary meeting of the session 1888-89, on Tuesday, the 21st of May, Sir George B. Bruce (President) in the chair, it was announced that the following associates had been transferred to the class of members: Humphrey Chamberlain, David Morris, Alfred Eley Preston, and Henry Badeley Smith. At the same meeting it was reported that John Henry Barker, William Edward Gilbert Belcher, Hilaire Belloe, Peter Clarke, James Stanhope Cockburn, Samuel Edward Cooper, Richard John Cracknell, William Joseph Bremner Davis, Sholto Hyde White Douglas, William Piercy Edwards, Assistant Engineer R.N., Bernard Morley Fletcher, Frank Laurens, John George Liversidge, Assistant Engineer R.N., John May, Henry Arthur Fitzherbert Musgrave' Harold Stanley Percival, John Smith, Wh.Sc., John Cuthbert Traill, B.A., Edward Vernon Waud, and Henry Richard Kemp Woodward had been admitted as students of the institution. The last ballot of the session resulted in the election, as honorary members, of Sir Henry Bessemer, F.R.S., Denmark Hill; and Sir William Thomson, F.R.SS. L. and E., LL.D., Glasgow University; and of 17 associate members, viz.: William Thomas Clifford Beckett, Bengal-Nagpúr Railway; John Watkins Brough, Stud. Inst. C.E., Beersse, near Antwerp; William Samuel Child, Kingston Hill; Stephen Butler Cottrell, Stud. Inst. C.E., M.S. and L. Ry., Chester; Alfred Fawcus, Stud. Inst. C.B., Govt. Railways, Natal; Charles Henry Gale, Stud. Inst. C.E., Kensington; George Hewson, Leeds; Reginald John Jones, Hampstead; William Turner MacLellan, Stud. Inst. C.E., Glasgow; James Marchbanks, P.W.D., N.Z; Lewis Prichard Moline, Melbourne; David Oldfield, Westminster; Norman Scorgie, Leicester; John Harris Hazlett Swiney, B.A., B.E. (T.C.D.), Belfast; Arthur Pepys Wood, Road Dept., Sydney; John Woodside, Stud. Inst. C.E., P.W.D., India; and Robert George Young, Colney Hatch.

ILLUSTRATED PATENTS.

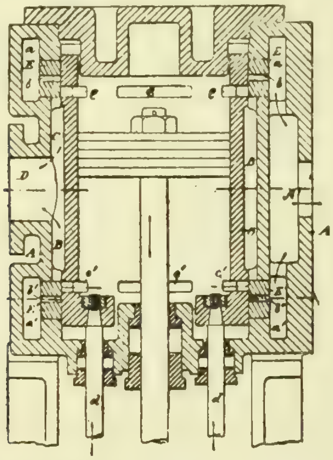
17,896. Gas Engines, C. D. Abel, London.—(The Gas Motoren Fabrik Deutz; Deutz-on-the-Rhine, Germany.)

For supplying vapour to the burners for heating the igniting tubes the apparatus shown is used. Liquid hydrocarbon is supplied from a reservoir R through an aperture regulated by a screw t fitting a long-tapped plug t^1 descending from the top of the reservoir. The liquid is evaporated in the tube u, preferably by a lamp p, supplied with vapour from the tube through the regulating valve q. o is a cup for containing oil for heating the tube at starting; m is a stopcock.—December 29, 1887. [8½d.]



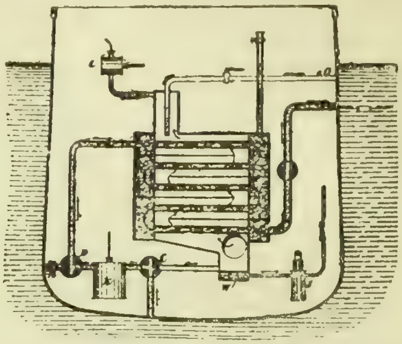
7,963. Steam and other Fluid-pressure Engines, D. Purves, North Dulwich, Surrey.

Consists in constructing the cylinder with a sliding ported liner for effecting the distribution of the motive fluid. At each end of the cylinder is an annular pace a, a^1, into both which the steam branch A^1 opens. These spaces have ports , b^1 presented towards the interior of the cylinder, over which work corresponding ports e, e^1 in the shifting liner C. In the body of the cylinder is an annular space B, surrounding the liner, which serves as an exhaust chamber, and is furnished with an exhaust branch D. The ends of the cylinders are furnished with packing rings E, E^1 cut diagonally across and held by clamps preventing rotary movement. The liner is reciprocated by rods d, d passing through stuffing boxes. December 31, 1887. [8½d.]



18,018. Marine Engine Condensers, A. Burckhardt and F. J. Weiss, Basle, Switzerland.

Relates to an arrangement of the pumps, &c., by which the water and air are separately withdrawn from surface condensers (the former by the ordinary feed-pump); and by which the circulation pump may also be applied to withdraw the water in case it is required to work with injection water. The object is to avoid waste of power occasioned by the use of the large air pumps usually employed. The figure gives a diagrammatic view of the arrangement. The water drains from the condenser into a well W, from which it is withdrawn by the feed-pump S, while the air is withdrawn from the top by the pump L, which is worked by a separate small engine. K is the circulation pump. Its suction and discharge pipes are fitted with three-way cocks C and D, by turning which it can be made to draw water from the well and discharge it at n when the condenser is worked as a jet condenser In this case the injection water is supplied by the pipe O. Baffle plates are fitted to cause the steam to flow through the condenser in a direction contrary to that of the water within the tubes.—December 1, 1887. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

May 18th.

8281 Water Gas, J. E. Bedford, Leeds.
8289 Pipe Joints, A. J. Boult, Middlesex. (A. Hansen, Denmark.)
8292 Hydrogen Gas, W. P. Thompson, Liverpool. (W. P. Hazard, United States.)
8295 Improved Monocycle, S. Meal, London.
8317 Gas Cooking Apparatus, W. M. Simpson, London.

May 20th.

8320 Steam Pumps, J. L. Jefferson and W. Henderson, Gateshead-on-Tyne.
8323 Breech-loading Small-arms, W. Phillip, Son, and W. Baker, Birmingham
8329 Hot-water Apparatus, T. Bradford, Manchester.
8330 Metallic Boxes, H. H. Chilton and H. J. Mitchell, Wolverhampton.
8333 Valve Gears, W. S. Bancroft and J. Horsfall, Halifax.
8334 Brake, T. B. Wilman, Bradford.
8337 Rolling Mills, D. Y. Cassels and R. Duncan, Glasgow.
8339 Vessels, J. I. Thorncroft, London.
8342 Furnaces, G. Olberg, London.
8348 Tubes, W. J. Marshall and J. Ford, London.*
8349 Heat-engines, A. Fehlen and The Engineering Joint-Stock Co., London.
8365 Portable Railways, F. H. Gill, London.
8369 Wood-paring Machine, C. L. P. F. Söhne, London.*
8371 Roller Mills, J. M. Case, London.
8374 Lathes, A. J. Boult, Middlesex. (Wilhelm von Pittler, Germany.)*
8375 Cylinders, A. J. Boult, Middlesex. (I. M. Lehman, Germany.)
8377 Lifting Jacks, W. P. Thompson, Liverpool. (C. T. N. Paschali.)
8381 Screws and Nails. G. W. Butt, London.
8387 Buffer Springs, F. Warren, London. (A. Spencer, Switzerland.)

May 21st.

8393 Clutch Mechanism, A. Tenner, London.*
8395 Pulley Coverings, A. S. Davis, London.*
8396 Buffers, F. E. Leather, Portsmouth.
8416 Nut-making Machines, J. Brettell, Birmingham.
8424 Signalling, F. Walter, London.*
8432 Turbines, J. McConnell, London.
8438 Coating Iron, T. Slater, Middlesex.
8440 Gripping Mechanism, J. H. Pendleton, C. Tiers, A. Bryson, jun., and L. Moss, London.
8443 Governors, H. H. Lake, London. (T. Backeljau, Belgium.)*
8446 Water Gauges, J. Donnelly, London.*
8449 Turbines, A. Valery, Comte de Vismes, London.*
8452 Roller Fulling Engine, J. Orlamünder, London.*
8461 Motors, A. W. Pearce and L. H. Johnson, London.
8464 Cable Tramways, E. Dainty, London.*
8466 Ventilators, D. Brown, London.
8472 Locomotive Engines, J. T. A. Mallet, London.

May 22nd.

8473 Expansion Engines, A. Brown, London.
8484 Expansion Rings, R. H. N. Lindley, Middlesex.
8486 Water Heaters, A. H. Wallis, Basingstoke.
8499 Compressing Air, H. E. Phillipson and R. E. Donovan, Dublin.
8515 Spanners, G. A. Nussbaum, London.
8518 Shafts and Axles, C. C. Vagniez, London.
8539 Furnaces, T. Henderson, Liverpool.
8543 Recarburisation of Steel, T. Twynam, Middlesex.

May 23rd.

8550 Lathes, W. Buckley, Sheffield.*
8554 Bearings, C. E. Hyde, London.*
8555 Coupling, R. J. Edwards, London.*
8561 Steam Traps, J. Conlong, Blackburn.
8578 Positive Cam, J. T. Ball and R. Whitaker, Farnworth.
8584 Metallic Packings, J. Drury, Halifax.
8591 Boiler Flue, E. C. J. Devis, Birmingham.
8594 Lock Nuts, E. P. Prince, Middlesex.
8599 Valves, D. Carmichael and A. Mackie, Glasgow.
8612 Jacquards, H. Fawcett, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE
PRACTICAL ENGINEER,
JUNE 14TH, 1889.

PRACTICAL FALLACIES RESPECTING SPIRIT ENGINES.

In our last issue we dealt generally with some points in the action of Mr. Yarrow's interesting petroleum spirit engines, and we should not have returned to the subject so soon but for a deliverance of our esteemed contemporary the *Engineer*—for we do esteem our contemporary, although its ideas on matters concerning the production of motive power from heat engines are radically in error—in which we find mistakes so serious as to require immediate correction. The *Engineer*, in discussing the applied theory of spirit engines as compared with other heat engines, falls into serious error, and propounds fallacies of a nature which should only have caught the most careless or uneducated of steam engineers. We are not surprised at this, however, as the errors are quite in keeping with the previous statements propounded by that journal, and are of the kind which the careless student of practical thermo-dynamics would probably make. We have already pointed out that the economy attained by these spirit engines, as compared with steam engines, had surprised some, and caused the formation of exaggerated ideas as to the possible application of the principle to large engines. We now find that the *Engineer* has gone astray precisely on the points anticipated by us, and supposes that Mr. Yarrow's investigation, together with that of Mr. Redwood, tend to prove fundamental error in the application of the second law of thermo-dynamics, and to show that all calculations of possible engine efficiency based upon that law have been mistaken and wide of the mark. It states the existing state of knowledge in this way: "It has hitherto been laid down as a fundamental principle that the efficiency of a heat engine is absolutely independent of the nature of the form of matter used as an agent for converting heat into mechanical work. If, for example, we expand air by heating it under a loaded piston, the piston will rise, and work will be done. If, instead of air, we cause water to expand, the result will be the same. The expansion of a metallic rod may be employed to produce a mechanical effect, or we may use steam. But in all cases the efficiency of the apparatus is represented by the formula, $E = \frac{T - t}{T}$."

Now, a most important omission is here made, which entirely vitiates the whole application to practicable heat engines. It is entirely forgotten, that in order that the efficiencies of all these modes of producing power should be identical, a certain prescribed series of operations must be performed in each case. Not only must the initial and maximum temperatures be identical, but the maximum temperature must ascend from the initial in a certain way, and the descent from the maximum to the initial temperature again must also be performed in a certain manner. It is not sufficient, for example, that air should simply expand under a heated piston to give the maximum efficiency, but the heat must be added in a certain way. Thus the air must first be compressed in such a way that no heat is lost, and its temperature rise during compression from the lowest to the highest; then heat must be added while the air expands at the highest temperature, and after a time the heat supply must be cut off and the air expanded sufficiently to fall—doing work—to the initial temperature again, after which it must be compressed, and heat abstracted at constant lowest temperature till the original volume be reached. Then the air is in a position to be again used as a vehicle for the conversion of heat into power. In the same way with water or a metallic rod, the liquid or solid must be put through precisely the same series of operations. With the iron rod or liquid water this is quite impracticable, as the volume changes are exceedingly small, and the pressures produced by these changes are enormous, so enormous that no mechanism could be devised to take the pressures, or to cause compression to the necessary extent.

The efficiency of the apparatus, each performing the same operations, but not the operations of the theoretically perfect engines, varies widely, and physicists are perfectly aware that it is so. If, for instance, heat be applied to air to cause it to expand and perform work while the temperature increases from t to T, the proportion of heat so converted into work is very different from that utilised in heating water from t to T, or through the same range of temperature, which statement holds good for other substances as well.

An engine using a series of operations, or an operation by which the power is obtained by mere increase of temperature, will have an efficiency which varies with the nature of the fluid used, and this is thoroughly well understood by our leading practical as well as theoretical engineers; but, although the efficiency changes widely, in no case is it so great as would be given by a perfect heat engine. The variation of efficiency of imperfect heat engines is always well within the limits there defined; and, as we have previously said, there is no difficulty in understanding the causes of the superiority of spirit over water under the conditions of actual use. Any engine in which water is converted into steam, and the steam at full boiler pressure is carried during the whole piston stroke, is necessarily an engine of low efficiency, even when it is supposed that all practical losses are avoided, and the possible efficiency may be calculated if the requisite data are at hand. In such an engine the whole latent heat of the steam is rejected into the atmosphere, and the portion which is converted into work is that expended by the displacement of the steam existing in the boiler at nearly constant pressure by the steam generated from the water. The efficiency of such an engine is therefore the proportion between the indicated work and the total heat of the steam, including heating the water from lowest temperature, plus the heat equivalent of the indicated work. As the whole latent heat of the steam used is discharged at every stroke, it follows that if a liquid with a less heat of evaporation can be used, which gives a greater volume of vapour for any given expenditure of heat at a given pressure, then a greater power will be obtained for a certain expenditure of heat. Greater power will be indicated for a certain amount of heat, and less heat will be discharged in the exhaust for a given indicated horse power. In Mr. Yarrow's case the experiments distinctly prove double power for the same expenditure of heat, but nevertheless the engines are far from economical compared with good steam engines, as the fuel consumption is about 3lb. of light hydrocarbon per indicated horse power per hour, which is equivalent to about 7lb. of carbon.

Mr. Yarrow's results are admirable for very small engines using boiler pressure the whole stroke, and the economy is the result of the combined increase in boiler efficiency and decrease in cylinder condensation, as well as the diminution in loss of heat discharged with the exhaust. But if expansion were used the advantage would disappear, and in engines of any considerable dimensions the economy of the modern triple-expansion engine would not be approached, as the limited range of temperature change would in our opinion more than compensate for diminished loss of heat in exhaust and diminished condensation. The advantage of the spirit vapour is evident when acting practically without expansion, but if expansion were adopted it would entirely disappear. Suppose, for example, that at the moment of cut-off the vapour filling the cylinder contains a total heat of one-half that of equal volume of steam: as the work done by expansion is done at the expense of that heat, the curve will fall away much more rapidly than with steam, so that the expansion part of the diagram will be less in proportion to the admission part. Consequently less work will be performed by the expansion of a given volume of spirit vapour between fixed pressures than with the same volume of steam, and with considerable expansions steam will prove far more economical. If, however, a hydrocarbon spirit could be used with a higher boiling point than steam, in our opinion great economy would be obtained, and the more rapid fall of temperature after cut-off would not be a disadvantage, as it would be caused by the performance of work, and there would consequently be less cylinder condensation.

There is no doubt in our mind as to the substantial correctness of Mr. Yarrow's and Mr. Redwood's conclusions, but there is also no such conflict, as our contemporary erroneously supposes, between the results obtained and those which would be anticipated by engineers well versed in the subject.

The professors whom our contemporary so contemns have, we fear, a very hard task before them if they attempt to enlighten persons so perversely incapable of understanding the present position and conclusions of the science of thermodynamics. It is an entire mistake to suppose, as the *Engineer* does, that thermo-dynamics rest upon insufficient experiment; on the contrary, the experiments upon which its laws are based are most complete and conclusive to those who take the trouble to study and understand their application to practice. It is not easy to apply them, however, with insufficient practical and scientific knowledge, and our contemporary falls into error through insufficient knowledge of the subject, which we feel sure could be remedied by a diligent course of study and practical experimental engine work.

We again express our regret that our contemporary, so deservedly esteemed in many respects, should reason so loosely and inaccurately as to mislead many who look to it for guidance on engine matters, and we regretfully feel it our duty to unsparingly criticise any erroneous statements so published. It is our wish to give our readers the best and most reliable information on all matters pertaining to the generation and production of motive power, and to that end it is very necessary to unsparingly point out errors likely to mislead engineers and inventors, and thus save much useless waste of labour and capital.

THE PENNSYLVANIA VALLEY FLOODS.

Last week the most appalling disaster ever caused by the failure of an engineering work occurred in America, whereby a large town, with its suburbs, was practically wiped out of existence almost instantaneously, and an enormous number of its inhabitants drowned, killed, and burned. The latest estimates, at the time of writing this, place the dead at no less than six thousand. However, it is not our purpose to enlarge upon the horrors of the catastrophe, but to examine, as far as possible, the structural or other causes of the failure. Many serious accidents with reservoir dams have occurred in this country, of which perhaps the most widely known was that of Holmfirth and Dale Dyke, near Sheffield. The loss of life in these cases was, however, comparatively insignificant.

The South Fork dam was constructed on the South Fork, a tributary of the Little Connemaugh River, and at a distance of 18 miles above the town of Johnstown, the level being about 250ft. above the town. The reservoir thus produced formed a lake about three and a half miles long and one mile broad at its widest part, and it was intended to supply a canal. But upon the advent of railways it was purchased by some capitalists, who utilised the lake for fishing purposes. The dam consisted of a wall of masonry 700ft. long by 100ft. high, and it has been known to be in an insecure condition for a year past, and the inhabitants of Johnstown have been repeatedly warned of their danger. Johnstown lies in a hollow, enclosed on the north by the Little Connemaugh River, and on the south by the Connemaugh River.

The rivers unite just below the town, and flow on to Cambria City, between it and the Cambria Ironworks, the largest iron and steel works in America.

The configuration of the country round those places directed any water from the reservoir between steep banks full upon them, and thus we should have supposed that the greatest care would have been exercised in maintaining the dam in safe condition, in the interests of the 30,000 people whose lives were at its mercy. Three days before the failure it is said that the whole stone front was leaking in an alarming way, so that jets of water sprang many feet out; but such was the general indifference, that even after the actual bursting of the dam had been telegraphed, an hour before the water reached the town, but few were persuaded to leave the town, so that when the flood swept down the consequences were frightful. Just below Johnstown there stands a strong railway bridge, carrying the Pennsylvania Railway over the Connemaugh, and when the flood carried off a great mass of wooden houses, the débris piled up against it and raised a dam 60ft. high. This wreckage contained over 2,000 human beings, and many were crushed and mangled. To crown all, the mass caught fire, and all were consumed. The three places—Johnstown, Cambria City, and Woodvale—were practically blotted out, and a frightful proportion of their inhabitants drowned, killed, and burned.

The wave advancing upon Johnstown down the valley was said to be fifty feet high, and the water seemed to leap forward with a frightful roar and crash, heard for many miles. Considering that the wave took an hour to travel the 18 miles, it is astounding to think that the people did not escape in greater numbers.

It is to be hoped in the interests of humanity that the cause of the failure may be thoroughly investigated, and it will be most criminal if any hints so given are not utilised to increase the safety of similar structures all over the world. In our country we could have no disaster of such frightful proportions, but still the safety of many hundreds even here depends upon such constructions, and so fearful a warning should not be neglected. However, our engineering works are much more solidly constructed than in America, and there is little reason for fear.

GASTON PLANTÉ, THE INVENTOR OF THE ACCUMULATOR.

The originator and discoverer of the modern electrical accumulator was M. Planté, who has just died in France. The accumulator, in various practicable and marketable forms, is now widely used, although as yet it has not attained the universal usefulness anticipated some years ago by Sir William Thomson, when he carried from Paris one of Faure's cells, the famous box of electricity of which we have heard so much; still it is largely used. Electrical launches, tramcars, and regulators for home lighting are largely indebted to it for their present degree of success. The action of the accumulator is most interesting, and although it has been much improved, and its details reduced to practice by M. Faure in France, and Messrs. Sellon, Elwell, and Parker in this country, yet in its main lines the discovery is due to the genius and patient research of M. Planté.

It is not a real storing of electricity, but a means of obtaining chemical energy from the electric current, in a form readily transformed to current again when required. Lead was found, when used for the electrodes of a battery, to have the remarkable property of forming negative and positive plates, one by the formation of metallic lead in a finely porous state, and the other plate by taking a coating of peroxide. When properly formed, considerable action occurred by the reduction of one plate and the oxidation of the other, which generated a current, as with a primary battery. The investigations of M. Planté upon this subject were most accurate and extensive. He was born in 1834, and became after a time the assistant of M. Ed. Becquerel, when he interested himself much in voltameters, and noted the effects upon which all modern storage batteries were founded. His experiments occupied him twenty years, extending from 1859 to 1879. He worked from a purely scientific standpoint, and patented none of his inventions in this field, so that many inventors owe him gratitude for the basis of their practical work.

He conducted many other investigations, but none so generally interesting as the storage battery. He was not elected to the Acadamie, for which Mr. Berthelot has expressed great regret, but in 1881 he was made a chevalier and officer of the Légion d'Honneur. He was of modest and retiring habits, although most genial, and his unpretentious presence will be deeply missed by all who knew him.

ENGINEMEN.

The attempts made during the last few years by those entrusted with the working of steam engines and boilers to obtain recognition as a skilled class of workmen, and the accounts published from time to time of meetings of enginemen for the purposes of combination, are all gratifying signs of the times which those interested in the safe and economical use of steam must be pleased to recognise.

Without expressing any opinion as to the advisability or otherwise of granting certificates to skilled enginemen, it may safely be asserted that the present position of those in charge of steam engines and boilers is anything but satisfactory. Although generally regarded as an unskilled class of labourers, many of these men fill positions of great responsibility, requiring more than ordinary care and watchfulness; and it is well known that large numbers receive salaries much higher than are paid to the great bulk of skilled artisans.

As a class, probably no body of men would be more benefited by combining and meeting together for mutual help and assistance. They are precluded by their peculiar, and in one sense isolated, position from acting together in the same way as a trades union—that is, attempting to force up wages by means of strikes. Every inducement, however, should be offered for organisation and union in such a way as will enable them to meet together for mutual improvement, or, as we find it stated in the preamble to the laws of one association of enginemen, to promote "the mental, moral, and social elevation of its members in all that appertains to safety and economy in the steam engine."

These are objects which everyone, whether favourable to granting certificates or not, can appreciate; and it is pleasing to note, from an interesting address before us, delivered some years ago at the opening of one of these engineers' societies, that in a neighbouring town, where an association had been formed some years previously, the wages of the members, which included about four-fifths of the whole of the enginemen of the town, had risen in the mass since the formation of the society.

In this society the men meet together "for intellectual intercourse and mutual instruction, holding discussion meetings and lectures upon subjects in connection with steam and the steam engine, inspecting each other's boilers, and occasionally going into each other's engine-houses, and assisting one another in making sundry alterations and improvements in their engines (by which means the younger members could have the advice and assistance of the more experienced and better informed members), by publishing reports of their lectures and proceedings, and giving advice with respect to the prevention of boiler explosions from time to time; by establishing libraries and fostering the habit of reading scientific works among their younger members, by purchasing steam-engine indicators for the general use of the members, so that every member might know in what condition his engine is, whether his employers cared to know or not."

No one can object to a combination with objects such as these, especially when the giving of "pecuniary assistance in times of distress and sickness and death" is also included, thus combining many of the advantages of a trade organisation with those of a friendly or benevolent society. It is not surprising to learn, further, that so far from the employers in the town in which this society exists being prejudiced against the members, as they usually are against trade unionists, they thoroughly appreciate the advantages to themselves likely to accrue from their enginemen belonging to the society, and a member of the association has, consequently, a much better chance of obtaining a good situation than a non-member. It was not an uncommon thing for applicants for engineers' situations to be asked "were they members of the Engineers' Society," and should the reply be in the negative, the usual remark was, "Then you ought to be."

The writer had the privilege not long ago of visiting a meeting-room of one of these societies, to give a short lecture, and noticed, chalked up on the blackboard, a sketch from an illustration in a recent number of *The Practical Engineer*, the subject of which had been up for discussion at their previous meeting.

Too much encouragement cannot be given to efforts made by any body of men to promote mutual improvement in this way, and it is gratifying to note the increasing number of meetings reported in the papers from time to time in different parts of the country, which give encouragement to the hope that the example is spreading.

Two weeks ago a conference of colliery engineers was held in the Town Hall, Southport, when delegates of the National Federation of Enginemen attended, including representatives from Lancashire, Yorkshire, Durham, Shropshire, and Cumberland, and amongst others the following resolutions were passed :—

(1) That this conference, having heard the reports from each district respecting the hours and wages of colliery enginemen, recommends that a general application be made for a working day of eight hours for all winding enginemen, believing that the continual excessive strain on their faculties and the responsibility of so many lives passing through their hands are such that the protection of the underground workmen's lives and the valuable property entrusted to their charge cannot be adequately performed for the excessive period of twelve hours per day, as at present existing in many parts of this country. (2) Believing also that the wages at present paid to all enginemen are not at all adequate to their responsibilities, an application be made for a general advance for all classes of enginemen. (3) That the applications carrying out the foregoing resolutions on hours and wages be made on or before the 29th June, 1889. (4) That members of Parliament be paid by the State, but should any candidate fail to poll a fair percentage of the votes of the electors of any constituency, a substantial fine be imposed on the losing candidate.

The bill for providing for the examination of people in charge of steam engines and boilers on land—a draft copy of which was submitted to the meeting—was approved, and it was resolved that every assistance should be rendered by the federation for its adoption. This gathering appears to have partaken of the character of a trades' union and political meeting combined. It is difficult, however, to see how a body of workers in the position of colliery enginemen, or indeed any kind of enginemen, would be able to enforce their claims as a powerful trades union would by striking, since there are only one or two men at each pit, or mill, or manufactory, and under present conditions almost any kind of labourer could be put in to fill the places of the men on strike. Hence it is not surprising that an attempt should be made to obtain recognition as a skilled body, by the issue of certificates to those already in the trade, and to limit in this way the number of those who would be available to fill up the vacant places in the event of a strike being determined upon.

The connection between the wages and hours of labour of enginemen and the payment of members of Parliament by the State appears to be much more remote, and, if we may venture upon a suggestion, it would be that the colliery enginemen devote at least some portion of their surplus energies to the attainment of a better knowledge of the machinery they control, in somewhat the same way as we have above indicated as now being done by their fellow-workers in so many of the large manufacturing towns of Lancashire and Yorkshire. In this way—that is, by improving themselves as a body—they will certainly not lessen their chances of promotion, if, indeed, they do not provide a much more likely means of advancement and of attaining the objects they have in view than by working simply as a trades union, and acting as though their labour and the capital of those employing them were antagonistic.

We have received a large number of intelligent inquiries from enginemen who evidently possess a considerable amount of practical engineering information, and as *The Practical Engineer* is largely subscribed to by all classes interested in steam engines and boilers, a considerable portion of our space will always be devoted, as it hitherto been, to the discussion of questions and the dissemination of practical information pertaining to steam engineering.

THE BARRY DOCK.—We learn that the Barry Dock—the latest addition to the dock accommodation of South Wales—is likely to be opened about the middle of next month. It is quite probable that it will affect the trade of Cardiff Docks to some extent, and it will in a degree increase the competition between the South Wales and north-eastern districts.

ALLEN'S STEAM STRIKER.

THIS ingenious little power hammer is intended by the inventor, Mr. S. W. Allen, of Exchange Buildings, Cardiff, to perform work intermediate between the steam hammer and the handwork of the blacksmith, and in bolt and nut making, rivet making, and swaging to displace the convenient but laborious Oliver. It gives all the convenience of the Oliver, with the advantages of the steam hammer as well, and it is not expected to supersede either handwork or the ordinary steam hammer, but to find an intermediate field of usefulness for itself. It is shown in our illustrations (figs. 1 and 2) in external appearance as at work and in section through the principal parts. It consists of a segmental steam cylinder, with a radial piston connected by a piston spindle or shaft to a lever carrying the hammer, and striking the anvil very much as is done in handwork. The hammer in this way passes clear away from the work, and leaves perfectly free space round the anvil and forging, which is a very great advantage with many kinds of work. The steam cylinder B (fig. 2) is bolted by a flange direct to the anvil block, as shown in the external view, fig. 1, and in it works a radial piston A, packed by brass slips pressed out against the cylinder face and sides by spiral springs, and formed in one piece with a rocking shaft piston rod, which passes through stuffing glands at both sides, and carries the hammer lever firmly keyed to it. The admission steam valve G is opened by a foot lever and closed by a spiral spring, and the steam is distributed by the piston valve C, actuated from a lever H, moved by a rocking shaft, and contained in the steam space I. The steam enters the interior of the piston valve, and passes to the ports D or E, according to its position. The piston valve rocking shaft is moved by a slot, or cam plate, attached to the hammer lever, and the stroke of the hammer may be adjusted by varying the length of the slot. At 40lb. per sq. in., 500 blows per minute are easily given, and the stroke may be varied from 3in. to 2ft. 6in.

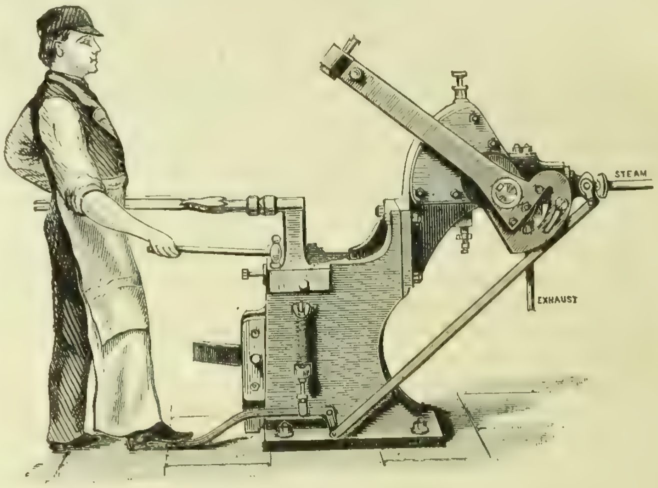

FIG. 1.

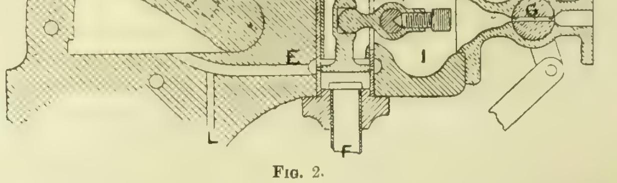

FIG. 2.

The valves are so adjusted that when the foot is raised from the foot lever, or treadle, a little steam is admitted, and finds its way underneath the piston, and lifts the hammer to the top of the stroke. This keeps it off the work and anvil till wanted. The exhaust pipe is shown at F, and it communicates by a cored port with the upper part of the cylinder, in which works the piston valve G, so that it takes the exhaust from both sides of the piston; the hole L serves to communicate with a blow-off tap to drain off water.

In our opinion Allen's steam striker will prove exceedingly useful in smiths' shops, and do much work more easily than could be accomplished with the ordinary steam hammer. We are informed that it is now quite a favourite in many engineering establishments, both here and abroad, for light work, such as we have indicated.

PORTABLE SPEED COUNTER.

Messrs. Schäffer and Budenberg, of Manchester and Glasgow, have recently introduced a most convenient form of counter for determining at a glance the velocity at which any shaft or spindle is rotating. In the ordinary forms of counter it is necessary to press the spindle on the end of the revolving shaft and determine by the watch the number of revolutions made in a given time. In this arrangement the principle of the well-known Tachometer is adopted, and the instrument at once indicates on a dial the required speed without the necessity for timing. Like the tachometer, the rotating spindle carries a small governor, the balls of which fly out and compress a spring, the pointer indicates the position of the governor balls, and so gives the speed. It is only necessary to press the spindle into a centre of the shaft whose speed is to be measured, as shown in fig. 1, and the hand at once moves on a dial to indicate the desired speed. The whole arrangement is exceedingly neat and handy, and is closed neatly in a case, as shown in fig. 2, when out of use. Variations of speed are at once indicated by the oscillation of the pointer, and the range of variation is readily determined. We have used the large tachometer ourselves for engine testing for many years past, and find it a most reliable and convenient instrument, as it determines not only the speed of the engine, but, within certain limits, the variation, even within one revolution. It is not by any means an easy matter to arrange an instrument for such small bulk as in the small tachometer we illustrate, and Messrs. Schäffer and Budenberg are to be congratulated on the ingenious way in which they have succeeded.

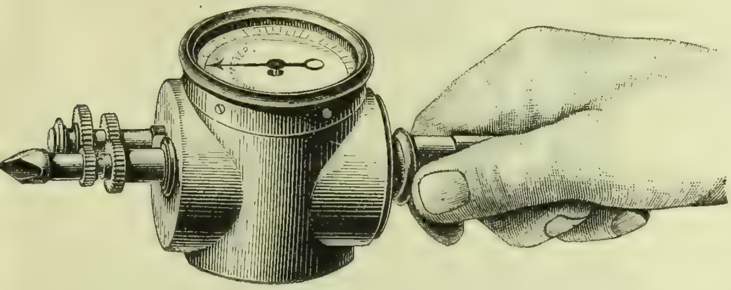

Fig. 1.

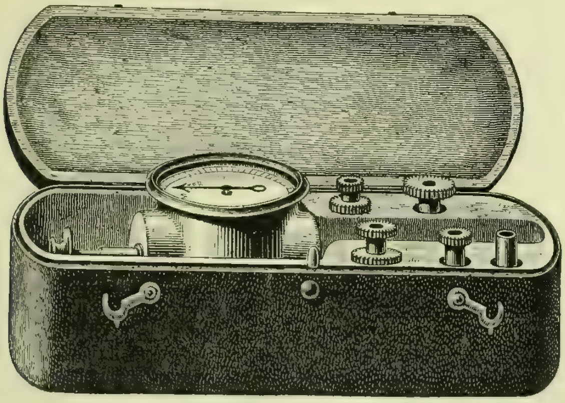

Fig. 2.

It has been found that when iron is plated with nickel by welding, as in Fleitman's process, the nickel undergoes a chemical combination with the iron, taking up as much as two per cent of the iron.

STEAM BOILERS BILL: COMPULSORY INSPECTION.

A bill is now before the House of Commons to secure the above-named purpose. The principle of the bill consists in providing for the compulsory periodical inspection, at the cost of and on the responsibility of the boiler user, of all boilers to which the act applies; and also for registration in a Government department of all such boilers at a small fee deemed sufficient to cover the expenses of administering the act. Any boiler user working a boiler for which he cannot produce a certificate from a duly qualified engineer, as defined in the act, is subject to certain penalties, but the boiler user is at liberty to select any engineer he chooses to furnish the certificate. It is not intended that the State should either provide certifying engineers or in any way assume responsibility by supervising their selection. The act repeals the Boiler Explosions Act, 1882, but re-enacts the same modified as follows, principally: (*a*) In the Explosions Act, 1882, the costs of a formal investigation can be charged without limit to any person summoned before the court, but the costs of a preliminary inquiry cannot be charged at all to any such person. In the present bill the costs of either a preliminary inquiry or formal investigation can be charged up to £500 to any certifying engineer who may be proved in fault, and in addition, he may be made to pay a sum of £150 to the boiler owner or user where he, or any company he represents, is not liable for that or a greater sum under a policy of insurance on the exploded boiler. (*b*) The amount for which a boiler owner or user may be made liable for the costs of an inquiry, or formal investigation, is also limited to £500, but under certain circumstances he becomes liable up to that amount where such costs cannot be recovered from any faulty certifying engineer he may have employed. (*c*) The investigation of explosions of land boilers is to be dealt with by the Home Secretary's department, as the inspectors of mines, and also of factories, who are to assist in carrying out the provisions of the act, are attached to the Home Office. (*d*) Both preliminary inquiries and formal investigations must be conducted in open court. No insurance company is allowed to grant a policy of insurance or a certificate for any boiler without proper inspection, and a policy becomes void on the expiration or cancellation of the certificate granted by such company.

THE ZALINSKI GUN.

High explosives continue to justify their position as the spoilt children of artillery science. Steady going old-fashioned artillerists shake their heads over them, but the sanguine predict great things of their future, and the War Office has, we understand, given encouragement to one of the latest of these infant prodigies by ordering for trial at Shoeburyness one of the largest of Captain Zalinski's pneumatic dynamite guns, which is to be ready for delivery in the autumn. This weapon, although it bears the name of a dynamite gun, might more correctly be described as an air-thrown torpedo. It does not in any way compete with high-power powder guns, but professes to do afloat or ashore the work which has hitherto been done by the torpedo and the mine. It claims for itself that it surpasses the torpedo in range, power, and accuracy; that as a means of harbour defence it has an entirely new and wide field of usefulness, and that vessels armed with it would be greatly superior to the highest-class torpedo boat, supposing, of course, that manœuvring power and speed were the same. The inventor, Captain Zalinski, is an officer of the United States artillery. His guns have been mounted at Fort Lafayette, in New York, and the American Government, as far back as the spring of 1886, were satisfied by the experiments carried out on land that the weapon was worth trying afloat.

A gunboat, the Vesuvius, was laid down in 1887, and she is now ready. Her pneumatic armament consists of three 15in. guns, which can throw projectiles carrying 500lb. of dynamite or other high explosive accurately to a range of 2,000 yards. Each gun has with it eleven projectiles. The Vesuvius will therefore be armed with 33 projectiles of 500lb. of dynamite each—that is, 16,300lb. of dynamite, with a scattering range of 2,000 yards; while the best-known torpedo only claims to throw 180lb. of gun cotton for about 400 yards, and the highest type of torpedo cruiser carries 20 such torpedoes, or a total 3,600lb., with a scattering range of 400 yards. The vessel which carries this formidable charge is 246ft. in length, and has a displacement of 811 tons. She carries 135 tons of coal, and has steamed at the rate of 21·65 knots over a distance of 2·54 knots. With 25 tons of extra coal carried on deck, she can steam for 6,000 miles at 10 knots an hour. She has twin screws, which enable her to be very readily manœuvred, and this is necessary, for the guns have no power of training in themselves, and can only be aimed by laying the vessel herself in the line of fire. They are fixed at an elevation of 18 deg., the lowest at which their projectiles will not ricochet, and are about 2·5ft. apart, parallel to the keel of the boat, and firing forward. They are cast-iron tubes 1·5in. thick, made in lengths of 12ft. A little more than 12ft. of the tube projects above the deck; the remainder runs down to the loading-room. The breech and about 12ft. of the breech end of the tube revolve about the base of the breech, and can be raised or lowered by a hydraulic ram. When in a horizontal position the chamber of the gun lies directly behind one of the cylinders of a five-chambered revolver, each cylinder of which contains a shell. Another revolver is directly in front, containing five more shells. With one shell in the gun, this makes eleven rounds per gun, and the revolvers serve the purpose of a magazine well below the water-line. After firing, the chamber is lowered, a shell is pressed into it from the revolver cylinder by a rammer, the rammer is withdrawn, the breech raised, and the revolver rotated until the next cylinder is in position—all by hydraulic power. Each working lever interlocks, and the rammer can only exert an absolutely safe pressure on the shell. At present the appliance for raising and lowering the breech comes from above, which is an evident defect, as it is exposed to damage from the enemy's guns, and there is no hand gear to take its place.

There are two main reservoirs, which are charged by powerful engines with air at 2,000lb. pressure. The firing reservoir, which has a capacity of five times the bore of the gun, receives air from them at a reduced pressure of 1,000lb., which is the limit at which pressure is exerted upon the projectile. The force is kept constant and the range is regulated by means of cut-off valves, which expose the shell to pressure for a shorter or a longer time. One of the greatest and newest advantages claimed for the gun is that it can throw what are called sub-calibre shells carrying smaller charges to ranges which increase in proportion as the weight of the shell decreases. The table of weights and ranges is as follows:—

Weight of projectile. lb.	Weight of charge. lb.	Calibre. Inches.	Length. Feet.	Range. Yards.
1,000	500	15	12	2,000
500	200	10	7	3,500
280	100	8	7	4,500
180	50	6	7	5,500

It may be seen from this that a charge of 200lb., which is still 20lb. more than the highest torpedo charge, can be thrown 4,500 yards, as compared with 400 yards, which is the range of the torpedo. The three guns of the Vesuvius, with all their machinery, weigh at present 100 tons. It is under consideration whether the whole of the hydraulic machinery might not be done away with, by using the revolvers in the same way as the chambers of an ordinary revolver. The employment of steel might also reduce the weight of the gun. The charge used in the shells is explosive gelatine, set in action by fulminate of mercury, exploded by electrical fuses, which have been designed with great care by Captain Zalinski himself. Each shell carries three. A wet battery screwed into the base causes explosion in striking any hard substance, when the metallic head, being crushed in, closes the circuit. A dry battery in the head, and another in the base, make sure of explosion in the water. An adjustable time train in the dry battery in the base provides for occasions when the shell is intended to be exploded at a considerable depth.

The guns for shore service differ, of course, in some details from those used at sea. The principal distinction is that they are mounted on traversing cones of sufficient weight to withstand the shock of discharge, and that they can be elevated by a hydraulic ram. The advantages that the pneumatic gun claims for itself are therefore, briefly, that it can throw what is practically a torpedo of nearly three times the weight of the largest torpedo which has yet been used through the air or through the water for five times the distance that any torpedo has ever reached; that it can shoot it with accuracy, while torpedoes hitherto have been most uncertain in their aim; that it can throw smaller projectiles from the same weapon for longer distances; and, further, that the projectiles can be freshly loaded and the fuses tested when they are required for use, thereby avoiding the damage and deterioration to which torpedoes are specially liable. It is evident, on the other hand, that considerable difficulties must attend the firing of a weapon at sea which demands that the ship on which it is carried shall itself be laid and aimed. The loading machinery, moreover, leaves still something to be desired, and many practical details demand revision. All that can be justly said of it in its present stage of development is that if it fulfils even half of the conditions that are promised for it, it is an arm that we cannot afford to neglect when we are on the eve of spending 21 millions upon the navy.

THE VICTOR TURBINE WATER-WHEEL.

Turbines, when correctly designed and constructed, are by far the most efficient motors for the utilisation of water power, and lately this fact is becoming generally recognised, and their use is being largely extended.

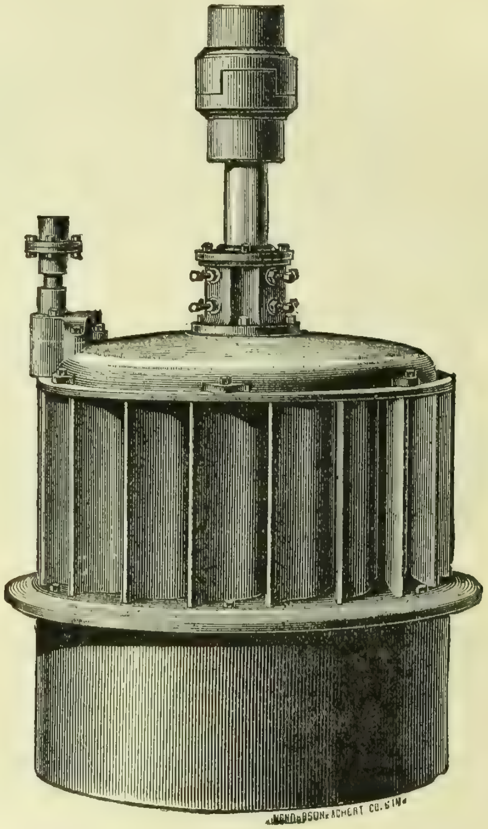

Fig. 1.

We here give illustrations of two types of the Victor turbine, made by Mr. Frederic Nell, London, from which excellent results are obtained. Fig. 1 represents the ordinary Victor turbine, in which the form of the wheel is quite different from that of any other in the market. Its principal peculiarity depends upon the fact that it receives the water upon the outside and discharges it downward and outwards, so that the lines of discharge occupy the entire diameter of the lower portion of the wheel, excepting only the space filled by the lower end of the shaft. This form of

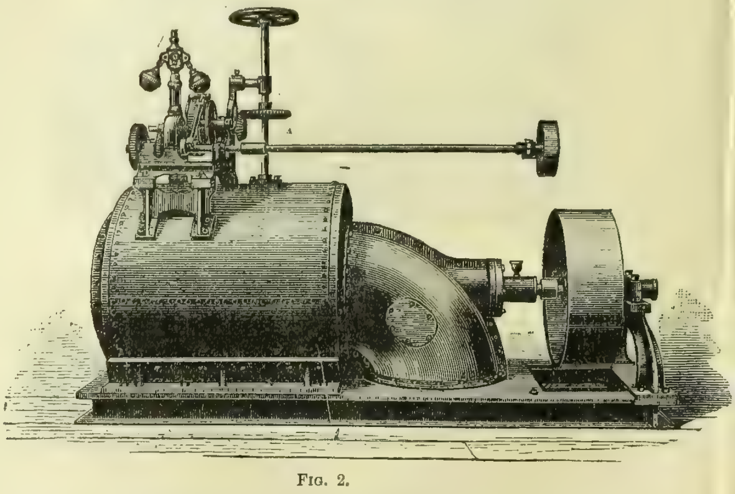

Fig. 2.

construction secures the maximum capacity of a given diameter of wheel, and allows also of great strength and durability.

Fig. 2 represents a single Victor turbine on a horizontal shaft, with flume, driving pulley, and outer bearing, all placed upon a cast-iron bed plate, ready to attach the supply pipe and draft tube. A governor for regulating the speed of the wheel is shown on the top of the flume. The engraving was made from a 15in. turbine furnished for driving a woollen factory, with a special attachment for driving the fire pump, by means of friction gear, directly from the turbine shaft.

A series of official tests have been made upon these wheels at the Holyoke Testing Flume to determine the power and efficiency, from the published results of which we observe that with a head of 18·06ft., and making 368 revolutions per minute, a 15in. wheel developed 30·17 horse power, or an efficiency for the water used of 89·32 per cent. This is an excellent result, even for so efficient a machine as a turbine, and we are informed that even at lower powers, with partial gate, proportionally good results were obtained.

From the nature of the detail construction of the Victor turbine, and the large number in use, we have no doubt whatever of its great durability as well as efficiency. Further information can be obtained from Mr. Frederic Nell, Mark Lane, London, E.C.

THE INSTITUTION OF CIVIL ENGINEERS.

The council have awarded the following premiums in respect of the original communications submitted during the session 1888-89 :—

For Papers Read and Discussed at the Ordinary Meetings.

1. A Telford Medal and a Telford Premium to Gisbert Kapp,[1] Assoc. M.Inst.C.E., for his paper on "Alternate Current Machinery."
2. A Watt Medal and a Telford Premium to William Henry Greenwood, M.Inst.C.E., for his paper on "The Treatment of Steel by Hydraulic Pressure, and the Plant employed for the purpose."
3. A George Stephenson Medal and a Telford Premium to Edgar Worthington, B.Sc., Assoc.M.Inst.C.E., for his paper on "The Compound Principle applied to Locomotives."
4. A Watt Medal and a Telford Premium to Charles Edward Emery, Ph.D., M.Inst.C.E., for his paper on "The District Distribution of Steam in the United States."
5. A Telford Premium to John Audley Frederick Aspinall, M.Inst.C.E., for his paper on "The Friction of Locomotive Slide Valves."
6. A Telford Premium to John Oliver Arnold, F.C.S., for his paper on "The Influence of Chemical Composition on the Strength of Bessemer Steel Tires."

For Papers Printed in the Proceedings without being Discussed.

1. A Watt Medal and a Telford Premium to Robert Runeberg, Assoc.M.Inst.C.E., for his description of "Steamers for Winter Navigation and Ice-breaking."
2. A Telford Premium to Bryan Donkin, jun., M.Inst.C.E., for his account of "Experiments with Gas-flame Jackets."
3. A Telford Premium to Professor Victor Auguste Ernest Dwelshauveres Dery,[2] for his "Reduction of Experiments on the Effect of Super-heating, Steam-jacketing, and Gas-flame Jackets on Cylinder Condensation."
4. A Telford Premium to Robert Henry Smith, Assoc.M.Inst.C.E., for his paper on "Stress Diagrams of Solid Structures."
5. A Telford Premium to Leveson Francis Vernon-Harcourt,[3] M.A., M.Inst.C.E., for his paper on "Alpine Engineering."
6. A Telford Premium to George Lopes, B.A., Assoc.M.Inst.C.E., for his account of "The Reparation of Betchworth Tunnel, Dorking, on the London, Brighton, and South Coast Railway."
7. A Telford Premium to Neil Kennedy, M.Inst.C.E., for his paper on "The Tachometer and its Uses."

For Papers Read at the Supplemental Meeting of Students.

1. A Miller Scholarship to Edward Carstenson de Segundo,[4] Stud. Inst.C.E., for his account of "Experiments on the Strain in the Outer Layers of Cast-iron and Steel Beams."
2. A Miller Prize to Henry Byrom Ransom, Stud.Inst.C.E., for his Paper on "The Cyclical Velocity Variations of Steam and other Engines."
3. A Miller Prize to William Wade Fitzherbert Pullen, Wh.Sc., Stud. Inst.C.E., for his account of "Water-Softening and Filtering Apparatus, for Locomotive Purposes, at the Taff Vale Railway Company's Penarth Dock Station, near Cardiff."
4. A Miller Prize to James Dennis Twinberrow, Stud.Inst.C.E., for his Paper on "Flexible Wheel-bases for Railway Rolling Stock."
5. A Miller Prize to Samuel Joyce, jun., Stud.Inst.C.E. for his Paper on "Electrical Measuring Instruments; their Properties and Calibration."
6. A Miller Prize to Richard John Durley, B.Sc., Stud.Inst.C.E., for his Paper on "Moulding and Casting Cylinders for Marine Engines."
7. A Miller Prize to Julian James King-Salter, Stud.Inst.C.E., for his description of "The 26-knot Spanish Torpedo Boat Ariéte."
8. Miller Prizes to Charles Henry Gole Stud.Inst.C.E., and Vernon Warburton Delves-Broughton, Stud.Inst.C.E., for their joint paper on "Photography for Engineers."

It has been determined to print the first four students' papers, either in whole or in part, in the Minutes of Proceedings.

IMPROVED TREBLE-GEARED SLIDING AND SURFACING BREAK LATHE.

We illustrate on page 412 an improved treble-geared sliding and surfacing break lathe, designed and constructed by Messrs. James Spencer and Co., engineers, Chamber Ironworks, Hollinwood, near Manchester, in which exceptional strength and rigidity has been allowed for the size of work taken in. It has been designed specially for sliding, surfacing, and boring heavy articles of large diameter, to meet the necessities of those producing the heaviest class of engineering work. It consists of a heavy foundation plate, with planed T bolt grooves running the full length. This carries a strong fast headstock; a short length of bed fitted with a carriage and compound slide rest and loose headstock; also a pair of standards or pillar rests, fitted with extra strong compound slides. The fast headstock has a steel spindle with parallel necks of extra large diameter and width, working in bearings of special gun metal. The spindle has a plate or flange of large diameter, forged solid on the end, to which the faceplate is bolted. All the driving shafts and screws throughout are of steel. The gearing throughout is very strong, and with ample power for turning large diameters, and is arranged so that it can be worked in either single, double, or treble gear,—the treble gear being through an internal spur wheel of large diameter, which is cast on the back of the faceplate, as seen in the illustration. The loose bed is made with three faces on the top, the extreme width across the vees being 3ft. 9in., so that the carriage is very firm and well supported when operating on work of the full diameter that will clear the top of the carriage. The loose headstock rests on the two back faces of the bed. The pillar rests are each mounted on a footplate, and are adjustable in planed T bolt grooves, either parallel or at right angles to the faceplate. The compound slide rests have a full swivel for sliding, surfacing, or turning conical, and any of the slides can be worked by a variable self-acting feed motion by a ratchet which puts on two feeds for each revolution of the spindle. The carriage can be traversed along the bed by the self-acting ratchet motion or by hand, by a neat arrangement of worm and wheel, combined with a pinion gearing into a rack which has the teeth placed vertically. The same arrangement is applied for moving the loose headstock along the bed, and is found to answer the purpose admirably.

With each lathe are included two ratchets to fit the slide rests, or the loose headstock screw for self-acting boring; also, an overhead driving apparatus, with two sets of fast and loose pulleys, and a set of case-hardened wrought-iron spanners.

The principal dimensions are :—

Height of centres.	Length of Foundation Plate.	Length of Loose Bed.	Admits between centres when break is open.	Break will admit		Dia. of Faceplate.
				In dia.	In width.	
Inches.	ft. in.	ft. in.	ft. in.	ft.	ft. in.	ft. in.
24	21 6	7 0	10 4	10	8 0	7 6

This lathe can be specially adapted for boring and turning flywheels; with pillar rest on front for turning periphery to any desired curvature, and a second pillar at the back fitted with a double slide rest for turning both edges of the rim at the same time. The faceplate is fitted with adjustable jaws for chucking the wheels internally or by the arms. A short bed movable on the foundation plate carries a self-acting boring headstock for boring the wheel whilst the turning of the rim is progressing, and this headstock is also provided with a self-acting facing slide driven at an accelerated speed, so that the boring and facing can be completed within the time occupied in turning the rim.

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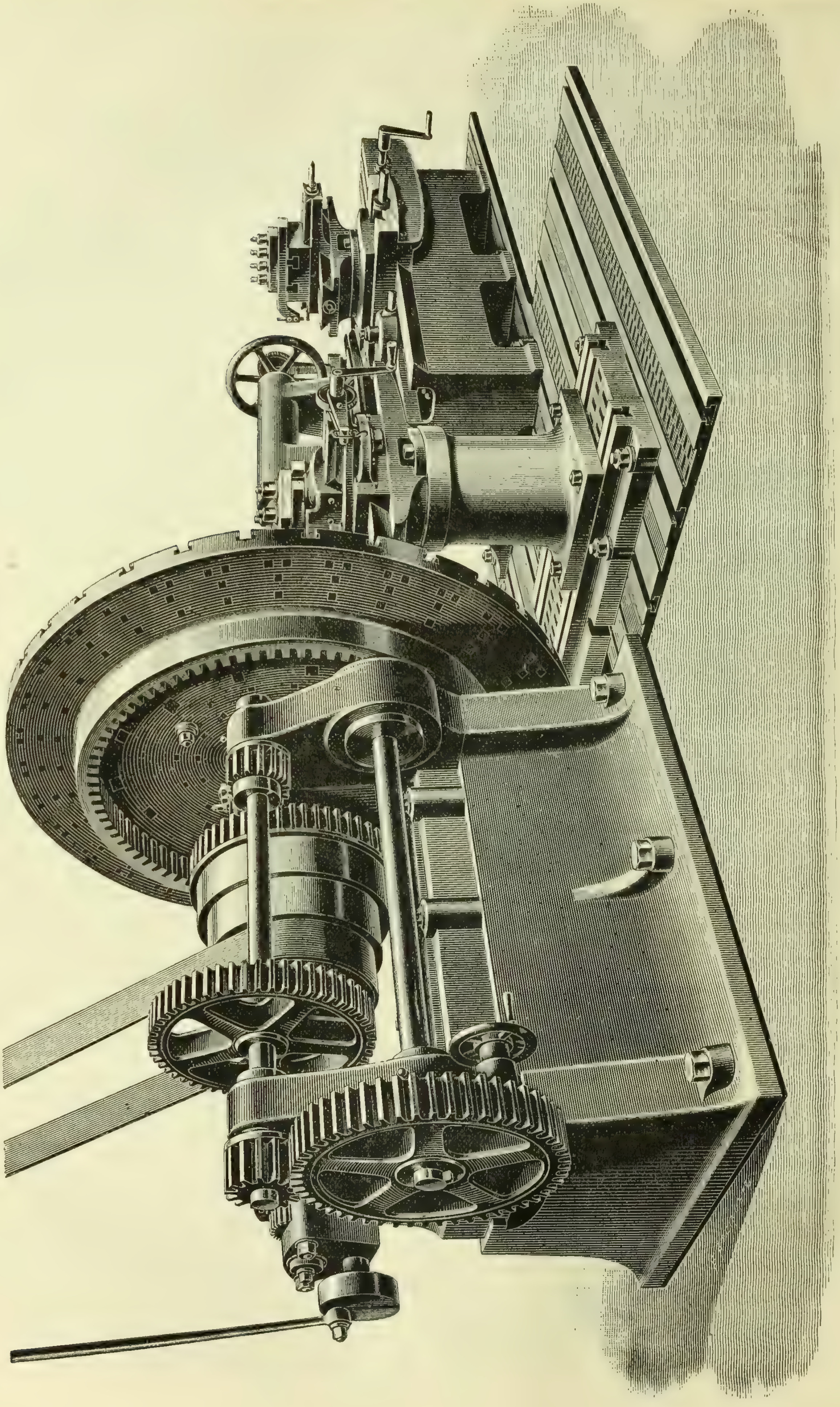
[1] Has previously received a Telford Medal and a Telford Premium.
[2] Has previously received a Watt Medal and a Telford Premium.
[3] Has previously received a Telford Medal and Telford and Manby Premiums.
[4] Has previously received a Miller Prize.



IMPROVED TREBLE-GEARED SLIDING AND SURFACING BREAK LATHE.

CONSTRUCTED BY MESSRS. JAS. SPENCER AND CO., ENGINEERS, CHAMBER IRONWORKS, HOLLINWOOD, MANCHESTER.

(*For description see page 411.*)

ELECTRIC WELDING.

(Continued from page 381.)

We have in previous issues described processes in which the weld is effected by means of the local heat set up by the passage of a large current through a broken circuit, the joint of which is simply pressed together.

We now pass on to a widely different method of obtaining a weld by means of the electric current, that in which a voltaic arc is set up at the point of union. The system was first explained to the world in 1885 by the inventors, Nicholas de Benardos and Stanislas Olzeuski, both of St. Petersburg. Since that time the process has attracted considerable attention on the Continent, and possesses several novel features from the processes of fusing and reducing by means of the electric current or the electric arc proposed by Siemens, Cowles, Thomson, and others. Professor Ruhlmann, of Chemnitz, has made a careful study of the processes at St. Petersburg, and has published several interesting articles in the *Zeitschrift des Vereins Deutscher Ingenieure* and the *Electrotechnishe Zeitschrift*, and in papers read before the Electrotechnical Society of Berlin. The process is used for the union of metals, their disunion or separation, the formation of apertures in metals, and the union of metals in layers.

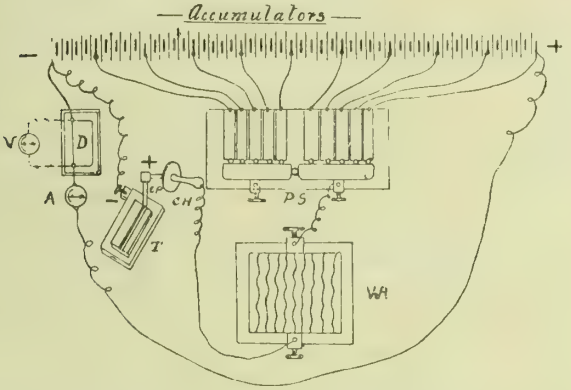


FIG. 8.

A voltaic arc is formed by the approach of a carbon pencil to the part of the metal to be operated upon. The carbon forms one pole and the metal to be operated upon forms the other pole. Generally the carbon forms the positive pole. The carbon used is of various forms. The most practical for operation on a small scale is either a solid or hollow pencil or rod. In some cases the hollow carbon is filled with various metals or their alloys, which play the part of solder. The carbon holder is carefully insulated to protect the operator. In previous attempts to use the arc as a welding agent the carbon was made the negative pole, as it was feared that otherwise the consumption would be too rapid. Hence the metal was used as the positive pole—*i.e.*, it became exposed to energetic oxidation—and a great number of the failures experienced by other experimenters arose from this circumstance. The carbon pencil used as a positive pole is quickly consumed, but can easily be replaced. This method secures a favourable reducing, instead of an unfavourable oxidising, action in the fused metal. When the poles are reversed the work becomes enveloped in a dense cloud of oxidised products. The action of the arc is purely local, similar to that of the blowpipe. The fused mass solidifies and cools very quickly. The most refractory metals are melted almost instantaneously by the intense heat of the arc. Little or no preparation is required. A thick layer of oxide will be reduced and drop off; while small quantities of oxide unite to form a slag with the sandy clay, sometimes used as a flux. The slag prevents the oxidation of the metal whilst cooling. No other fluxes are required. The operation can be carried on under water, but the gases generated cause trouble. An apparatus has been constructed to facilitate such work, wherein the water is forced away from the parts under treatment by means of compressed air. The sketch, fig. 8, gives diagrammatically the ordinary connections. The shunt, dynamo D, charges the fifty accumulator cells in series. A voltmeter and an amperemeter are inserted at V and A. From the positive terminal of every fifth cell a wire leads to a plug switchboard PS. From this the current passes through a variable resistance VR, and from thence through a flexible cable to the carbon holder CH and the carbon pencil CP. The operator manipulates his holder CH, the metal to be fused, placed upon the table T, being joined directly to the negative terminal of the battery. By inserting the plug in the switchboard PS, the operator may obtain currents from five cells, twice five, four times five, and so on up to the 50 cells. If large masses of metal are to be dealt with, currents of great strength are needed. Those are obtained by grouping the batteries of certain cells in parallel. Suppose the dynamo gives currents of 175 volts and 120 amperes, that there is a battery of 70 cells in series, and that it is desired to solder two boiler plates of 10 millimetres thick ($\frac{2}{5}$in.), the carbon holder is connected with the positive terminal of the fortieth cells of three groups. The carbon pencil is allowed to touch for a fraction of a second, and is immediately taken out of contact, leaving between the plate and the pencil an arc of a few millimetres in length. The metal melts very rapidly; but here the action is too powerful, and the molten metal evaporates distinctly. In such a case one of the three parallel groups is cut out. Should the action then be too slow, one or more of the parallel groups is added. Sometimes the arc proves too small, or extinguishes frequently. In such cases the number of cells in each group has to be increased. The carbon holder often consists of two copper bars, having a round hole near the end, in which the pencil is firmly fixed by means of a screw or wedge. The flexible cable passes through the wooden handle. When working, the holder becomes hot, and may have to be cooled by plunging into cold water. The operator wears strong gloves of leather, his hands being further protected by a metal screen fixed on the holder. For a protection for the eyes and face a dark glass is used. The lungs, also, may need protection from the vapours of copper, lead, and other metals and alloys. The most efficient way would perhaps be that of carrying them off by a blast of air. A quick replacement of the carbon in the holder can be effected. The diameters of the carbons vary very much for different kinds of work. For small or fine work, where a few cells would suffice, fine pencils of only 1·5 millimetres ($\frac{1}{16}$in.) are required. Such articles as boiler plates are welded together by means of thick carbon rods of upwards of 2¼in. in diameter. The carbon in all cases is pointed on the working end before using. The ordinary kind of light carbons do not answer well, as they are generally too soft. Mr. Benardos prefers "Carre" carbons.

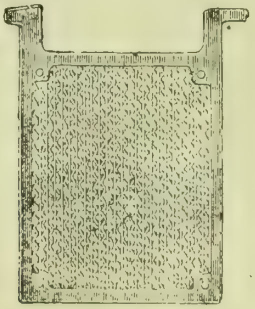


FIG. 9.

FIG. 10.

FIG. 11

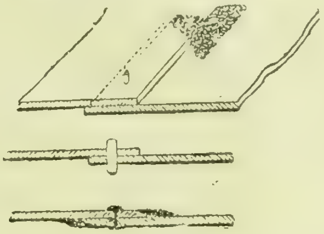


FIG. 12.

FIG. 13.

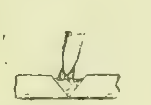


FIG. 14.

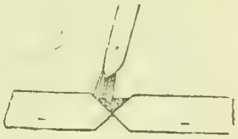


FIG. 15.

It is evident that an electric welding plant, to be capable of doing fine work (such as wires, &c.), also heavy work (such as flywheels), must have powers of regulation between very wide limits.

particular case. The volts and amperes must be under easy control. The tension or electromotive force and the quantity or amperes must be varied within very wide limits. A dynamo alone could not be made to do this. There must be accumulator or secondary cells also, and these of a special kind, capable of being charged with strong currents, and discharged either at a few amperes or at several hundred times that amount. Faure and Plante's accumulators are not adapted to such work, for they cannot store up a sufficient quantity of electricity, although they bear strong charging currents. Mr. von Benardos has, therefore, constructed storage cells for the work, which have answered the purpose very well. They are very similar to the ordinary type. Professor Ruhlmann saw at St. Petersburg some cells in very fair condition which had been in use for more than a year and a half. Serious difficulties were met with at the Criel works (where the process has been in use for some time) until the accumulators already there were exchanged for the Benardos battery. The cell complete weighs 15·9 kilogrammes (about 35lb.), and contains nine lead plates, all of the same kind, four of them positive and nine of them negative. Each plate consists of a frame cast of pure lead (fig. 9), 16 by 20 centimetres (6in. by 7¾in.) surface, and 0·5 centimetres (0·2in.) thick. The interior of the frame is filled with strips of thin lead (figs. 10 and 11), alternately straight and corrugated, soldered into their places. The corrugated strips are so arranged that the upward currents in the liquid are facilitated. Such currents arise during charging owing to the development of gas, which, if kept within proper limits, is thought advantageous to these cells.

The curvature of the strips assists the liberation of the gas bubbles, and checks the formation of larger bubbles, which would cause buckling. Caoutchouc prisms separate the positive and negative plates, which are soldered to the stronger lead strips running along either side of the cell. Diluted sulphuric acid, of 1·25 specific gravity, is used, and has full circulation between the plates. The total weight of the complete cell (35lb.) is made up of 10·5 kilogrammes for the nine plates, 3·5 kilogrammes for the acid, and 1·8 kilogrammes for the glass jars. The cells have an interior resistance of ·002 ohm., and give 2·5 volts when continually charged whilst at work; 50 to 70 of these cells are joined in a battery; several batteries are grouped in parallel, and are continually charged by a shunt dynamo.

The intense heat of the arc forms alloys which are hardly known under other circumstances; so that iron and copper, tin, zinc, lead, steel, cast iron and wrought iron, steel, aluminium, and platinum can be united. Professor Ruhlmann has exhibited specimens of iron plate welded to copper, iron plated with tin, and iron plated with lead. In such cases there is most likely a layer of alloy at the junction of the two metals. Chemical manufacturers desire cheap copper retorts, coated inside with platinum, and iron vessels coated with lead. Professor Ruhlmann saw at St. Petersburg a number of copper tubes soldered with cast-iron plate, and this plate coated with copper several millimetres in thickness. Another application is the piercing of holes (fig. 12). To pierce a hole 1in. in diameter through plates of ½in. thickness takes about four minutes. Plates have been riveted together in this way, as shown in fig. 12, where the plates were ½in. thick and the rivet ¾in. in diameter. The operation took eight minutes. It seems, however, more advisable to punch or drill the holes.

It has been said already that the metal undergoes but little chemical change under this treatment. The question seems very important for iron whose behaviour is so remarkably influenced by small variations in the composition. To test this, wrought-iron droppings from the welding process were fused again, by means of the arc, to a bar of about 15 millimetres thickness, and this bar turned down to 10 millimetres. The breaking weight of this bar was 37·5 kilogrammes per square millimetre (23·8 tons per square inch), with an elongation of 17·5 per cent. The fracture was fibrous, like that of soft steel. This electrically fixed iron resembles soft steel in other respects, notwithstanding its origin. It is malleable, can be welded, can be bent both hot and cold, and is scarcely harder than soft steel. Fig. 13 is a sketch of one bent specimen.

(To be continued.)

A New American Torpedo Boat.—The Herreshoff Company are building a torpedo boat for the United States Government, which is to be 138ft. long, 14ft. 6in. broad, with a depth of hold of 8ft. Its draught loaded will be 3ft. 7in., its displacement under the same conditions is to be 99 tons, and the speed fully equipped is to be twenty knots, though it is stated that the builders expect to get twenty-three. The boat is to be fitted with twin screws and with engines indicating 1,500 horse power. Each engine has five cylinders, having diameters of 11¼in., 16in., 22½in., 22½in., and 22½in. The price of the boat is to be 82,750 dollars.

ON OIL-CARRYING STEAMERS.

(Continued from page 395.)

Figures 4 to 11, in the calculations for which I have been assisted by some of my students, represent the stability of a vessel under a variety of circumstances. She is supposed to have arrived at New York with enough coal in the lower bunkers for the return journey to Europe. Her curve of righting arm in that condition is A (fig. 4). The filling of one compartment 24ft. long is then begun. When the oil has risen to a height equal to one-fourth of the depth of the tank the curve of righting arm, assuming the cargo not to shift, is shown by A (fig. 5). With the cargo free to shift, and with an oil-tight middle-line bulkhead, the curve falls to B (fig. 5), and with the middle-line bulkhead perforated it is further reduced in height to C (fig. 5). When the oil has risen half way up the tank the curves of righting arms under the above three conditions are A, B, and C (fig. 6). With the oil filling three-fourths of the tank the curves are A, B, and C (fig. 7); and with the tank full, so that shifting cannot take place, the three curves come together, forming B (fig. 4).

Figs. 8, 9, 10, and 11 give the curves of righting arm when two tanks are filled simultaneously, instead of one, as in the preceding example. A (fig. 8) is the curve of righting arm when the two compartments are one-fourth full, the cargo being supposed not to shift; B is the curve of righting arm on the assumption that the cargo shifts, and that the middle-line bulkhead is oil-tight; and C is the corresponding curve on the assumption that the middle line bulkhead is perforated. In the latter case it will be seen that the vessel does not stand upright, but inclines away through 19¼ deg. before attaining a position of equilibrium. With the compartments half full the corresponding curves are A, B, and C (fig. 9). Here, in the most critical condition, the inclination at which the vessel comes to rest is 18 deg. With the compartments three-fourths full the curves are A, B, and C (fig. 10); and with the compartments quite full they unite, forming A (fig. 11). It will be noticed in the above examples that when the two tanks are partially filled, the middle-line bulkhead being perforated, while the vessel inclines away from the upright through a considerable angle before coming to rest, the reserve of stability remaining is but small, and if it were attempted to fill three tanks simultaneously under the above circumstances the vessel would in all probability capsize.

The curve on fig. 12 shows the manner in which the inclination varies as the depth of the oil in the two compartments changes under the above circumstances; and it will be of interest to trace the vessel's behaviour during the filling of the tanks. Assuming her to be upright when the oil begins to pour into the tanks, she will continue upright until the oil attains a definite height. Owing to the low position which the incoming oil occupies, the common centre of gravity of hull and cargo falls, but *m* rises rapidly as the oil in the tanks rises because of the rapidity with which the free surface grows, and M usually falls. When *m* and M coincide, the vessel is in neutral equilibrium. This occurs when the oil has risen to a height of 15in. in the case under consideration. Immediately afterwards, as the oil continues to pour into the tanks, *m* rises above M, and the vessel inclines rapidly, reaching a maximum inclination of 19½ deg. From that point onward the vessel begins to right herself, but very slowly, until the oil surface rises to near the level of the deck edge. Thereafter the inclining effect of the transfer of the wedge of oil from one side to the other diminishes rapidly, and the vessel moves fast towards the upright until at last *m* passes below M again, when the oil is only a few inches below the crown of the tank, and she becomes upright.

In respect of the demands made upon her stability, the oil-carrying steamer differs greatly from the ordinary cargo vessel. With ordinary cargoes a vessel's stability is most tasked when she is rolling amongst the waves at sea. She there requires a sufficient range to provide a margin against the heave of the sea, the inclining effect of the wind pressure, and against that prolific cause of disaster, the shifting of cargo. Whilst loading or discharging in dock, or alongside a wharf, no great amount of initial stability is necessary, and if a list does take place through an unequal distribution of the cargo, it becomes at once so apparent that the necessary steps may be taken by regulating the stowage to restore her to the upright. An oil steamer is, however, in a somewhat different position at sea. So long as the tanks remain full shifting of the cargo is made impossible; but on the other hand, if from any cause a subsidence in the level of the oil takes place, shifting does occur with a celerity unparalleled with non-liquid cargoes. Wheat, for instance, does not shift when at rest until its surface has a slope of some 26 deg., and even when at

The arc must have a different volume and temperature in each sea, although shifting takes place at a somewhat smaller inclination, owing to causes whose effects are discussed and measured in the paper on the shifting of cargoes to which I have already referred, the inclination still remains considerable. With free oil or other liquid, however, the slightest inclination of the vessel causes a corresponding change of surface. The most obvious way of minimising the danger from this source, next to careful workmanship and sufficiently close riveting, is to divide the cargo hold so as to restrict the area affected in the event of leakage taking place. The latter end is most effectively attained by fitting a practically oil-tight middle-line bulkhead, which, as I have already shown, has a most important effect in conserving a vessel's stability. In that case, I may remark, however, that it is desirable to provide appliances for filling or discharging tanks lying opposite each other at the same time. If this be not done, serious inclination may result owing to the shifting of the common centre of gravity of hull and cargo away from the middle line, as already explained. Numerous transverse bulkheads, too, while they have no such effect as the middle-line bulkhead in respect of transverse stability, limit the area over which leakage can extend, and reduce the straining effect which longitudinal motion of the cargo would cause.

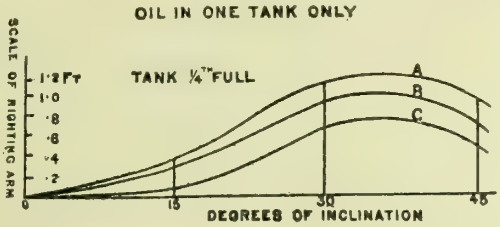


FIG. 8.

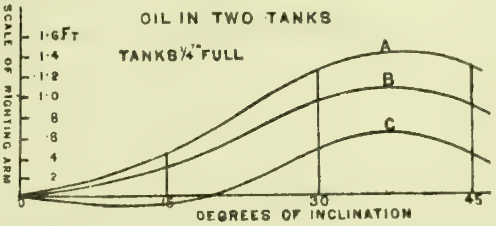


FIG. 5.

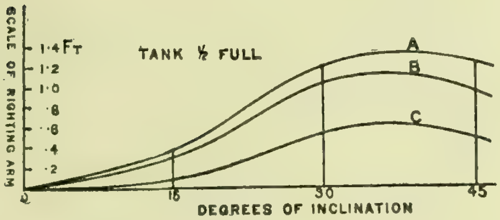


FIG. 9.

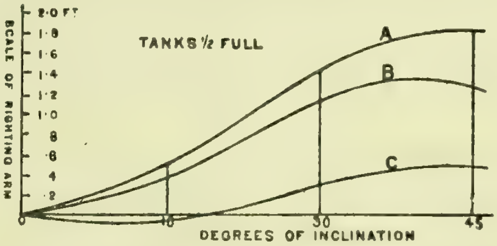


FIG. 6.

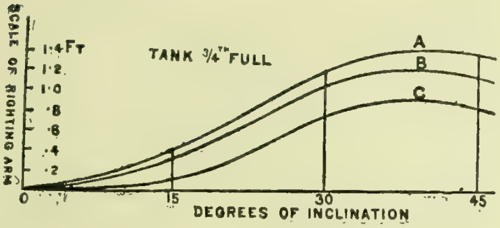


FIG. 10.

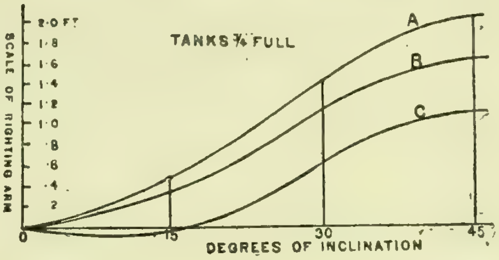


FIG. 7.

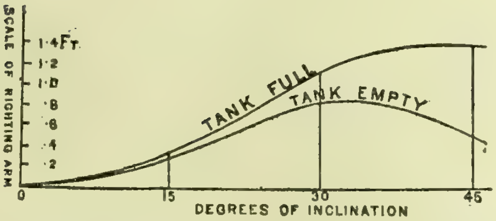


FIG. 11.

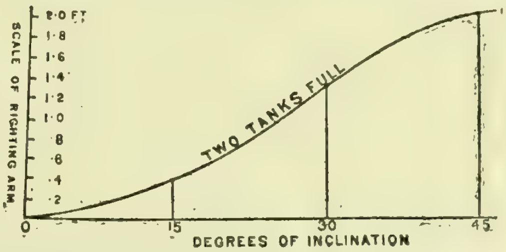


FIG. 4.

Table giving the EXPORT of PETROLEUM, and its Products, from the United States during each of the past 5 years.

YEAR.	EXPORT IN GALLONS.
1884, - - -	513,660,092
1885, - - -	574,628,180
1886, - - -	577,781,752
1887, - - -	592,803,267
1888, - - -	578,351,638

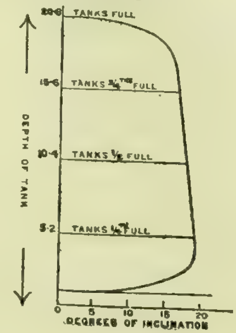


FIG. 12.

But while the oil steamer at sea is particularly safe as regards stability so long as the level of the oil in the tanks does not fall, and can indeed afford to prosecute her voyage with a smaller curve than most other classes of vessels, it is during the process of loading or unloading that usually the need for large initial stability and effective longitudinal subdivision is most felt. When the vessel is brought alongside the wharf and communication effected between the tanks and the reservoir on shore, the greater the number of tanks that can be filled simultaneously the sooner is the loading completed, and the earlier is she able to put to sea. Similarly as to the discharge of the cargo. As we have seen, the condition which limits the number of tanks that may be so treated is one of stability only, as alike during loading and discharging the tanks soon become partially filled, and if too great a number are being so treated the vessel will cease to remain upright, and may incline over to a considerable angle before attaining a position of equilibrium. It might be thought that one good way of increasing the number of tanks that may be filled simultaneously is to make the vessel very broad. Such a result would no doubt be attained in that way, since M rises in the vessel with increase of breadth more rapidly than m, but oil steamers have as a rule quite enough initial stability when laden, and any important increase of breadth would lead to great stiffness, and therefore heavy rolling, which I need hardly say is very undesirable with this class of vessel.

(To be continued.)

RAILWAY UP MOUNT PILATUS.—A romantic mountain railway from Alpnach to Esel, on the summit of Mount Pilatus, was successfully inaugurated recently. The designs of the track and the locomotive are entirely new. The incline is twice that of the Rigi—namely, 48 in 100, and extraordinary engineering difficulties have been surmounted. The ascent of 6,000ft. is accomplished in 1 hour and 40 minutes.

STRIKE OF ENGINEERS IN HULL.

We mentioned last week that the men were willing to accept the services of Mr. Charles H. Wilson, M.P., as "mediator" between the two conflicting parties. As the result of the services of that gentleman, the masters decided to offer an advance of one shilling per week at once, and a further advance of one shilling per week from the 3rd of August next. This offer has been accepted by the men, and on Thursday morning of last week they resumed their work.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

RESISTANCE OF PIPING TO WATER.

To the Editor of "The Practical Engineer."

Sir,—In answer to "T. M.," where he says, in your issue of the 31st ult., "Medium" "should state what size pumps, &c., he is going to use to force the water (30 gallons per minute) through, then one might state what pipes would be sufficient," I beg to say that I am going to use a 4in. double-acting plunger pump, having a 16in. stroke. But I may here observe that neither the length of main, gradient, nor size of pipes mentioned in the question I asked can be altered. Therefore, if your correspondent "T. M." can throw any more light on the subject, I shall feel obliged.—Yours, &c., Medium.

THE STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

Sir,—The two letters in yours of the 31st May do little to assist me to a solution of the above question. First, because I am unable to apply Mr. D. K. Clark's formula, to which he refers in yours of October 5th, 1888, page 472. I must have something more simple than raising d to 1·75 times its power. I would like him to apply his rule to the case I give below. If the statement at the foot of page 471 *ante* agrees with his rule, viz., that the collapsing pressure for a flue 35in. diameter, by ⅜in. plates, is 58lb. per square inch, then the case named below is a living example of its error.

Passing to the rule given by "W. J. Ellis," and referring to his previous letters in your columns, I am afraid he has only added another voice to the medley already sounded on this matter.

I recently, with a view to purchase, went to see a second-hand Cornish boiler. The flue was 22ft. 1in. long, 3ft. ½in. by 3ft. ¾in. diameter, by ⅜in. plates, with nothing more than ordinary lap seams. Now, this had worked for years at from 60lb. to 70lb.; and on pointing out that the back end plate was bulged outwards, I was told that they had often seen it at 100lb., and even more. If this be true, what is the worth of Mr. Ellis's rule—

$$\frac{16\,t^2}{D^2} = \frac{16 \times 36}{9} = 64\text{lb.},$$

the pressure at which the above should have collapsed? Such cases are stubborn facts in the path of a Practical Man.

To the Editor of "The Practical Engineer."

Sir,—The article contributed by W. H. Booth in your issue of the 7th inst., entitled "Common-sense Engineering as Applied to Steam Machinery," is very interesting in connection with the above controversy in so far as it relates to cross tubes having no effect in stiffening flues against collapse. I believe I express the opinion of a considerable number of men who profess to have some knowledge of the subject, that cross tubes have a stiffening effect on flues, and it is difficult to see how it can be otherwise, as the tube cannot fail to stiffen the flue in a line parallel to its axis, and it is generally admitted that as the sides of a cylindrical flue collapse inwards, the top and bottom extend outwards, or *vice versa.* But the water tube, if properly riveted or welded into the flue, will have a very considerable effect in stiffening it against either collapse or extension parallel with its axis, and consequently at right angles thereto as well. I am sure it would be very interesting to a large number of your readers if Mr. Booth will produce any data more convincing than "Common-sense" to support his statement, that "water pipes have no effect in stiffening flues against collapse."—Yours, &c., Boiler.

NON-CONDUCTING COVERING FOR STEAM PIPES.

The following important letter appeared in a recent issue of our contemporary *Engineering*:—

Sir,—I have recently fitted up an apparatus for measuring the amount of heat lost by radiation and convection from steam pipes and the like, and have already made four tests with it, of several hours' duration each, on May 10, 14, 16, and 17. As the subject is one likely to interest your readers, I enclose a plan and elevation of the apparatus and the results of the last test, which, however, do not sensibly differ from those of the preceding days. So far, the experiments have been directed to determining the relative losses from (1) bare pipes; (2) pipes covered with 1in. of fossil meal composition; and (3) pipes covered with 1in. of fossil meal composition and three layers of hair felt.

According to the sketches on this page the testing surfaces are represented by three cast-iron steam pipes 5in. internal diameter and 6ft. long, with blank flanges on each end. They are suspended from the roof by two short lengths of hoop-iron fitted with clips and bolts, so that the pipes can be raised or lowered in their proper positions.

The 1in. steam pipe is carried direct from the top of a vertical 12 horse power boiler, and leads to M'Dougall's steam drier connected with M'Dougall's steam trap; this is done to ensure dry steam for testing. The steam pipe, as well as the steam drier, is covered with 1in. of fossil meal composition and 1in. of hair felt and canvas.

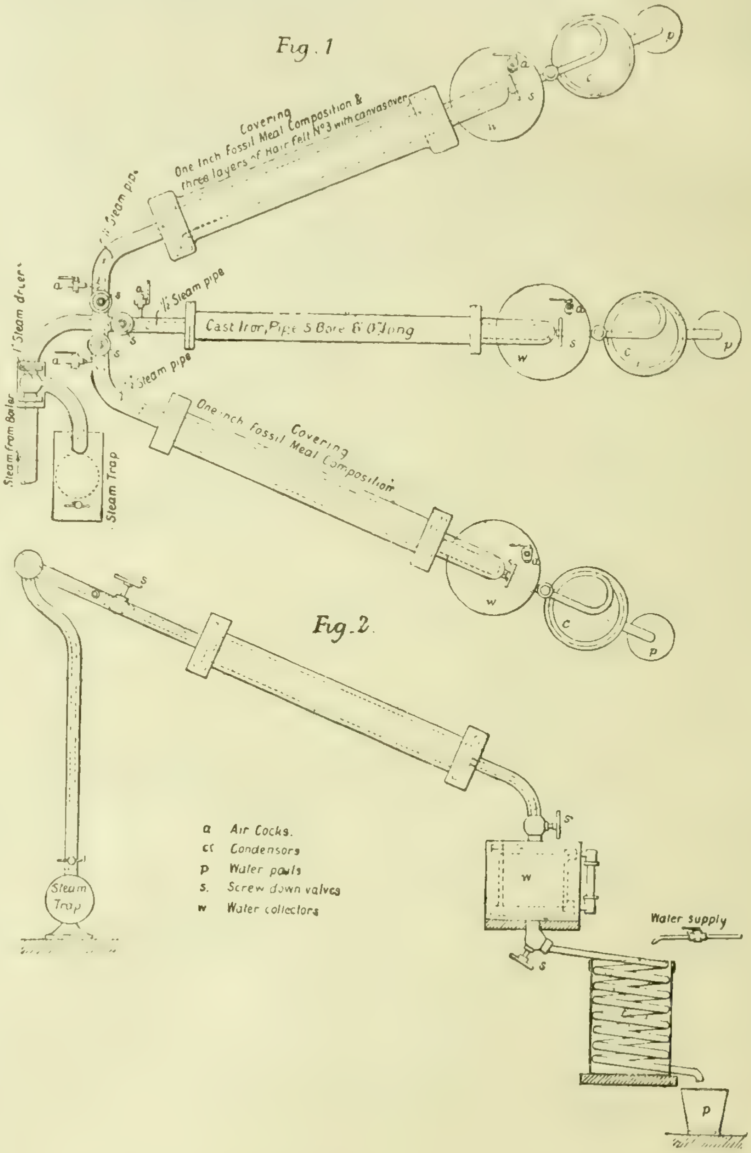


Fig. 1
Fig. 2

After the steam has passed the steam drier it enters into a crosspiece from which three short lengths of ½in. pipe convey it to the three respective test pipes. In each of these short connecting pipes is fixed a turn-off cock and a small air cock.

The three test pipes are spread out like Prince of Wales feathers, the top flanges being about 1ft. apart and the lower flanges about 3ft. The fall from the steam drier to the top of the water collector is 3in. in every foot.

From the lowest point of each test pipe a short length of ½in. steam pipe leads to a cast-iron cylinder 14in. high by 12in. internal diameter, with blank flanges on top and bottom, and wheel valves for shutting off the steam, both immediately over the top flange and below the bottom flange. These three cylinders are provided to collect the water condensed in the three ranges of pipes, and have gauge glasses to show the height of water, and a small vent cock on the top for blowing off air.

From the lower wheel valve a ½in. pipe connects the cylinder with a cooling arrangement, viz., a ½in. copper worm 30ft. long, fitted in an ordinary petroleum barrel in such a manner that every foot of pipe has a fall of at least 1in. The end of the pipe projects from the lower part of the barrel, and the condensed water is there delivered into pails and weighed. All the ½in. connecting pipes, as well as the water-collecting cylinders, are covered in the same manner, viz., 1in. of fossil meal composition, 1in. of hair felt and canvas, so as to reduce the loss of heat from these surfaces to a minimum.

During the trial specified herewith, No. 1 test pipe was covered with fossil meal composition, 1in. thick; No. 2 was left bare; No. 3, 1in. fossil meal composition, three layers No. 3 hair felt (½in. each). As the surfaces and covering of the ½in. connecting pipes and water collectors are the same in all three ranges, it is necessary to calculate approximately what percentage of the condensation in No. 3 range is due to loss from the test pipe, and which proportion must be put down as due to the supplementary parts, for this latter portion must evidently be deducted from all three ranges in order to give accurate results.

The exact measurements of the heat-losing surface on each range of the apparatus are as follow:—

	sq. ft.	
Test Pipe :		
Between flanges, 5ft. 9¾in. by 1ft. 7½in.	9·45	
Two flanges, circumference 2ft. 7¾in., width 2⅝in.	·52 ·52	
Two flanges, diameter outside 10in.	·54 ·54	
„ „ inside 10in. less 7in.	·17 ·17	
Eight bolts inside (square)	·23	
Eight nuts outside (hexagonal)	·19	
		12·33
Supplementary Surfaces :		
½in. steam pipe, 7in. by 2⅝in. circumference	1·53	
Cylinder between flanges 1ft. by 3ft. 8in.	3·67	
Two flanges, circumference 4ft. 8in. by 2¼in width	·87½ ·87½	
Two flanges, diameter outside 1ft. 6in.	1·77½ 1·77½	
„ „ inside 18in. less 14in.	·70 ·70	
Twenty-four bolts and nuts	1·26	
Fittings (approximately)	1·	
		14·16
Total area of each range		26·49

As the 14·16 square feet representing the supplementary surfaces also contain all the fittings, viz., steam cock, two air cocks, two wheel valves, and gauge glass, which are partly bare; and as, further, the 12·33 square feet representing the test pipe in No. 3 range are covered with an additional ½in. of best hair felt, it seems safe to attribute to the supplementary surfaces at least equal shares of the condensation in proportion to the number of square feet, viz.,

$$\frac{14·375 \times 14·16}{26·49} = 7·68\text{lb. of condensed water.}$$

If this amount, then, is deducted from the quantities received from each test pipe in a ten hours' trial, the result is found by the following figures, which show the amount of condensed water drawn off, less 7·68lb. in each case, are 13·44lb., 81·82lb., and 6·71lb. respectively:—

	lb.	lb.	lb.
	21·125	89·5	14·375
	7·68	7·68	7·68
	13·445	81·82	6·695
or,	16·43 per cent,	100 per cent,	8·18 per cent

water left, or, in other words, a covering of fossil meal composition 1in. thick saves out of the total possible loss of 100 per cent as much as 83·57 per cent, and if over this covering 1½in. of hair felt is placed with canvas, the extra saving is only 8·25 per cent. or 91·82 per cent out of the total loss.

If 81·82lb. are condensed by 12·33 square feet in ten hours, then 0·663lb. is condensed by every square foot in one hour, or 5,808lb. in one year of 365 days, and if 1lb. of steam coal is required to evaporate 8lb. of water into steam of 60lb. pressure, then 6½ cwt. of steam coal are required every year to make good the loss of heat from every square foot of uncovered steam pipe. This loss will, of course, be much greater in the winter, or where the pipes are exposed to wind and rain, or where steam of higher temperature is employed.

Finally, I beg to combat an opinion which is firmly established in the minds of many users of steam, viz., that the outside temperature of a non-conducting composition applied to hot surfaces is a measure of its non-conducting efficiency.

I consider this test of measuring the temperature either on the outside by placing the hand upon the covering, or even by thermometer readings, as unreliable and misleading, and base my opinion on the following reasons:—

1. Thicker coverings give greater circumference and consequently more heat-losing outside surface.

For instance, a 2in. steam pipe measures per *running foot*, if covered 1in. thick, about 1·18 square feet; if covered 2in. thick, about 1·70 square feet; provided the two coverings had the same ability of giving off heat from equal areas, then the temperature ought to be, if 100 deg. above freezing point on the thin composition, $\frac{100·118}{170} = 70$ deg. only, above freezing point on the larger surface, or say 132 deg. Fah. and 102 deg. respectively, in order to transmit the same amount of heat from the pipe.

2. Good non-conductors will not allow the heat to escape quickly, but retain it in the surface just as tenaciously as in the interior; in that case the supply of heat from the steam inside is greater than the loss of heat from the surface, and consequently the outside feels warm.

Inferior non-conductors, however, give the heat from the surface quicker to the surrounding space than it can be supplied from the interior source of heat; thus it can happen that the outside surface feels cooler, when in fact it loses more heat than the better covering.

I consider the measuring of condensed water as practised in my tests as the most reliable method of investigation at present existing, but shall be glad to be informed of any improvements which can yet be made in my experiments.—I remain, sir, your obedient servant,

Albert Haacke.

Kieselguhr Wharf, Hackney Wick, London,
May 21st, 1889.

Copy of Test made May 20, 1889. Weather clouded till noon, afterwards finer.

Explanatory Note.—No. I. thermometer outside, No. II. inside against wall, No. III. inside between pipes, No. IV. on the main steam pipe, No. V. on fossil meal 1in. thick, No. VI. on bare pipe, No. VII. on No. 3 pipe.

EXPERIMENTS ON NON-CONDUCTING COVERINGS FOR STEAM PIPES.

	I.	II.	III.	IV.	V.	VI.	VII.	Steam Pressure.
a.m.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	lb.
9-15	..	..	..	..	..	..	..	45
9-30	58	69	71	88	105	279	87	60
9-45	57	68	70	87	105	280	86	63
10-0	57	69	72	86	108	278	86	60
10-15	57	67	72	85	107	274	85	55
10-30	57	67	72	85	107	275	84	59
10-45	57	66	72	84	128	276	84	58
11-0	58	66	72	84	128	276	84	60
11-15	59	67	72	84	139	280	84	61
11-30	59	66	72	84	132	278	84	59
11-45	60	68	74	84	135	282	85	61
12-0	61	71	77	86	138	282	88	60
p.m.								
12-15	61	73	78	88	140	280	90	60
12-30	64	74	80	90	141	281	92	60
12-45	65	74	81	90	142	281	92	60
1-0	65	72	78	91	141	281	92	60
1-15	66	74	76	92	140	266	92	60
1-30	66	74	76	92	140	266	92	60
1-45	66	73	76	93	140	268	90	60
2-0	66	75	80	92	140	280	90	60

Pail No. 2 weighed 27 12
Tare 3 10
—— 24lb. 2oz.

	I.	II.	III.	IV.	V.	VI.	VII.	Steam Pressure.
2-15	66	75	80	93	139	263	93	60
2-30	65	72	78	92	138	270	92	60
2-45	65	73	78	93	138	270	92	60
3-0	68	74	78	93	139	268	92	60
3-15	68	76	82	95	140	259	95	59
3-30	69	76	82	96	142	274	96	59
3-45	68	73	78	94	140	275	93	60
4-0	68	73	78	93	141	274	93	60
4-15	66	73	77	94	138	280	91	60
4-30	66	71	76	93	138	276	90	60
4-45	64	73	78	93	138	276	92	60

Pail No. 2 weighed 30 8
Tare 3 10
—— 26lb. 14oz.

	I.	II.	III.	IV.	V.	VI.	VII.	Steam Pressure.
5-0	64	74	78	94	139	278	92	60
5-15	64	74	79	94	139	279	92	60
5-30	64	70	76	94	138	278	92	60
5-45	64	73	78	94	139	278	92	60
6-0	64	72	77	94	138	278	92	61
6-15	63	71	76	94	136	276	92	61
6-30	61	72	67	94	138	278	93	60
6-45	62	72	76	94	137	276	92	60
7-0	61	72	77	95	137	277	92	61
7-15	61	74	74	96	137	277	92	62

Pail No. 2 weighed 30 0
Tare 3 10
—— 26lb. 6oz.

Result of Cylinders being Emptied.

	No. 1—24 12	No. 2—15 12	No. 3—18
	Tare 3 10	Tare 3 10 lb. oz.	Tare 3 10
	Net 21lb. 2oz.	12 2	Net 14lb. 6oz.
		24 2	
		26 14	
		26 6	
		net 89 8	
	No. 1—21·125	No. 2—89·5	No. 3—14·375
	7·68	7·68	7·68
	13·445	81·82	6·695
or	16·43 per cent water left	100 per cent.	8·18 per cent.
or	83·577 „ condensation prevented,		91·82 „

Note.—In order to get rid of any air in the testing apparatus, the steam has been passed through all three ranges with full force for half an hour previous to beginning of trial; this caused the lowering of steam pressure at 9-15 a.m.

To the Editor of "The Practical Engineer."

Sir,—I am glad to hear that you consider the result of my experiments on non-conducting covering for steam pipes, as reported in *Engineering* of the 24th ult., of sufficient importance to induce you to reproduce same in your columns.

Based thereon I have made some more calculations, which perhaps may interest your readers. According to Molesworth's "Pocket-book," page 500, the dimensions of stationary condensing engines are as follow: Cylinder of 40 H.P. nominal engine, diameter 32½in., stroke 6ft., number of strokes 21 per minute. The cylinder contains, therefore, at every stroke (if no allowance were made for the displacement of piston and piston rod), 59,753 cubic inches of steam, or per minute 1,254,813 cubic inches. The diameter of steam pipe is 8in., or the area 50·3in. The steam has to pass, therefore, through the pipe at a speed of $\frac{1254813}{50 \cdot 3}$ = 24,946in., or about 2,079 feet per minute. Allowing for displacement of piston, &c., and for lower speed in smaller pipes, I will, for argument's sake, take the speed of steam in a 5in. steam pipe as 1,500ft. per minute only.

The contents of a 5in. steam pipe 1,500ft. long would be about 204 cubic feet, and if this pipe was filled with steam of 60lb. pressure —which, according to the table on page 451 of Molesworth, has a specific volume of 353—it would contain $\frac{204.62 \cdot 4}{353}$ or 36lb. of water. As it receives this amount every minute, it has received in one hour 2,160lb. of water in form of steam. Every 6ft. length of such pipe, however, would condense, according to my tests, 8lb. of water per hour; therefore the whole pipe $\frac{8.1500}{6}$ = 2,000lb. Therefore, allowing for wind and rain, under practical working conditions all the steam, which would have been sufficient to drive the engine if it had been close to the boiler, would have been condensed before it came to the other end of the pipe, in case the engine is 1,500ft. away from the boiler. In order, therefore, to work the engine, it would be necessary to let the steam travel at double the speed. That means to put double the amount through the pipe, and to waste half the fuel which is burnt in the boiler. Even in places where fuel would cost nothing, it would certainly, in such a case, be a good investment to do the covering at say £100, than to pay for a new boiler say £200, and to pay a man continually firing it.

Further, if this pipe was carefully covered, the saving would be 50 per cent of the fuel burnt, and proportionately less for shorter pipes. The rate of saving is, therefore, a relative one, and varies with the amount of steam-piping. It will be more perceptible where the heat-losing surface, represented by steam-pipes, is very large than where the steam pipes are only short. Three hundred square feet covering on a small vertical boiler, with a system of 1in. and 1½in. steam pipes, will perhaps reduce the fuel consumed by half, whilst 300 square feet of main steam pipe in a large spinning mill, covered in the same efficient manner, will perhaps not make a difference of 1 per cent in the fuel account of the firm. The saving per square foot, however, is a fixed amount, and can be measured by the condensation, and the 300 square feet in the large works, where the saving does not visibly affect the fuel bill, must in money value save the same as the corresponding surface in small works. I am referring here, of course, to 300 square feet *uncovered* surface, whilst according to the rules of the covering trade the measurement is taken on the outside of the covering after it has been finished. Owing to this the covering of the small pipes costs, of course, more per square foot of bare metal than the covering of the large pipes. But even in this, the fossil meal covering being only an inch thick, offers a considerable advantage in measurement as compared to the thick clay compositions which are applied 2in. and 3in. thick without giving the same efficiency as the thin fossil meal covering. 100ft. of 2in steam pipe, covered 1in. thick, measure 117·85 square feet; covered 1½in. thick, 130·80 square feet; covered 2in thick, 170·23 square feet.

To prove that it is hardly necessary to use a greater thickness than one inch of fossil meal composition on steam pressures up to 60lb., I beg to enclose a copy of test made a few days ago, comparing 1½in. thickness on No. 1 pipe with the same covering on No. 3 and the bare No. 2 pipe. The results are :—

No. 1, 16·625lb. left. No. 2, 85·625lb. left. No. 3, 12·125lb. left.

Deduction for supplementary surfaces :

	6·481	6·481	6·481
	10·144	79·144	5·644
or,	12·82 %	100 %	7·13 %
or,	87·18 % saved.	nothing.	92·87 % saved

The covering on the supplementary surfaces has been increased by an additional layer of ½in. hair-felt and canvas, in order to reduce any loss of heat from these surfaces further still.—I remain, sir, yours obediently, Albert Haacke.

QUERIES AND REPLIES.

35. Locomotive Driving Wheels.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

41. Hot-water Pipes.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse?—Water-heater.

49. Proportions of Pipes to Hydraulic Ram.—We have a 10in. ram, with 1¼in. inlet and outlet pipes, pressure 700lb. per square inch. Is this a correct or good proportion? if not, how is the correct proportion calculated? Steam Crane.

50. Small Air Pump.—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

51. Straightening and Bending Angle-iron Bars.—Will any practical man kindly give me a ready method of straightening and bending angle-iron bars about 5in. by 5in. by ¾in.? A sketch or description of suitable machine will much oblige.—Outsider.

52. Details of Oliver.—Can any reader oblige me with details of an "Oliver," to work by foot, for making bolts from ⅜in. to 1in., with dimensions?—H. C., Egypt.

53. Dash Pots.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made, and what is the approximate cost?—Crank Pin.

54. Boring Out Crank Pin Hole.—What is the best method of boring out an old crank pin hole, to be most easily done?—Crank Pin.

TO CORRESPONDENTS.

W. G. H., Ramsgate.—Thermo-regulators such as you require are sold by Messrs. Elliot, Strand, London, or Messrs. Browning, London. You can also get them from Messrs. Baird and Tatlock, Sauchiehall Street, Glasgow.

J. D., Glasgow.—Beechwood is very generally used in the circumstances you mention.

J. H., Pudsey.—Messrs. Schäffer and Budenberg, Deansgate, Manchester, make the Thompson indicator, which is exceedingly good. We have had one from them, and find it does its work admirably.

F. T. T., Sydney.—We are making arrangements for a series of articles on triple-expansion engines, which will appear shortly. A large number of Babcock and Wilcox boilers are now in use, and they work well. By referring to our correspondence on water-tube boilers recently, you will there find information both for and against that type.

On Saturday, June 1st, Messrs. C. S. Swan and Hunter launched from their shipbuilding yard, at Wallsend-on-Tyne a steel screw-steamer, built to the order of Messrs. Huddard, Parker, and Co., of Melbourne. The vessel is 304ft. b.p., by 39ft. by 23ft. 2in. depth moulded, built to Lloyd's highest class, and is intended to carry about 3,250 tons. She is fitted with all the latest improvements for loading and discharging cargo, including four steam winches, two steam coal whips, large horizontal donkey boiler. There are five steel bulkheads and web frames. There is the usual accommodation for officers and crew. Water ballast in a cellular double bottom is fitted all fore and aft, and also in a large after-peak tank. The engines are by the Wallsend Slipway and Engineering Company, of Wallsend, capable of indicating 1,400 horse power, and the boilers are fitted with forced draught on the on the closed ash-pit system. The vessel was named the Santon by Mrs. G. B. Hunter,—On the same day there was also launched from the same yard a steel screw-steamer of the following dimensions: Length, 280ft. b.p., by 37ft. 6in. by 21ft. 8in. depth, moulded, designed to carry about 3,200 tons deadweight, and built to the order of Messrs. J. J. and C. M. Forster, of Newcastle. This vessel is built to Lloyd's highest class, and has all the most modern improvements, including web frames, and longitudinal stringers instead of hold beams, large hatchways, engine and boiler casings carried 6ft. 6in. high, full poop aft, long raised quarter-deck, long bridge house carred forward of foremast, and open top-gallant forecastle. There are five water-tight bulkheads. Water ballast is fitted in a double celular bottom all fore and aft, also in a large after-peak tank; and there are four steam winches, large patent vertical donkey boiler, steam windlass, &c. The engines are by Messrs. Black, Hawthorn, and Co., capable of indicating 1,250 horse power. This vessel was named Mewquay.

MISCELLANEA.

A Great Fleet.—The Peninsular and Oriental Steam Navigation Company may claim to own the largest fleet in the world. It has 51 ocean steamers, varying from 6,362 tons down to 2,588 tons. There are eight steamers over 5,000 tons each, and thirteen others above 4,000 tons each. Nineteen out of the total are built of steel. This fleet, owned by one company, is far larger than the aggregate ownership of some of the maritime countries.

France claims the honour of utilising a higher water pressure than that recently put in operation in the Chollar shaft on the Comstock lode, in Nevada. At Brignoud, two kilometres from the valley of Grèsivaudad, near Grenoble, a turbine 9ft. 10in. in diameter was put into operation in the year 1875, utilising a head of 1,638ft. The *Engineer and Mining Journal* says it is still working, and gives 1,400 horse-power, with a flow of 300 litres of water per second.

National Association of Draughtsmen.—At a general meeting of the members of the National Association of Draughtsmen at Newcastle on Wednesday evening, June 5th, after the ordinary business of the society, a paper was read by a member, the subject being "Cross Curves of Stability." The lecturer, after defining stability and the principle upon which this intricate calculation is worked, stated that in his opinion a great number of the vessels which have been lost at sea owed this to their unstable condition, and that, if the owners of vessels would give this question their consideration, many disasters would be averted.—A discussion took place on the paper.

The World's Steam Engines.—A German technical authority, says a Berlin correspondent, has expressed it as his opinion that four-fifths of the entire number of steam engines now at work throughout all parts of the world have been constructed within the last 25 years. France is believed to possess, as nearly as possible, about 49,500 locomobiles and stationary engines, 7,000 locomotives, and 1,850 marine engines; Germany about 59,000 locomobiles and stationary engines, 10,000 locomotives, and 1,700 marine engines; while the number owned by Austria-Hungary is said to be about 1,200 locomobiles and stationary engines, and 2,800 locomotives. The total value of the engines actually worked is estimated at 7,500,000 marks for the United States, 7,000,000 marks for Great Britian, and 4,500,000 marks for Germany.

Compound Locomotives.—We understand that there are under construction at the present time at the Gateshead Works of the North-Eastern Railway Company five compound passenger locomotives of exceptional power and size. Since the introduction, by the present locomotive engineer of the company, Mr. T. W. Worsdell, of compound locomotives on the Worsdell and Von Borries system, the company have had a large number built, both for working passenger and goods traffic. Several are now running express passenger trains with, we understand, good results. Nearly all those running have four coupled wheels, 6ft. 8in. in diameter, with bogeys in front. Two, however, which are bogey engines, have single driving wheels, 7ft. in diameter. They all have cylinders of 18in. and 26in. diameter respectively, but we believe the five now under construction are intended to be bogey engines with single wheels, 7ft. 6in. in diameter, and having cylinders of 20in. and 28in. in diameter respectively. When completed they will be amongst the largest and most powerful locomotives possessed by a company which can boast of a stock of splendid engines.

Institute of Mining Engineers.—On Thursday, June 6th, a meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers was held at the Mason College, Birmingham. Mr. H. Lee presided, and before the ordinary business was proceeded with he referred to the resignation of the late president, Professor Benton. He spoke of the services the late president had rendered to the association, and said he was well qualified to hold that office by reason of his long and varied experience of matters concerning engineering. By his retirement they had sustained a great loss; but while they lamented their fate in that respect they had good ground for congratulating Professor Benton on his appointment, and offering him their best wishes. (Hear, hear.) The Chairman read a paper on "Electrical Units of Measurement." Mr. H. W. Hughes read a paper upon "Electricity applied to Mining," as the introduction to the adjourned discussion on Mr. A. Sopwith's paper on "Electric Lighting at Cannock Chase Collieries," and Mr. F. Brown's paper on "The Transmission of Power by Electricity." Mr. Hughes gave particulars of various installations at collieries and mines in England and America, and contended that the time was not far distant when electricity would be generally adopted in mining operations.

Opening of the New Railway to Wimbledon.—The new railway from Putney to Wimbledon was opened for public traffic on Monday, June 3rd, by the Metropolitan District Railway Company, the first train leaving the Wimbledon terminus at 5-38 a.m. The new line, which has been constructed at the cost of the London and South-Western Railway Company, commences by a junction with the Metropolitan District Railway at their Putney Bridge Station. Thence it crosses the river to Putney, passes through the western part of Wandsworth known as Southfields, and crossing the Wimbledon Park estate, terminates at Wimbledon at a special terminal station that has been erected at the side of the existing station of the South-Western Railway. The main object of this line, which was originally promoted by the owners of the Wimbledon Park estate in the face of strong opposition from the South-Western Company, is to give direct access from Wimbledon to the City and West End *via* the District Railway. The connection with the South-Western line is at East Putney; but this company will not, it is understood, take part in working the new railway until some time next month.

Engineering Society, King's College, London.—On Thursday week, Mr. Chas. Mittelhausen read his presidential address to the above society on a few recent engineering advances. The author showed experimentally how sewage could be precipitated electrically by means of iron electrodes on a small scale, and indicated how this long-known scientific fact had been turned to practical account with the Webster process. In referring to the execution of criminals by electricity, it was pointed out that exhaustive experiments had now demonstrated the superiority of alternating currents for that purpose. The series system of electrical traction was then taken up, and by means of a model it was shown how the system had been made a complete success by the use of highly insulated conductors. Speaking on the advantages of photography for engineers, Grimston's new patent shutter was mentioned both on account of the simplicity and accessibility of its mechanism. The author also referred to Messrs. Siemens Brothers' new Morse instrument and Edison's new phonograph, whilst *à propos* the question of national defence the newest methods of operating submarine mines were explained. In the civil engineering world the chief features of the Forth and Lansdowne bridges were described, whilst the address terminated in an apology for the much maligned Eiffel Tower. After a vote of thanks to Mr. Mittelhausen for his interesting paper, the meeting adjourned.

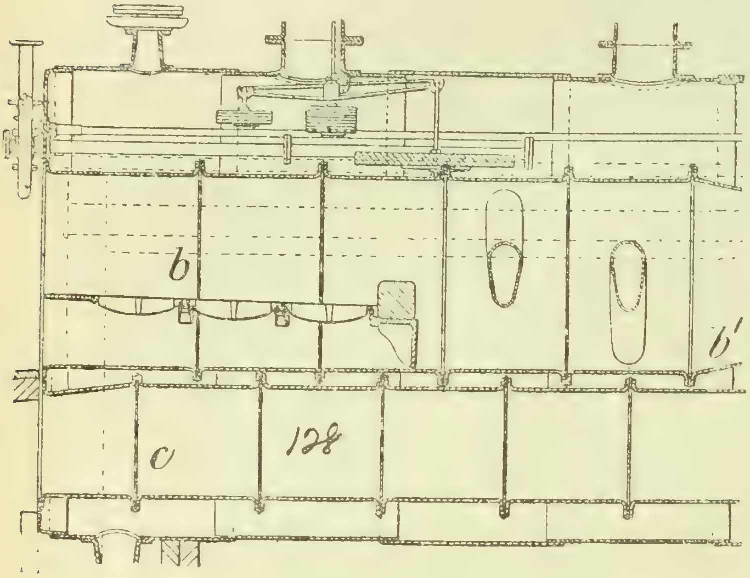
Mining in South-Western China.—The British Consul at Ichang, in his last report, states that efforts are being made to restore and develop the mining production of the Yunnan and Kweichow provinces, which had much decayed. An ex-governor of the former province, who was in disgrace, was appointed in March, 1887, to superintend the work, and Japanese mining experts were engaged at his request. Attention was given in the first place to the copper deposits in North-eastern Yunnan, and those of lead in the neighbouring part of Kweichow. Native processes were to be employed in the first instance; if these did not succeed, foreign methods would be tried, and, in course of time, other districts would be taken in hand. On the other side of Kweichow vigorous efforts are being made to develop the iron mines. Machinery and plant have been purchased in England, there was a good supply of coal, and, in spite of local opposition, it is believed that the furnaces are now at work. The iron is said to be soft or flexible and tough, like Low Moor iron. The lead mines in the eastern half of the same province are also being examined, with a view to increasing their development. Mr. Gregory, in the same report, refers also to trade in the curious and beautiful insect white wax—not bleached beeswax. It is widely used in China, and, though known to science, seems to be unfamiliar in the home markets. Its high price has been against it, but this has fallen very much of late. The wholesale cost in Ichang, 700 miles from the centre of production, is 1s. 3d. per lb., which, with duty, freight, &c., would mean 1s. 6d. in the London market, and the consul suggests that, in view of its beauty, hardness, and high melting point, it might be acceptable in the manufacture of candles, to serve as a coating or otherwise.

Collapse of a Locomotive Water Tank.—The *Zeitschrift der Lokomotifühhrer* records the collapse of a locomotive water tank which is noteworthy in several respects. The tanks were located at both sides of the boiler, measured about 18ft. by 2½ft. by 1½ft., and held, together, about 123 cubic feet. They were connected by a 4in. pipe, and the water level was shown by a float and suitable index. The walls of the tank were stiffened by angle irons and flat braces riveted to the inside. The engine, having just come in from a run, was to be housed, and as the tanks were nearly empty a water supply pipe was coupled on, and the right-hand tank filled. The right-hand injector was still feeding while steam from the boiler, which was at a pressure of about 2 atmospheres, was being blown into the left-hand tank. This lasted about three minutes, when suddenly this tank collapsed with a loud noise similar to that produced by a hammer blow against an empty tank. The force of the collapse was such as to bend or break all the angles and to bend the braces to one side. The tank plates above and below the angle irons were torn and the top and bottom plates forced outward. One of several plates, about 7in. wide and 0·7in. thick, by means of which the tank was bolted to the engine frame, was wholly broken off. The extent of the damage points to the fact that the partial vacuum produced by the inflow of steam to the tank must have been considerable, and can be explained by the circumstance that an appreciable quantity of cold water overflowed from the right-hand tank, which had become full, into the one on the left, in which there was only a small quantity of water, not sufficient to condense the steam in it. The covers on the tanks were practically air tight, having become battered down by the constant concussion while on the road, and being furthermore held in place by springs. Entrance of air was, therefore, impossible, there being no special provision for this, as in the engines of more recent build.

ILLUSTRATED PATENTS.

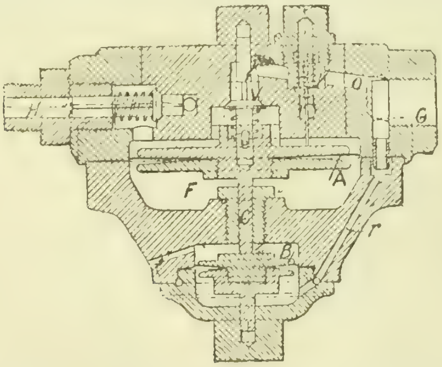
128. Steam Boilers, D. Adamson, Dukinfield, Cheshire.

The internal flues b, b^1, preferably two in number, and tapered towards the rear, are placed as high above the axis of the boiler as the depth of water and their diameters will allow. The lower portion of the boiler is provided with one or more return flues c, which open into the ordinary external flues. The combustion chamber, which at the rear connects the furnace and the return flues, is supplied with a regulated amount of atmospheric air through pipes in the setting. To protect the end plate of the boiler against the heat of the combustion chamber a coating of firebrick or other suitable material may be employed.—January 4, 1888. [11½.]



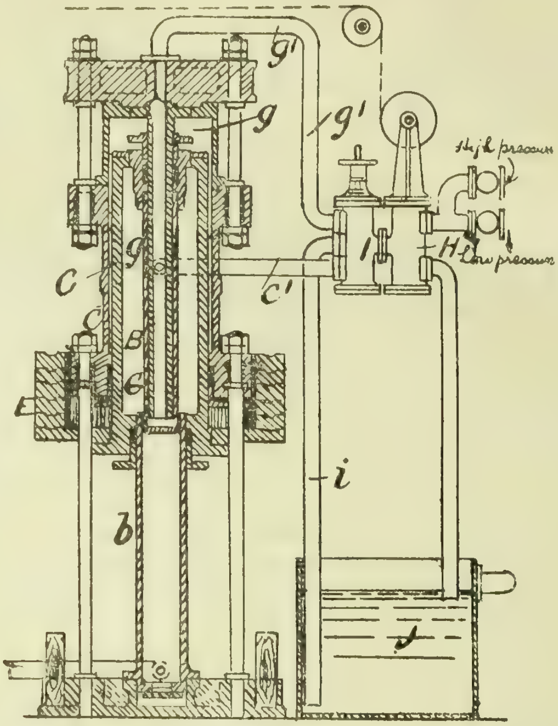
107. Brakes, A. P. Kapteyn, The Westinghouse Brake Co., Middlesex.

Valve Mechanism: This is an improvement on the triple valve of the "Westinghouse system," by which the fluid pressure in the brake cylinder may be only partially removed by increasing the train-pipe pressure after application of the brakes. The figure is a section of the improved valve. The ordinary diaphragm A is provided with a stem C extending downwards, and resting on an auxiliary diaphragm B, which forms the chief feature of the invention. The space F below A is in connection with the train-pipe, and the space above A communicates with the auxiliary reservoir at H, and also with the brake cylinder at G, through a passage O, closed by a valve V, the stem of which is attached by a slotted connection with the diaphragm A. The space below the diaphragm B communicates with the cylinder by a passage r, and the space above B is opened to the atmosphere. The exhaust from the cylinder is closed by a valve K, the stem of which rests on the diaphragm A. The diaphragm A being in its middle position, if the train-pipe pressure be reduced, the diaphragm falls and opens the valve V, thereby admitting air from the reservoir to the cylinder to apply the brakes, the air at the same time passing through the passage r to the lower side of the diaphragm B, causing the latter to rise and lift the diaphragm A until the upward and downward pressures on A are in equilibrium, when the valve V will again close. When the brakes are to be partially released the train-pipe pressure is increased, causing the diaphragm A to rise beyond its middle position and to lift the exhaust valve K, but at the same time the upward pressure on the lower surface of the diaphragm B, which helped to support the diaphragm A while the brakes were on, is now partially removed with the cylinder pressure, the result being that the diaphragm A will fall and close the valve K before the cylinder pressure is wholly removed. This operation may be repeated several times, thus placing the degree of brake pressure quite within the control of the driver. The invention is applicable to other triple valves for pressure or vacuum brakes.—January 3, 1888. [8½d.]



252. Hydraulic Lifts, W. R. Green, London, S.E.

Consists in fitting those lifts which are furnished with a balancing cylinder with two rams of different diameter for working by either high or low-pressure water. The weighted balancing cylinder is seen at B, working on the fixed ram b. B also acts as a ram within the cylinder C, and it carries a small central cylinder G which works upon the fixed ram g. C acts as the low-pressure cylinder and G as the high-pressure one. Either high or low-pressure water is admitted by the valve H, and led by the pipes g^1, c^1 to the cylinders G, C respectively, according to the position of the valve I, which, while putting one cylinder in communication with the pressure, puts the other in communication with the tank J by the pipe i to prevent the formation of a vacuum. Instead of telescopic rams, as shown, they may be arranged tandem-wise, and they may have pistons.—January 6, 1888. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

May 24th.

8620 Girders, R. H. Cousins, New York, United States.*
8626 Copying Drawings, J. Donnelly, and T. Farrell, Manchester.
8637 Water Purifier, B. H. Foster, Newcastle-on-Tyne.
8651 Feeding Millstones, W. J. Wilders, Northfleet.
8652 Couplings, R. J. Rae, London.*
8660 Dust Collectors, W. P. Thompson, Liverpool. (C. M. Hardenburgh, United States).
8670 Snow Ploughs, W. P. Thompson, Liverpool. (E. P. Caldwell, United States.)
8674 Electrical Tramways, J. Hopkinson, London.
8676 Looms, G. Wassermann, London.
8679 Branding Machines, G. P. Nightingale, London.
8686 Malt Kilns, M. Bauman, T. Sederl, and F. Wirk, London.
8687 Vacuum Pumps, E. F. Varaldi, London.
8688 Picking Mechanism, C. S. Brooke, and E. Beaumont, Huddersfield.
8690 Spring Hooks, C. H. Fauchereau, London.
8695 Furnaces, G. West and J. Kelly.

May 27th.

8707 Projectiles, A. Houston, Dublin.
8708 Mitre Cutting Machines, J. Ford, Birmingham.
8711 Furnace Bridge, B. Darbyshire and J. Entwistle, London.
8713 Steam Generators, A. F. Shanks, Glasgow.
8714 Furnaces, J. A. Norberg, Birmingham.
8715 Lubricators, J. Dewrance and G. H. Wall, London.
8717 Single-crank Engines, R. Patrick, London.
8718 Explosives, Sir F. A. Able and J. Dewar, London.
8719 Type-writers, J. Gardner, Manchester.
8729 Sifting and Dressing Machines, J. Stevenson, London.
8733 Railway Signals, C. Barry, Manchester.*
8735 Spanners, C. L. Heerman de Hundertmark, Manchester.
8759 Steam Boilers, F. H. L. Stelling, Manchester.
8767 Steam Vent, C. Le Fevre, jun., Little Moorfields.
8774 Steam Engines, C. Wells, London.
8778 Motor Engines, O. Imray, London. (F. C. Glaser, Germany.)
8780 Electrical Switches, E. Emmanuel de Facien, London.
8781 Fog-signalling Apparatus, W. Smith and G. Stevenson, London.
8785 Swivel Ball Joint, J. N. Sperryn, London.
8791 Preventing Corrosion, J. B. Dodds and J. R. Fothergill, London.
8792 Rock-boring Drills, R. Stephens and W. C. Stephens, London.
8797 Feed-water Apparatus, G. L. J. Porion, London.
8798 Propulsion of Vessels, P Oriolle, Fils, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

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Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER,

JUNE 21st, 1889.

REGISTRATION OF PATENT AGENTS.

In accordance with the Patents, Designs, and Trades Marks Act of 1888, which became law on the 24th December of that year, all patent agents practising in Great Britain or Ireland must be enrolled upon a register not later than the first day of July of this year, after which time no person is entitled to describe himself as a patent agent, by advertisement or otherwise, unless registered in pursuance of the Act, and the Board of Trade is empowered to make rules defining the qualifications necessary for those desiring to practise. We have now before us a copy of those rules, which have just been issued, from which it appears that the register is to be kept by the Institute of Patent Agents, and a correct copy is to be printed once a year and placed on sale under their direction. All those who have been *bona fide* practising as patent agents prior to the 24th December, 1888, are entitled to be enrolled, but they must prove to the satisfaction of the Board of Trade that they have so practised. Any other person desiring to enter the profession can do so by engaging for seven consecutive years as assistant or pupil to one or more registered patent agents, and passing a final examination as to knowledge of patent law and practice and the ordinary duties of a patent agent. This examination is to be such as the institute shall from time to time prescribe.

The seven years' pupilage or apprenticeship is dispensed with in the cases of solicitors entitled to practise in the Supreme Courts of Judicature of England and Ireland or law agents of the Court of Session of Scotland, who may become patent agents at once upon passing the final examination only. Those also who have passed the matriculation examination at any university in England, Scotland, or Ireland, or the Oxford or Cambridge Middle-class Senior Local Examinations, or the examinations of the Civil Service Commissioners for admission to the Civil Service, are also entitled to practise after passing the Institute of Patent Agents' final examination only. Further, the institute has the power, with the approval of the Board of Trade, to substitute for these other examinations. The final examinations are to be held by the institute at least once a year, commencing on the first day of July, 1889, and at such times and places as they may determine.

These regulations and conditions constituted the important and generally interesting portions of the Board of Trade rules, which came into operation on the 12th instant. Our readers will remember that the Act occasioned considerable opposition, in which we, in common with many other engineers and engineering journals, thought it proper to join. We still adhere to our opinion as to the evils occasioned by such an act, and the inadvisability of meddling with the ordinary laws of commercial competition in the business of the patent agent. We still consider that the form and provisions of the bill are capable of improvement; yet, as it has now become law, it is our duty to examine as impartially as possible its probable effect upon patent matters, and upon the interests of inventors. It would be idle to deny that many incompetent and a few unscrupulous agents are in practice at present, and in so far as the addition of incompetents is prevented, and the more objectionable practices of the unscrupulous controlled, the public will reap advantage from the Act—if not immediately, at least in a few years. To some extent conditions will be improved, as the Board of Trade has power to erase from the register the name of any person proved to have been guilty of disgraceful professional conduct, or any committing an offence which in England would amount to a felony or misdemeanour. In this manner those enrolled are subject to a certain amount of supervision, just like solicitors or medical men, and their status will be undoubtedly improved thereby. Inventors will feel that those in whom they confide belong to a body of men liable to answer for their acts to a competent tribunal, and in danger of being struck off the roll for unprofessional conduct.

The standard of education among agents will also be raised, though in one particular, however, we fear that deterioration will be occasioned. We refer to the provision in favour of solicitors and law agents, and it seems to us very remarkable that they, as a class, should be considered as in any way specially qualified. Patent law is admittedly difficult, but extensive engineering and scientific knowledge is more essential to the efficient performance of a patent agent's work. It is difficult to imagine a man who is merely a lawyer drafting a good specification, clearly describing an engineering invention, and differentiating the claims in such manner from previous inventions as to cover the novel points. On the other hand, an engineer with but slight knowledge of law may be able to describe and claim very clearly the essentials of an engineering invention. We do not for a moment deprecate a thorough knowledge of patent law in an agent; it is absolutely necessary for first-class work, but we are distinctly of opinion that a specification drawn by an engineer in ignorance of patent law is far more likely to pass the ordeal of the law courts with success than one drawn by a lawyer ignorant of engineering. To be valid, a specification must so describe an invention that a workman skilled in the branch of industry can readily manufacture or carry into effect the improvement which is the subject of the invention. Now, engineers as a class possess a much wider knowledge of general industrial operations than lawyers as a class can possibly do, and are, therefore, much more competent to draft specifications. We accordingly regret that the legal influences among patent agents have been sufficient to distinctly favour the solicitors as compared with engineers, when a proper understanding of the necessities of the case would have shown reason for the reverse order of preference. However, after all, it does not greatly matter, as an engineer wishing to enter the profession need only study up to pass one of the university matriculation examinations, and that condition is one which is common to the medical and other professions.

We are of opinion that patent work can be best performed by engineers educated in patent law and experienced in the general industrial applications of science, and that it is most unwise to encourage the formation of a class merely versed in office work, which will be one of the effects of the Act in question as at present in force. The standard of general and book education among patent agents will no doubt be raised, but to the detriment of their practical knowledge of engineering and industrial applications, which can only be acquired in the workshops.

It should not be forgotten that our leading experts in patent matters are engineers, and that many of them have had very extensive workshop experience before acquiring legal experience. Under the old system all the old-established firms acquired their present position and experience, which in many cases, we venture to think, could not be improved upon by the most perfect system of examination.

We are not of opinion that the new law will act adversely on the whole to the interests of inventors, as it does not interfere in any way with their right to draw their own specifications, and file them at the Patent Office. It may act hardly in some cases of those wishing to join the profession, which is now a closed one, similar to law or medicine, but a little hard work will overcome even that difficulty. It will take some years of working under the Act to discover whether the public are as efficiently served under the new conditions as under the old; but if the legal element among patent agents increases at the expense of the engineering and industrial portion, as we very much fear will be the case, then it will be necessary to insist upon the alteration of the patent rules by the Board of Trade.

RIVAL GAS ENGINES.

A SERIES of interesting letters, by the Messrs. Crossley and Mr. Atkinson, have recently appeared in the columns of our esteemed and able contemporary *Engineering*, on the relative merits of the Otto and Atkinson engines. We are very familiar with the good and bad points of both engines, and cannot help thinking that the combatants hardly do each other justice. No doubt the Atkinson linkage is very clumsy and an eyesore to the steam engineer, as the Messrs. Crossley in effect allege; but, notwithstanding that difficulty, it does its work fairly well, and by its means great expansion, and consequently great economy, is obtained. We confess, however, that we share the Messrs. Crossley's prejudice as to the ungainly appearance it gives to the "Cycle" gas engine, and we are not without some doubt as to its durability compared with ordinary steam-engine work. In a recent article* we congratulated Mr. Atkinson on the great economy of his engine against the Otto, as proved in the recent Society of Arts trials; but nevertheless we, as engineers, quite disapprove mechanically of the means whereby it is attained. In the early days of the steam engine many ungainly forms were produced, with numerous levers, pins, and links; but, through years of competitive trial, they have all disappeared, leaving the direct-acting horizontal and vertical engines practically masters of the field.

In like manner we feel confident that the Cycle engine linkage, theoretically beautiful and clever as it is, will not permanently satisfy engineers. Although an impulse is obtained at every revolution of the flywheel, yet the piston itself makes four strokes for every impulse, in that respect precisely resembling the Otto engine. We cannot imagine an Atkinson engine competing with a steam engine for high speeds; the great strains set up in the toggle linkage and heavy masses in reciprocating motion, as compared with steam-engine moving parts, in our opinion, disqualify it for high velocities. The weak point of the Otto engine is, of course, the fact of its getting only one impulse for every two revolutions; but notwithstanding that difficulty, the mechanical actions precisely resemble those of the ordinary horizontal steam engine, and the speed is only limited by similar considerations. We accordingly doubt very much whether the Atkinson engine is essentially an advance upon the Otto.

We do not doubt, of course, the proved advance in economy made by Mr. Atkinson at full and half load, but we believe that the new linkage will ultimately be superseded; indeed, we fail to see why Messrs Crossley could not expand as much as they chose with their present form of engine by a very small rearrangement of details. The average pressure would, of course, be less, and the engine would be heavier for a given power, as is the case with expansive steam engines compared with non-expansive, but the economy would be materially improved. We can see no reason why an engine of the Otto type should not be arranged to give at least the economy of the Atkinson at full load, while retaining its low consumption when running without load. This is to be done, of course, by a suitable rearrangement of compression and expansion. The horizontal or vertical direct-acting type of steam engine, with the power transmitted direct from crosshead to the crank pin by a connecting rod, have been proved superior in steam-engine work, and in our opinion it will prove its superiority in the long run in all points with gas engines also.

NAPHTHA.—The report is that the quantity of naphtha sent up the Volga this year in order to be used as fuel in Middle Russia will as is believed, amount to a million tons. Last year the quantity wa 880,000 tons. As we understand it, "naphtha" in the report means crude petroleum from the wells on the shores of the Caspian.

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* *The Practical Engineer*, p. 107, 1889.

ENGINE PATTERNS.—II.

In each of the examples which I shall take in this series I draw on my own experiences. Every pattern to be described has passed through my hands, so that these are not hypothetical, but actual cases from practice.

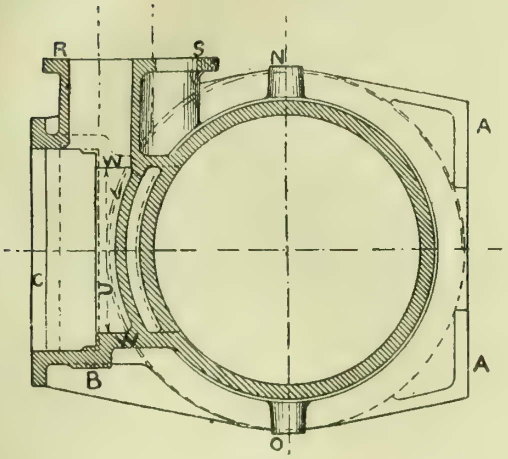


Fig. 1.

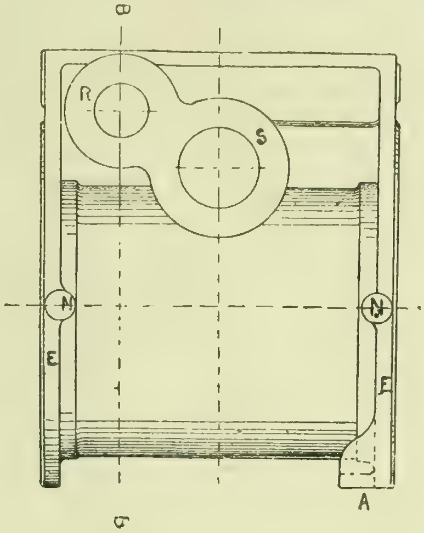


Fig. 2.

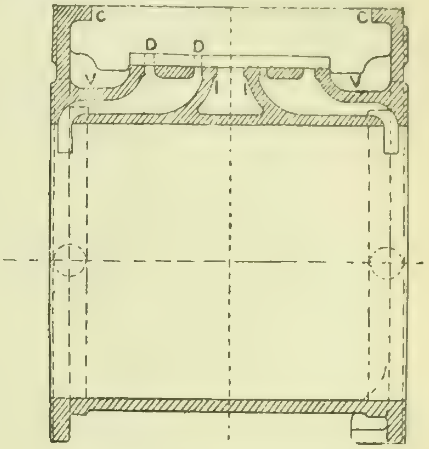


Fig. 3.

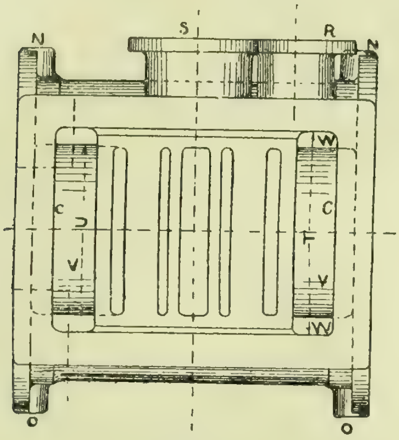


Fig. 4.

The subject which I have selected for illustration in this article is the low-pressure cylinder of a 50 horse power horizontal engine. This and the high-pressure cylinder were bolted together by the lugs (figs. 1, 2, 3, A). The foot B, fig. 1, was bolted to the bed plate, framed of channel iron, on its side, a corresponding foot on the high-pressure cylinder being also bolted to the bed plate on its side. I shall describe the high-pressure cylinder next, since it affords an example of coring out in some respects different from the low-pressure. As these examples are of pattern work only, and not in any way connected with design and proportion, I need not figure the drawings. But they are made to scale, and the bore of this cylinder is 1ft. 11in.

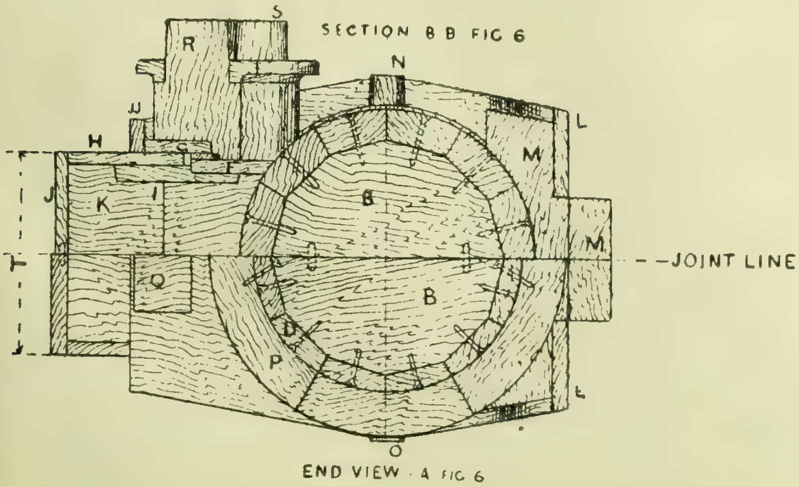


Fig. 5

Looking at these figures, it is obvious that there is only one feasible method of jointing the pattern, that shown in fig. 5. If it were in a plane, at right angles therewith, all the space between the back of the steam-chest flange and the body of the cylinder would have to be cored—work which is quite unnecessary.

Note the method of construction of figs. 5 and 6. First, there are blocking pieces B, one at each end, and also one at the centre, upon which the lagging strips are fitted with close joints, glued, and either nailed or screwed. One-half the pattern is thus built on the joint board, which ensures the truth of the joint. It is then turned over, blocked up steadily, and the other half—that, namely, with the dowels—built upon it. The two halves are then secured with dogs or with centre plates, are chucked between centres, and turned. Observe the head metal C, and the parallel form of the prints D. No taper is requisite for delivery, because the pattern moulds upon its side—that is, with the joint surfaces in a horizontal plane. The body of the pattern is grooved to receive the end flanges, by which device their accurate position at right angles with the axis of the body is ensured, and they cannot become shifted out of place by accident. The grooves are wide enough to include the hollows or the backs of the flanges.

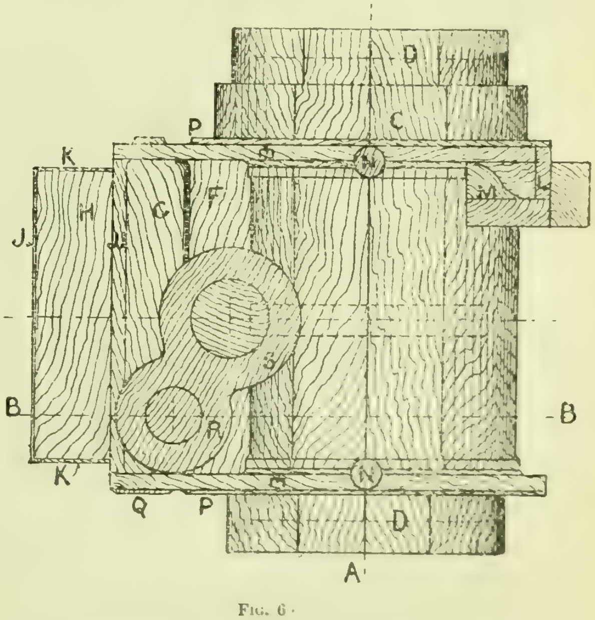


Fig. 6

The pieces for the flanges are planed to the thickness of the groove, making a close fit therewith, and are cut to the outlines seen in end view, figs. 1 and 5. The thickness E (figs. 2 and 6) is gauged, and the inner faces and the hollows curving around the cylinder body are either turned in the lathe on the face plate, or worked round with rebate plane and paring gouge.

When the flanges are worked they are screwed with two screws in each, inserted diagonally from the joint (fig. 6). The blocking for the steam chest and its flanges is then fitted between (see section B B, fig. 5) to proper dimensions.

Since this is a pattern of large size, we should not think of making the blocking of solid stuff. We box it up, using wood of about an inch in thickness. There are first the longitudinal pieces F (figs. 5 and 6) forming the metal flanking the steam passages, and fitting closely between the end flanges. Beyond these are the pieces G, giving the metal round the steam chest, and as the thickness of G would be rather excessive if brought directly down upon F, a piece of wood is interposed, and forms the hollow. The piece H, forming the face of the print, is fastened to the inside of piece G. If the inside of G did not happen to coincide with the print face, then the piece H would be rebated. Battens I, screwed within, stiffen the boxed-up structure. The outside of the print is formed by J, and the ends by K, fitting within the end flanges, with packing blocks interposed. These blocks form those portions of the steam chest flange which flank the ends of the prints. The portions of the flange at the top and bottom are lastly put on the prints H as strips J J.

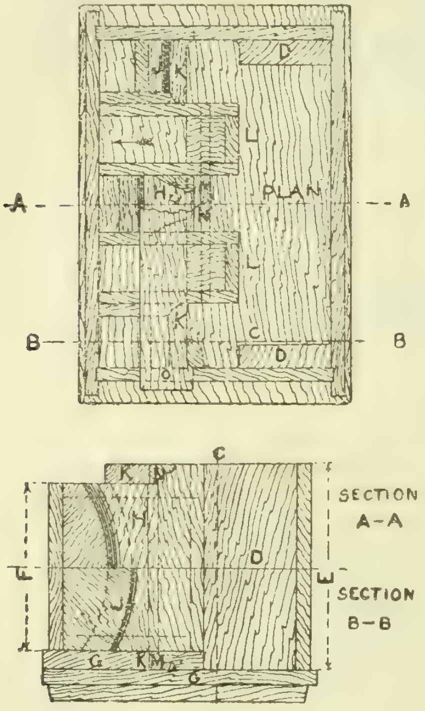


Fig. 7.

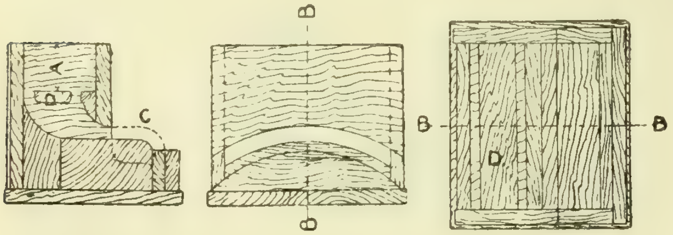


Fig. 8.

That half of the print which comes in the cope is sometimes made about $\frac{1}{4}$in. wider every way than the bottom half, as shown in figs. 5 and 6. This prevents it from crushing the top half of the core when the cope is being lowered upon it. In these figures the upper portion of the pattern is that which subsequently goes into the drag part of the flask.

At L, figs. 5 and 6, we show the patterns of the lugs by which the cylinders are bolted together, and at M the prints by which the cores coming underneath their brackets are carried. Obviously these brackets could not be left loosely wired and drawn back, because the sand outside the flanges would be in the way. Coring over them, they deliver with the pattern. The bosses N are for the indicator, and the bosses O beneath are for the drain cocks.

It is better to fit the end facings—P for the covers, and the facing Q for the bracket that carries the valve rod bushes—as distinct pieces, than to cut them solid with the flanges.

The facings P are made in segments in this case, because the diameter of the flange is too great to permit of their being cut judiciously from a solid width of stuff.

The branch R, which receives the steam pipe from the high-pressure cylinder, and S, which exhausts into the condenser, are each fitted with a butt joint to the pattern body and screwed from the inside. The flanges in each case are made loosely-fitting over the prints, which are tapered.

In moulding, the upper half in fig. 5 is rammed first, and then turned over, the branches therefore going into the drag part.

The other half is then put in place with its dowels level with the joint of the flask, and rammed. The mould is cored up while in the horizontal position, and when the cores and their vents are all secured, and the flask jointed and cottared, they are turned up bodily with the head metal portion upwards, and rammed closely around with sand in a shallow pit, ready for pouring.

There is a considerable amount of work involved in the core boxes for the steam chest and passages. The cylinder is double-ported, and the ports are very long in proportion to their width, and this increases the difficulty of making and setting them accurately. Hence the reason of the device adopted and shown in the figures.

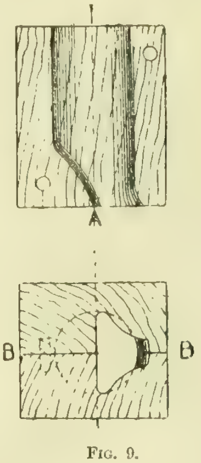


Fig. 9.

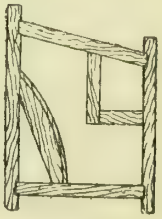


Fig. 10.

Compare figs. 7 and 8 with figs. 1, 3, 4, and 5. Fig. 7 is the box for the steam-chest core. The face of the steam chest coincides with the dotted line C, and the pieces D coincide with the ends of the print H in fig. 6, and form the internal flange C in figs. 1, 3, and 4. In fig. 7 the width E coincides with the width T of the steam chest in figs. 1, 4, and 5, and F in fig. 7 coincides with the width U of the passages in figs. 1 and 4. Hence there is a bottom board formed of two steps G G, in fig. 7, and the top edge of the box is also correspondingly shouldered down. A portion H of the exhaust core is formed in this box, the remainder in the box, fig. 9. The curved pieces I, corresponding with the curves I I in fig. 3, are left loosely wired, to be withdrawn sideways after the main portion of the box has been removed away from the core in the direction of the arrow. The sweeped parts J form the faces V in figs. 1, 3, and 4, and the parts K form the metal W, figs. 1 and 4. The projections L are the prints which carry the double-ported cores made out of the box, shown in fig. 8. In the latter figure, therefore, the width A is print fitting into L, in fig. 7. At a casual glance, it would appear as though the better course would have been to have put on prints, each for its own part, as shown dotted in fig. 3 at D D, and make the box to correspond. But I have found that by the plan in fig. 8 more accuracy can be assured, and the moulder's task is easier than when two narrow tongues of sand of $\frac{7}{16}$in. or $\frac{1}{2}$in. in thickness have to be fitted to corresponding prints, as in fig. 3, D D.

Fig. 8 is not an easy core to make. The upper curve at C has to be strickled, the strickle working transversely; the piece D has to be withdrawn endways after the removal of the sides. A grid is made to partially fill the space A, and curved rods cast in it pass round the double curves.

In fig. 7 one guide strip for the slide valves is shown at M, nailed on the bottom board ; a portion of the other strip is shown at N, nailed to the loose bar K. But when the cores made from box (fig. 8) are put in, they, being only of the depth F in fig. 7, have to be stopped over in the top. At the time of stopping over a guide strip is bedded in and formed in the top, of the same length and section as M, in the bottom.

The cores made in box, fig. 10, are for coring out beneath the lugs A, in figs. 1, 2, and 3. The box has to be reversed to make the cores right and left handed. The correspondence of the box with the joints M in fig. 5, and the curve of the cylinder body, with its belt, is apparent. The box is also an example of the economising of material in the construction of irregular forms.

J. H.

PROGRESS OF THE FORTH BRIDGE.

The progress that has been made in the construction of the Forth Bridge during the past year has been very striking. The three cantilevers have nearly approached completion, and when so much has been done in that time there seems no reason to doubt that the whole structure will be finished, as the contractors promised, about the close of the present year. The work now going on is confined almost entirely to the extremities of the arms of the cantilevers, of which, when completed, two will measure 1,514ft. from point to point, while the middle one will measure 1,620ft. These huge structures have been built first upwards and then outwards on both sides, from the foundation piers, somewhat after the manner of a coral reef, so that each foot forms the basis for the next foot. All the three cantilevers are in nearly the same state of advancement, and they are now within measurable distance of completion. When they are finished, the landward extremities of the northern and southern ones will rest on the cantilever piers—solid masses of granite masonry 160 feet high—but the difficult work will remain of connecting their outward ends with those of the middle cantilever, which rests on the island of Inchgarvie. This latter junction is to be effected by the insertion of lattice-girder bridges, each 350ft. long, which bridges will be built out yard by yard from the ends of the cantilevers, in the same way that these structures have been built. The whole erection, says a correspondent of the *Times*, is now sufficiently advanced to enable one to form a very fair idea of the appearance it will present as a complete structure. It will not be a beautiful erection. It is suggestive of vastness and strength, and perhaps a certain picturesqueness, but not at all of beauty or of grace. It has been estimated that if two Eiffel Towers were stretched out horizontally, base to base, they would together be nearly equal to one of the Forth Bridge cantilevers. From this comparison some idea may be formed of the vastness of these erections. The impression of vastness becomes greatest when one regards from below the great tubular columns, 12ft. in diameter, and rising to a height of 360ft., and the arching struts which extend outwards to a length of 650ft. The effect is still further heightened by observing the men who are now at work on the upper and lower members, and who are like swarms of flies clustering about the ends of a wire trap. Two things strike one in viewing the bridge as a whole. The one is the enormous size of the substructure and the superstructure in comparison with the slender thread of the railway line which they are designed to support. As has been said already, a train passing through it will resemble nothing so much as a bird hopping on a spar of an enormous cage. The second point is, the comparative narrowness of the bridge when viewed longitudinally. That, however, is due in part to the former feature ; but partly also to the great length of the cantilevers, both the height and the length taking from the breadth. That, however, is merely in appearance ; there is no more reason to doubt the stability of the bridge than there is to doubt that of a broad-based trestle standing on level ground.

LAUNCH OF HER MAJESTY'S SHIP VULCAN.

Laid down at Portsmouth on the 18th of June, 1888, the Vulcan was launched on Thursday, the 13th inst., with the customary formalities. Though light, being destitute of armoured protection, she is the longest vessel hitherto built at the dockyard, and she has the further distinction of being the first ship of the kind expressly designed for the navy, for though the Hecla performs similar duties afloat, and may on that account be regarded as a sister ship, she was purchased into the service and converted into a torpedo depôt. In spite of her bulk, the total weight of the Vulcan's hull does not exceed 3,200 tons, of which 2,500 were actually on the blocks at the time of launching. Though capable of either fighting or avoiding an action, her special province in war (says the *Times*) will be to act as a base of operations for a torpedo boat flotilla or the torpedo boats of a fleet. She is officially described as a swift protected cruiser, equipped with all the requisite appliances for lifting and carrying a number of the largest torpedo craft of the second class, which is an absolute necessity, considering the manner in which these little craft are knocked about in stormy weather and their liability to steam long distances. In addition to fulfilling these functions, she will be provided with a laboratory and a factory or workshop for the purpose of repairing torpedoes and torpedo boats and their machinery, and will contain all the gear necessary for submarine mining operations on a large scale, besides being a practice and training ship for all kinds of mining and torpedo work. The Vulcan measures 350ft. between perpendiculars, and 58ft. in extreme breadth. Her load draught of water will be 22ft. forward and 24ft. aft, giving her a displacement when fully equipped for sea of about 6,620 tons. The stem and stern posts are formed of large castings of steel, and she is provided with an under-water ram of a very formidable character. The double bottom extends for about half the length of the hull, and is well sub-divided into water-tight compartments. Practically, however, the double bottom is continued to the extremities by the water-tightness of the flats to the compartments in the hold. A strongly-plated deck is worked throughout the ship below the water line. Ample protection is provided by this deck to all the vital parts of the ship, such as machinery spaces, magazine, and shell rooms, and the steering compartment. Additional protection against falling splinters and injury to the machinery is afforded by a light *débris* deck in the boiler rooms. The upper part of the structure is strengthened by a large amount of plating, including special tie-plates on the upper deck, while the whale-back contour of the fore and after parts of the deck outside the breakwaters will assist in freeing the vessel of any seas that may be shipped. The amount of coal to be carried is 1,000 tons, which is stowed in bunkers both in the hold and on the protective deck, throughout the spaces occupied by the machinery. The total amount of fuel carried will, it is estimated, give the Vulcan a radius of action of 12,000 knots at a 10-knot speed. The ship will be fitted with a large balance rudder, which can be actuated both by hand from the upper deck and by steam from the bridge, wheelhouse, conning tower, and tiller compartment. The steam-power provided will be sufficient to put the helm through 70deg. in 30 seconds while the ship is driving at full speed. Though the ventilation will be generally effected by natural means, forced draught from steam fans is provided for the main engine and hydraulic pumping engine-rooms, and to all the compartments below the protective deck abaft the engines. In addition to the usual complement of ship's boats, the Vulcan will carry no fewer than nine second class torpedo boats. Provision is made for hoisting the torpedo craft in and out of the ship by hydraulic cranes weighing each, including gear and engines, 50 tons. Each of the cranes is so arranged that it can command seven of the nine boats, and lift them out in any desired order, while the details of the fittings will enable the remainder to be run across the deck on trollies, thereby bringing all the boats within reach of either crane. The ordinary ship's boats will be controlled by means of a hydraulic derrick attached to the main mast. The pumping, flooding, and drainage arrangements, both by hand and steam, are very complete. The Vulcan will be lighted throughout by electricity, and will in addition carry four powerful electric search lights. For this purpose, three complete sets of combined engines and dynamos will be employed, the latter being of the direct current pattern and of 400 ampères each at 80 volts. The system of voice-pipes will be in general accordance with the report of the committee appointed to consider the whole question Besides containing a torpedo factory and laboratory, the ship will carry a large quantity of electric cables, submarine mines and stores, and other special gear for the supply of the squadron to which she may be attached. The armament will consist exclusively of quick-firing and machine guns of the most recent construction. It will consist of eight of the most powerful 4·7in guns, mounted upon the Vavassaur central pivot principal, four forward and as many aft upon the upper deck with plating protection for the crews in charge. Both the bow and stern guns will be capable of firing across the keel. In addition to these there will be 12 three-pounder rapid-firing guns on the main deck, and a complement of machine guns upon the upper deck between the quick firers already mentioned. The Whitehead equipment will consist of a fixed torpedo tube at both the bow and stern above the water, two fixed submerged tubes forward, and possibly two broadside training tubes above the water aft. The positions of these tubes will be specially protected and so arranged that the torpedoes may be discharged by electricity, either from the conning tower forward or (so far as the tubes are concerned) from a director tower on the after part of the lower deck. The number of torpedoes carried will be 30. The propelling machinery, which will be furnished by Messrs. Humphrys, Tennant, and Co., of Deptford, will comprise two independent sets of engines of the three-cylinder triple-expansion vertical type, guaranteed to develop a mean of 12,000 horses with forced draught for four hours, and a mean of 7,200 with natural draught for 12 hours. Steam will be supplied by four double-ended cylindrical boilers and one single-ended auxiliary boiler, constructed of Siemens-Martin steel, the furnaces being of corrugated steel. The large boilers will weigh about 46 tons each. The working steam pressure is 150lb. per square inch, and the forced draught system will be used with an air pressure in the stokeholds not exceeding that of 2in. of water. Under the former condition the Vulcan is expected to realise a speed of 20 knots, and under the latter a speed of 18 knots. The various features enumerated will show that the ship bids fair to prove an invaluable auxiliary to a fleet. Her speed being at least as great as any large vessel yet afloat, and hardly less than that attained by the quickest torpedo craft, she will be able either to accept or to decline an action, while the power and rapid fire of her armament will justify her in engaging any enemy short of a battleship. Her total estimate of cost is £283,955 exclusive of guns, which are expected to cost £8,152 extra.

INSTITUTE OF MARINE ENGINEERS.

At a recent meeting of the Institute of Marine Engineers, held in the Langthorne Rooms, Broadway, Stratford, presided over by Mr. J. McFarlane Gray (vice-president), Chief Examiner of Engineers to the Board of Trade, a paper on "Shafting in the Mercantile Marine" was read by Mr. G. W. Manuel (vice-president), superintendent engineer Peninsular and Oriental Steam Navigation Company. About 90 members and visitors were present, including several Board of Trade and Lloyds' engineer surveyors, and many well-known superintending engineers.

The author of the paper, which was well illustrated by diagrams and specimens, referred to the introduction of steel as a material for shafting, when considerable uncertainty existed as to its use for such a purpose. The importance of the shafting through which the power of the engines is transmitted to the propeller to drive the steamship is such that a broken shaft may involve the total loss of valuable property, as well as the endangering of more valuable lives. In former years, engineers were considerably exercised and troubled by the heating of the revolving shafting. At the present day, with all the modern improvements, and the use of white metal for the bearings, it is unusual, with ordinary care and attention, for any difficulty to be experienced. The process of the manufacture of shafts in the forge was described, and several very interesting facts in connection with the testing of samples were given in a tabulated form. The experiments made with and the attention given to the manipulation of steel by the well-known manufacturers, Messrs. Vickers, of Sheffield, were referred to, and the results shown to be satisfactory, not only to shipowners, but all concerned.

While steel may be considered as suitable for crank and intermediate shafting, and probably more so than iron, it would appear that it is not so suitable for propeller shafts, on account of the sea water acting along with the brass where the shaft is lined at the bearings in the stern tube, and setting up a corrosive action at a part which can only be examined on the shaft being drawn when the ship is in dry dock, involving detention in dock and considerable labour and cost. Steel is deemed liable to quicker deterioration by corrosion than iron. The samples of steel exhibited were of great interest, and amply proved the great superiority of the material. The drawings illustrating the several points to which Mr. Manuel called attention were suggestive of much thought and care taken by the author in the preparation of his paper.

Messrs. A. Beldam, A. J. Maginnis, A. Gibb, White, and others took part in the discussion which ensued.

The Hon. Secretary, in the course of a few remarks, proposed that, as the subject was of wide interest, the discussion should be continued at a future date, when many members who had not entered into the discussion would have an opportunity of doing so; and on the proposal being put to the meeting, it was heartily approved. It was ultimately resolved, after consulting with Mr. Manuel as to his convenience, to continue the discussion at eight o'clock on Thursday, June 6th.

A vote of thanks was proposed to Mr. Manuel by Mr. McFarlane Gray, who in the course of his remarks expressed the satisfaction he felt in seeing the institute so well and so ably supported.

Mr. A. Beldam proposed, and Mr. A. W. Robertson seconded, a vote of thanks to the chairman, not only for presiding that night, but for the very manifest interest he has taken in the success of the institute.

Mr. Manuel and Mr. Gray duly responded, and the latter gentleman presented to the institute a coal-testing machine, by means of which the steaming quality of any coal can be gauged.

RAILWAY ENTERPRISE IN JAPAN.

The London correspondent of the *Manchester Guardian* writes as follows: From two or three different sources I hear of large railway orders for Japan being given in this country just now; indeed, I am told of one on its way which includes ten engines, about one hundred carriages, and many thousand casks of cement, while a cargo of steel rails is on its way out, and many other orders are in various stages of completion. The curious point about this is that for three years past, although the Japanese have been constructing railways with extraordinary activity, scarcely a single order for railway material was placed in this country, though prior to that they had all come here. They stopped suddenly for two or three years, and are now beginning quite as suddenly again. The secret of the matter is, that all the Japanese railways are either Government lines or constructed under Government guarantees; in one way or another the Government exercises a powerful influence over them. Three years ago, when the Treaty Conferences in Tokio were about to sit, and while they were sitting, Japanese statesmen were straining every nerve to conciliate the Ministers of the leading Powers, and it was soon found that large orders were the most effective instruments for that purpose. Accordingly Japanese naval orders went largely to France, and those for railway material went to Germany, chiefly to Krupp's, at Essen. Railway boards, under Government pressure, and no doubt also from patriotic motives, gave their orders where they were told it was highly important in the interests of the country they should be given. But with the failure of the conferences the pressure was removed; a new Foreign Minister came into power, and trade once more resumed its natural and usual channels. In this way it comes about that railway orders of considerable magnitude are once more pouring into this country in considerable numbers from Japan, and they are likely, I am told, to continue for a long time, as many hundreds of miles of railway are either in course of construction or are projected in Japan just now.

DOUBLE RADIAL DRILLING MACHINE.

Messrs. Dean, Smith, and Grace, of the Worth Valley Toolworks, Keighley, now make a very convenient form of double radial drilling machine, useful for many kinds of work, which we illustrate on page 427. It consists of a strong cast-iron base plate made in box form, with a planed upper surface, having the usual T slots for bolting down the work. Two strong pillars are mounted upon the base plate with turned trunnions, and each carries a radial arm and drill carriage or slide. Between the two arms there is ample range to cover any point in work which can be bolted upon the table. Sufficient stiffness is allowed in the pillars and radial arms to allow of absolutely true boring at right angles to the face of the base, and the driving is effected by a double-geared headstock, with a four-speed cone attached to each pillar. The drill spindles are steel, and slide on long tubes with conical bearings and adjustments for taking up wear. Hard steel thrust pieces connect the spindles with the feed screws, which are also so made as to be adjustable for wear.

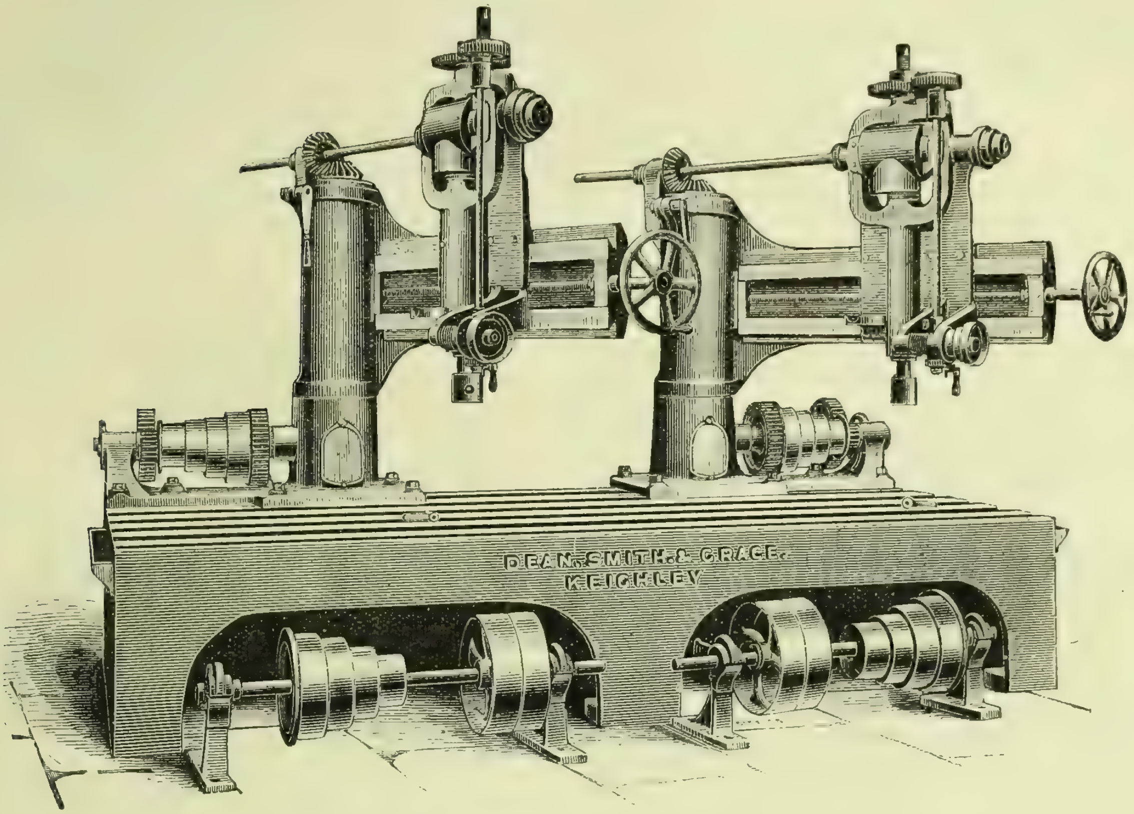
In this way the drop of the spindle, when the resistance of the metal ceases upon the hole getting through, is avoided, and breakage of drills and cutters is prevented. The feed screw works in a long gun-metal nut, and has both self-acting and hand traverse, while the drill carriages can be quickly adjusted by rack, pinion, and lever, or by screw, as required.

We are informed that the first of these machines was supplied to Messrs. Robey and Co., engineers, of Lincoln, and that seven of them have since been supplied to Messrs. Armstrong, Mitchell, and Co., where they are much appreciated and do good work. A double radial drilling machine is exceedingly useful for many classes of engine work, when holes can be drilled simultaneously in different positions.

DOUBLE RADIAL DRILLING MACHINE.

CONSTRUCTED BY MESSRS. DEAN, SMITH, AND GRACE, ENGINEERS, KEIGHLEY.

(For description see page 426.)



THE BIRMINGHAM ELECTRICAL EXHIBITION.

We hear that the space for the exhibits in the Electrical and Industrial Exhibition to be held in Bingley Hall this year has all been taken up, and that the preliminary arrangements have been settled in a most satisfactory manner. It is interesting to find that Birmingham has been well represented in the various pioneers of the now rapidly developing science of electricity. The original dynamo, or electro-depositing machine, which will be shown in the exhibition, was invented by a Birmingham man, and built in the works of Messrs. Prime and Sons, the well-known electro-platers. An interesting collection of electric-lighting apparatus, including one of the early incandescent lamps, is being sent over by Dr. Woodward, of Toronto, who was born in Birmingham. It is said that Dr. Woodward's inventions were sold to Mr. Edison at the time he commenced to bring out the system of lighting which has since become so popular. The contract for erecting the boilers, engines, and other foundations, the orchestra, and the general works connected with transforming Bingley Hall into a fitting home for the exhibition, has been let to Mr. John Parker, Conybere Street, and the works will be pushed forward with all possible despatch. It is intended to open the exhibition on Thursday, the 1st of August, and arrangements have been made with the leading railway companies in the kingdom to run excursion trains at frequent intervals, to give an opportunity for people at a distance to visit the exhibition at a low charge.

DOMESTIC MOTORS WORKED BY RAREFIED AIR.[*]

Mr. Boudenoot's earlier accounts of the system of supplying power for domestic motors by rarefied air have already been noticed.[†] In 1885 fifty of the air motors were in operation, and the vacuum was maintained by means of an exhausting engine. At present there are from one hundred and twenty to one hundred and fifty motors of $\frac{1}{2}$ H.P., 1 H.P., and $1\frac{1}{2}$ H.P., placed at from 2,000 to 2,500 feet distant. There are three exhausting engines of from 90 H.P. to 100 H.P. There is, in addition, a steam engine of 110 H.P., by which are driven two dynamos supplying from 1,200 to 1,500 electric lamps placed in the neighbourhood. Mr. Boudenoot shows that amongst the various means of transmission of power—cables, steam, water under pressure, gas, electricity, and air—this last alone is worth considering, when it is required at the same time to transmit power over a short distance, and to sub-divide it for local distribution. He adds that whilst rarefied air yields from 40 to 45 per cent of efficiency, compressed air, under like conditions, yields from 18 to 22 per cent.

At the central station, the indiarubber packing applied to the pistons of the air cylinders has been replaced by bronze packing. The indiarubber packing wore out quickly, and leakage took place between two sides of the piston ; the separated lumps of indiarubber were agglutinated with the dust drawn in, and blocked the grids of the valves. With bronze, the first objection disappeared, and the collection of dust was diminished. The grids are cleared three or four times yearly. In the presence of dust, the clack-valve is preferred to the slide valve ; the latter is liable to excessive friction and wear, due to the interposition of dust. The air cylinders are cooled by means of fine spray or water mist injected into them, in preference to water applied externally ; and the pumps are worked slowly. A vacuum alarm is employed, by means of which the operations of the machines are so regulated that a constant vacuum is maintained at the extremities of the conduits, notwithstanding the variation of the demands of the users. The revolutions of the motors are registered by means of an apparatus which shows from hour to to hour the variations of the work done by the motors, and the total number of revolutions made each month. These instruments, with the vacuum gauges placed at various points, constitute a very useful set of controlling apparatus. With regard to the loss of head in the pipes, the formula of Stockalper, $J = \alpha \, Q^2 \, \delta$, has proved to be approximately correct in practice.[*]

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[*] By L. Boudenoot, Inst.C.E., Foreign Abstracts.

[†] Minutes of Proceedings Inst.C.E., vol. xc., p 527 ; and vol. xciii., p. 571.

[*] Minutes of Proceedings Inst. C.E., vol. lxiii., p. 318.

Of the three forms of motors employed—the oscillating, the rotative, and the trunk—the last alone is now in use, and there are now trunk motors of

NOMINAL WORK PER MINUTE.

100 kilogrammetres (or 43,500 foot-pounds), which yield more than $1\frac{1}{2}$ H.P.
50 ,, (or 21,750 ,,), ,, nearly 1 H.P.
25 ,, (or 10,875 ,,), ,, $\frac{1}{2}$ H.P.

The motors are tested at the works before being hired out. The performance of a 50-kilogrammetre motor, for example, as tested, was as follows :—

Condition.	Air per Minute.	Pressure.	Power Developed in the Cylinder.	Power Developed at the Brake.	Efficiency of the Motor.
	Cubic Inches.	Atmosphere.	Foot-pounds.	Foot-pounds.	Per cent.
Light work	427	0·282	353	243	68
Medium ,, ...	671	0·414	489	397	81
Full ,, normal	976	0·540	587	514	88

It is expected that the rarefied-air system will be adopted at St. Etienne, for the use of the lacemakers, where hydraulic power is available for working the pumps.

The electric lighting installation comprises a horizontal Corliss steam engine of 110 H.P., two Gramme dynamos of 370 ampéres and 110 volts, with the transmission necessary for a distribution of 200 volts to three conductors, with the lamps.

LESSONS IN MECHANICAL DRAWING—XXVIII.

By Prof. A. MacLay, B.Sc., C.E.

Slider Crank Parallel Motions.

Both the slider crank and the quadric crank chain may be illustrated by exercises on the class of mechanisms called Parallel Motions. In these, it may be explained, the object is to get one or more points to move accurately, or at least very approximately in a straight line through a considerable range of motion, without the direct use of sliding pairs. This has already been illustrated to some extent for the quadric crank chain in the last lesson. In the present lesson, let us take a look at some of the applications of the slider crank, and in the first place at the geometrical principle upon which these arrangements are based.

In Ex. 130 attention was directed to the fact that if a circle rolls within a fixed circle of exactly twice its diameter, the path of a point on its circumference (the hypocycloid) is a perfectly straight line, and in Ex. 141, that the path of any other point not on the circumference (curtate or prolate hypotrochoid) is an ellipse.

It was also shown in Ex. 92 that if the extremities of a straight line are constrained to move in two straight lines at right angles to each other, then the path of any point on the line produced is an ellipse; in Ex. 97, that of the middle point of the line a circle; in Ex. 107, that of any point between the extremities, an ellipse.

In fig. 178 of the present lesson, these properties are shown in their connection with one another. ABC is a rolling circle, AB a diameter of it. FEG is its guiding circle, of radius equal to AB. As ABC rolls on FEG, the points A and B (the extremities of the diameter AB) trace out FG and DE respectively, two diameters of the guiding circle, which intersect at right angles at C. R, the centre of the rolling circle, traces out the circle KRH of diameter, equal to AB. Any other point between A and B, such as R^1 and R_1, or beyond A and B, such as R^2 and R_2, traces out an ellipse.

It will now be evident to the student that if we guide two points of the line AB in their proper paths, a third point may be found which will move in a straight line, circle, or ellipse as may be required. For a parallel motion the third point is required to move in a straight line; therefore it must be either A or B; and for a slider crank parallel motion one of the guided points must be either B or A. The other guided point is made to move in an arc of a circle, which is as close an approximation as possible to the actual elliptic path of the point, as shown in the diagram. For a range of angular deviation of AB to either side of its central position, not exceeding 25 deg., approximation can be found by finding the centre of a circle which will pass through the middle position and the two extreme positions of the point. Thus, for example, when B is the one guided point, R_1 is the other. A point C_1 is found, which is the centre of a circle passing through $R_1 a_1 b_1$. We have thus here in diagrammatic form the lengths for a mechanical arrangement, in which a swinging link AB, guided by a sliding pair at B along the line CE, is so controlled by a link C_1R_1 turning round a fixed centre C_1, that its other extremity A moves very approximately in the straight line FG. In the following diagrams the same letters denote the same relative positions of the points.

(1) Elliptic Parallel Motions.

Exercises.

Ex. 191, Fig. 178.—Draw the diagram representing the figure which has just been described, supposing the rolling circle to be 3in. diameter, and ∠ ABC $\not>$ 25 deg. Find the paths of the points R^2, A, R^1, R, R_1, B, and R_2, assuming them to be at, say, $\frac{1}{4}$ AB apart.

Ex. 192, Fig. 179.—From the diagram in the last exercise take the proportions for a swinging slider parallel motion, in which B is the one guide point, R the middle point of AB is the other, and A is the point whose path is required.

These proportions (CR = AR = BR) give the grasshopper parallel motion of Scott Russell, already referred to in Ex. 181. Since R moves in a circle, no approximate arc is required, and the path of A is a perfectly straight line, which would be of range equal to the diameter of the guiding circle in fig. 178, or = 2 (CR + RA). This case, therefore, differs from the others in the present lesson in being not an *approximate* but an *exact* parallel motion.

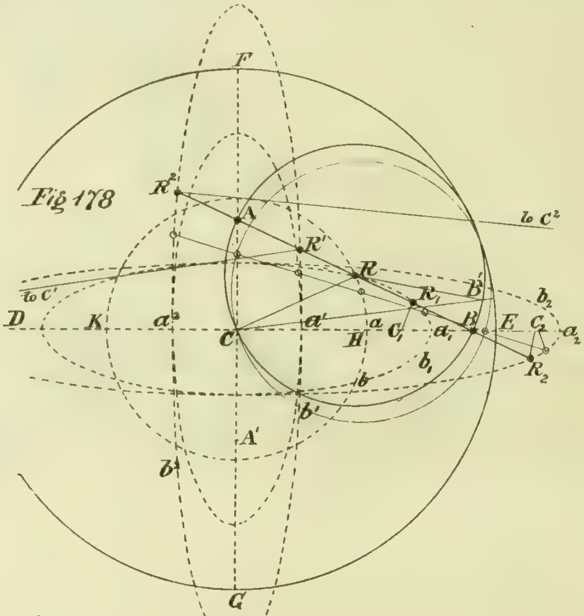


Fig 178

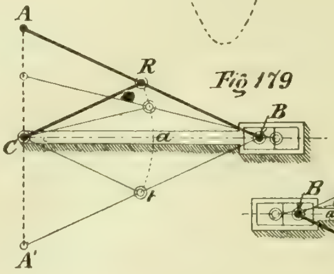


Fig 179

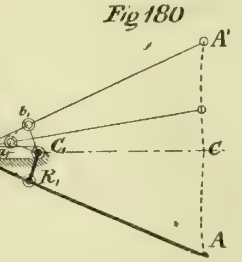


Fig 180

Ex. 193, Fig. 180.—Take next the point R_1 of fig. 178 at $\frac{1}{4}$ AB from end B as the second guided point, and find the path of A.

To get a good approximation to a straight line path, it will be found necessary to limit the *total* range to 25 deg. in this case. The reason is that the actual path of R_1 here occurs at that part of the ellipse where the rate of change of curvature is greatest, and consequently the approximation of the circular arc to the elliptical arc least complete.

Ex. 194, Fig. 181.—Let the second guided point lie on AB, produced as at R_2, beyond B in fig. 178. Find the path of A for a total angular deviation of 25 deg.

This case is like the last in respect that the actual path of R_2, like that of R_1, occurs at a similar part of the ellipse, viz., towards the extremity of the *major* axis.

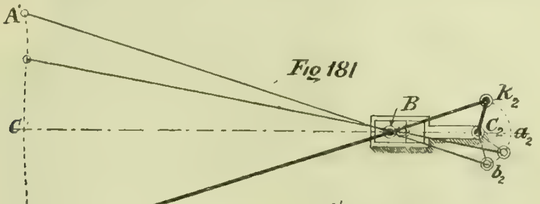
Ex. 195, Fig. 182.—Let B be the one guided point as before; but let the other be placed nearer to A, as at R^1, fig. 178. Find first the radius of a circular arc which closely approximates to the elliptic path $R^1a^1b^1$ in that figure, then the path of A.

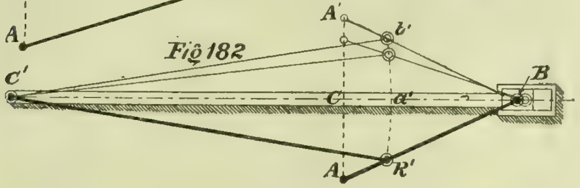
This arrangement gives for the path of A a line which is practically straight, as the range of R^1 is in this case to either side of the *minor* axis, where the rate of change of curvature is at a minimum.

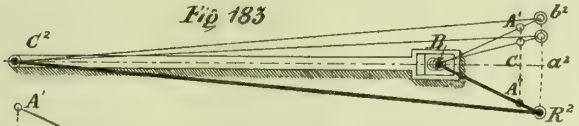
Ex. 196, Fig. 183.—Take now for the second guided point the point R^2, which lies beyond A, as in fig. 178. Find first, as in the last case, the radius for a circular arc through $R^2a^2b^2$, then the path of A.

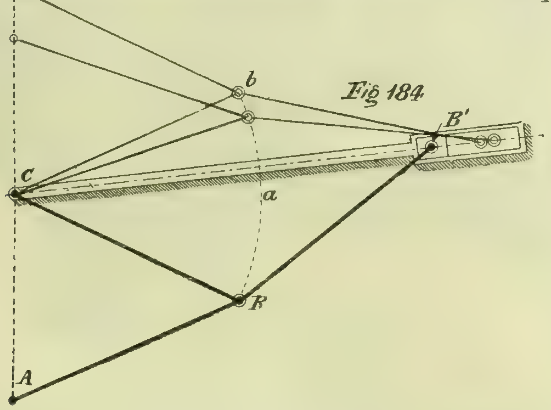
Skew Arrangements.

In the foregoing examples the points A and B are taken at the extremities of a diameter, so as to move at right angles to each other, which is the more common arrangement, but A and B may be any points on the circle ABC. For example, suppose B to occupy the position B^1, its path is then B^1C, and the guide for its motion must lie along that line. But it is evident that this has no effect on the line of direction of A's motion.









Ex. 197.—From fig. 178 take the proportions for a slider-crank arrangement $ACRB^1$, and show the path of A, as in fig. 184.

Ex. 198.—Draw an arrangement of the slider, corresponding to the points AR^1B^1C, in fig. 178, and show the path of A.

Ex. 199.—Draw a similar arrangement to the last, but take the point R^2 instead of R^1.

Referring to Ex. 171 (p. 6), it was there shown (fig. 148) how to draw the curve known as the conchoid of Nicomedes. In the same way conchoidal curves, traced by various points on the line, may be drawn. The more general form of the problem may thus be stated: Given a fixed point B (fig. 185), and a straight line RS in the plane of the paper, one point A on the line PQ is constrained to move along RS. Find the path of a second point—*e.g.*, R^1—on the line PQ, if the latter passes through B. Several such paths are shown in fig. 185.

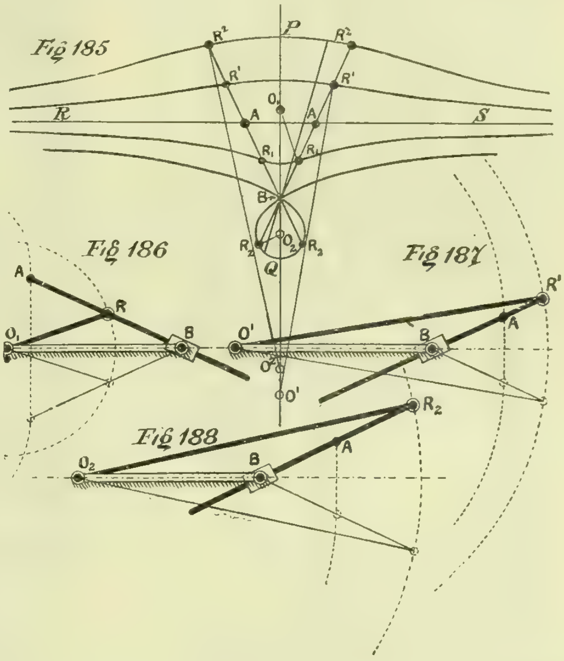
This condition evidently offers itself readily for application as a means of obtaining a parallel motion. For if the point R^1, say, be guided in its conchoidal path, then the point A will move in a straight line. And, as in the case of the ellipse, for a limited range of motion, a circular arc may be found which approximates sufficiently to the conchoidal arc to make the motion of A practically rectilinear. Thus, in fig. 185, the four points R^2, R^1, R_1, and R_2, on the line PQ trace out the curves shown, while the line PQ turns about B, and the point A is guided directly in the straight line RS. Conversely, if we guide any of those four points in their respective curves, R^2R^2, R^1R^1, &c., then A moves without direct guiding in the straight line RS. For the limited range of angular deviation shown (25 deg. from the central position on each side), a circular arc can be drawn, which closely approximates to the conchoidal arc. Thus O^2 is the centre of a circle which passes through the three points R^2, P, R^2. This circle coincides so very nearly with the conchoid through R^2R^2, that the path of A, in fig. 188 (where O^2R^2 is the length of the radius bar), is practically a straight line within the range required.

Exercises.

Ex. 200, Fig. 185.—Draw a diagram from which to obtain the proportionate lengths for the four conchoidal parallel motions illustrated by figs. 156 and 186-87-88.

Take PQ as 4in. long, and place the points R^2, R^1, A, R_1, B, and R_2 at a distance of $\frac{1}{5}$ PQ apart. Show the paths for 2in. on each side of the middle position PQ.

Ex. 201.—Find first the centre of a circle to pass through R_1 R_1 in fig. 185 as at O_1, then adopting the proportions found in that diagram, draw the form of parallel motion of fig. 186, and show the exact path of A.



Ex. 202.—Find O_2 the centre of a circular arc to pass through R_2 R_2, fig. 185. Then draw a parallel motion such as was illustrated in fig. 156, page 110.

Ex. 203.—From fig. 185 obtain the proportions for the mechanism, fig. 187, in which R^1 is the guided point, and trace the path of A.

Ex. 204.—Similarly, from the diagram, find the proportions for fig. 188, where R^2 is the guided point, and show the path of A.

A Hanging Road.—The cantonal authorities of the districts around Mount Pilatus have under consideration a proposal for the construction of a novel kind of road which has been submitted to them by M. Leonardo Torres, of Santander, through the Central Government at Berne. This road would connect the so-called Oberhaupt, or highest point of Pilatus, with the Klimsenhorn. The object would be to make the ascent of the mountain easier on the northern side and to shorten the ascent for tourists coming from Hergiswyl. The difference in level between the two points is set down at 194 metres, the distance between them at 465 metres. The road apparatus (for such it must be called) would consist of six wire cables, quite independent of one another, on which six light pulley wheels will move, and from these wheels a small omnibus capable of carrying eight persons will hang. The omnibus will be drawn by a rope attached to a steam engine to be placed on the Oberhaupt, near the Bellevue Hotel.

THE OTIS HYDRAULIC ELEVATOR.

CONSTRUCTED BY THE AMERICAN ELEVATOR COMPANY, ENGINEERS, LONDON.

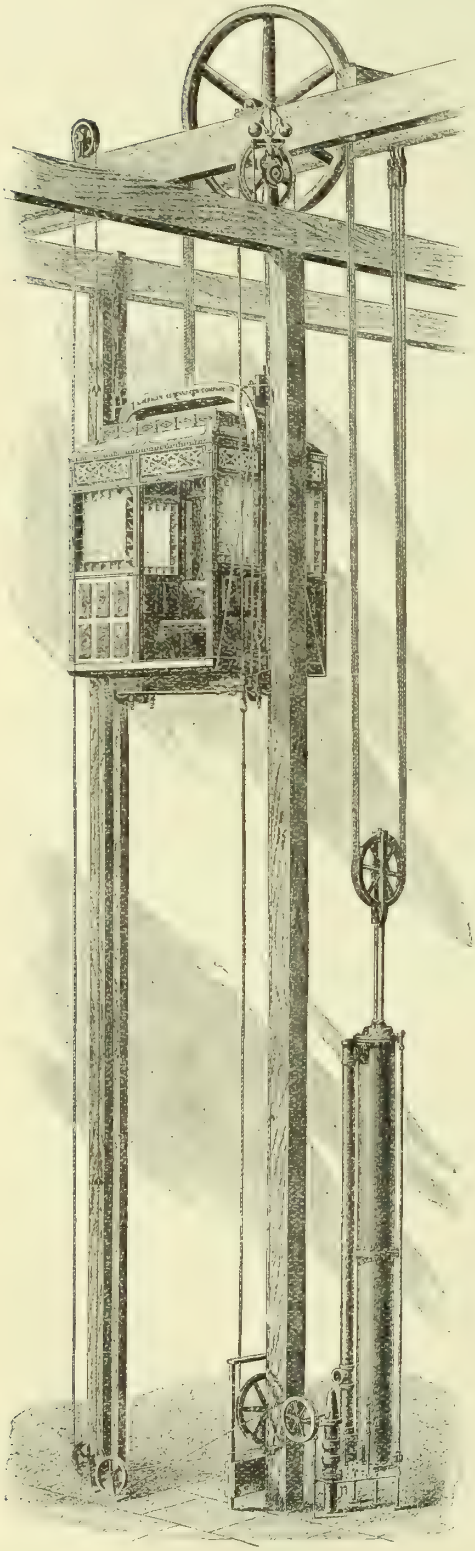


FIG. 1.

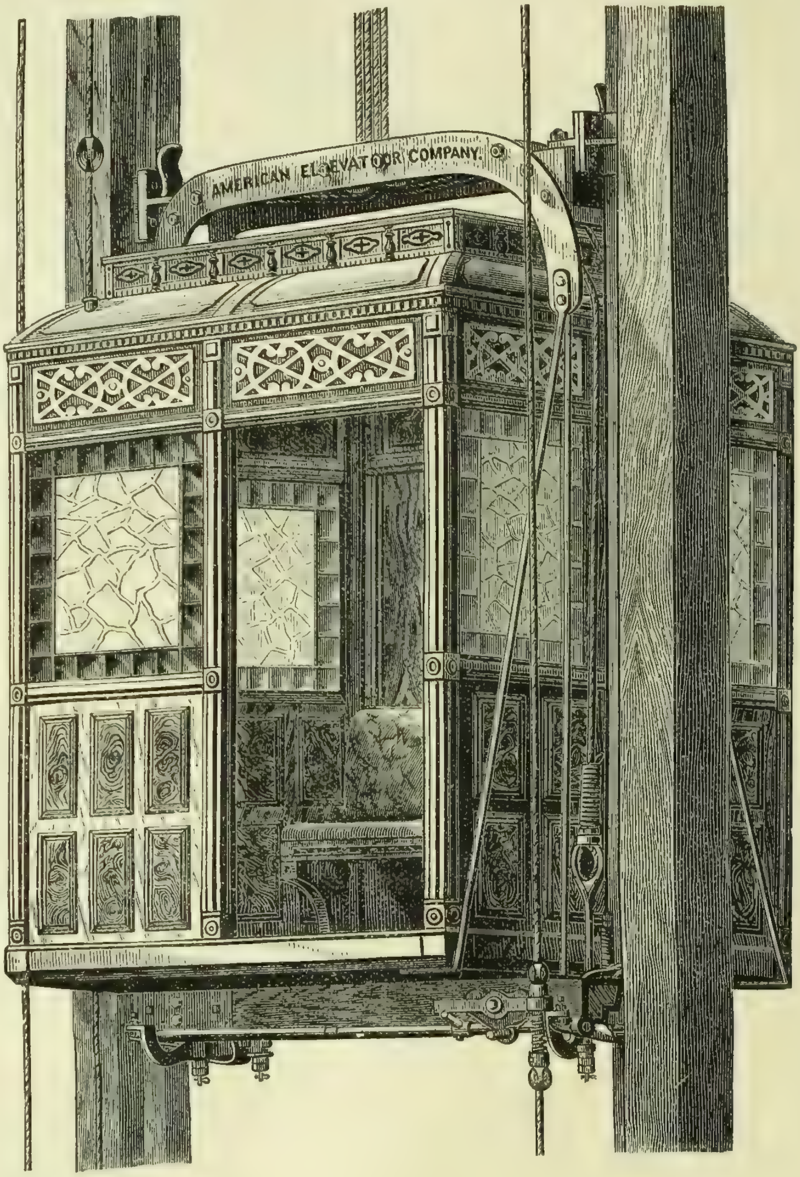

AMERICAN ELEVATOR COMPANY.

FIG. 2.

CONSIDERABLE attention has been drawn to the Otis hydraulic elevator by its use at the Paris Exhibition in the Eiffel Tower, and by the accounts of experiments made upon its safety appliances there, which have been exceedingly successful. The safety appliances attached to many ordinary hoists have unfortunately proved useless just at the critical moment when they ought to come into action, and in this country we are apt to distrust automatic devices intended to operate should a rope break. The arrangements of the Otis elevator are exceedingly ingenious and perfect, and we have much pleasure in illustrating and describing its leading features. In our large English towns very many buildings are now in use of many stories high, and passenger lifts are becoming more common daily. But they are not yet in such universal demand as in America, where the staircase has long been considered too slow a means of ascension, and the elevator is almost established as one of the necessities of business and domestic life. American engineers have consequently had much greater experience of high-speed passenger lifts than we have, and have devoted more time and study to their principles and details. Foremost among American lifts is that of Messrs. Otis Brothers and Co., of New York, represented in Britain by their branch house, the American Elevator Co., of Queen Victoria Street, London. The firm has been engaged in the manufacture of elevators for over thirty-five years, and during the whole time no accident has occurred to any part of their apparatus such as to cause loss of life. This enviable immunity has been attained by the almost extravagant precautions taken in the design and construction of the elevators, so that every contingency which can possibly occur in practice is adequately met, without danger to the occupants of the lift. In passenger lifts the first condition is absolute safety, and that this condition is really attained is seen from the fact that in New York alone the Otis elevators carry more passengers per day than travel in a similar time upon the underground railway in London, and that without accident.

Referring to our illustrations, fig. 1 is a general view, showing the arrangement of hydraulic cylinder valves, cage, and ropes. Fig. 2 is on a larger scale, and shows the cage and details of its attachment to the sustaining ropes. Fig. 3 shows separately the hydraulic cylinder and valves, while fig. 4 shows details of rope attachments and safety wedge. The motive power is supplied by the hydraulic cylinder, the piston of which is actuated by water from a tank at the top of the building, which may be pumped up in any convenient way by steam or gas engine, or if the town's water is cheap enough, that may be used. The hydraulic piston communicates by two piston rods to a stirrup carrying a pulley, under which pass four wire ropes fixed at one end above the cage, and connecting to the cage in a special manner after passing over a pulley, as seen in fig. 1. When the cage is in its lowest position the piston is at the top of the hydraulic cylinder, and the weight is lifted by moving the controlling piston valve (seen in front of fig. 3) by the rope wheel (also shown), to allow the pressure to act upon the upper side of the piston by the side pipe, and cut off communication between the upper and lower sides of the piston.

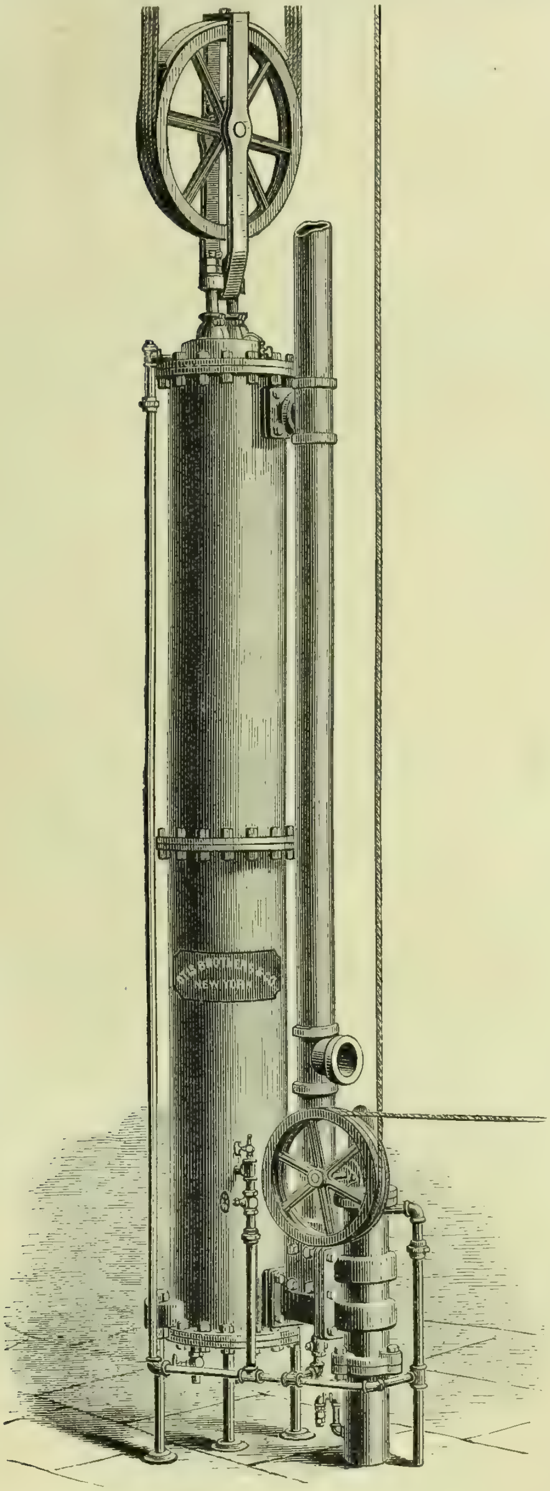


Fig. .

The lower part of the cylinder is open to the discharge, but the level of discharge is never more than 30ft. from the highest position of the piston. In this way the piston is forced down by a column of water above it, and the pressure under it is diminished by the height of the column having a maximum of 30ft. But as it moves down the column above increases and the column below diminishes, and so the available pressure forcing it down is kept constant. The suction of the column below diminishes just as the pressure above increases. By this device the available pressure actuating the piston is kept perfectly constant through the whole lift of the cage. When the cage reaches the top, the piston has reached the end of its stroke, and if communication be then opened between the two sides of the cylinder, although the full pressure of water is upon it, yet as it acts on both sides of the piston equally, or with a difference only due to the area of the piston rods, the weight of the cage causes it to descend. The water then passes from the one side of the piston to the other, and none is discharged. The cylinder must never exceed 30ft. in length, so that the column of water may be able to follow the piston completely to the top by atmospheric pressure.

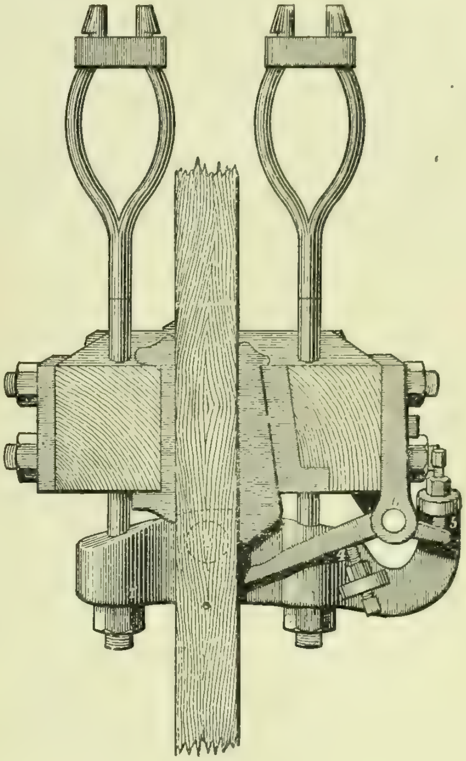


Fig. 4.

The four wire ropes sustaining the cage pass through an iron yoke, seen in fig. 2, and are guided separately by pulleys down the sides, in pairs, to the supporting beam at the bottom, where they are attached to the ends of eye or loop bolts, shown clearly in fig. 4. The loop bolts pass easily through holes in a cross lever, figured 1, 3, which pivots at the point 2, where a pin is firmly attached to the beam. The weight of the cage is thus taken by two cross levers, one at each end, under it, arranged to move freely on points such as 2. The four ropes are adjusted in length to keep these levers horizontal, and each rope must necessarily take one-fourth part of the total strain. If any one rope should by constant use become longer than the others from any defect, then the cross lever assumes an inclined position, the direction depending on the rope unduly stretched. If, for instance, the eye bolt at the end marked 1 is allowed to get lower, then the cross lever is inclined upwards, from 1 to 3, and a contact screw 4 in a projection attached, lifts the lever, pivoting at 6, and the gun-metal safety wedge is forced in and grips the guide rail. The pivot 6 is really a weigh shaft passing across the cage, and if moved by the lever at either end the wedges at both sides at once engage. If this should happen when the lift is rising, it is not arrested, but whenever lowering is attempted the wedges at once seize. In this way the smallest failure of either of the four ropes at once stops the working of the cage, and the attendant has to examine matters to find the flaw.

It is exceedingly improbable—indeed, almost impossible—that all four ropes should fail absolutely simultaneously, as if all broke, yet one would part before another, and bring the safety wedges into action; but even this exceedingly remote contingency is provided for. A centrifugal governor, seen in fig. 1, at the top of the lift framing, is driven from the cage by an endless rope attached, as shown, to a lever acting on a projection from the weigh shaft. Springs are arranged to allow sufficient power for the governor without moving the weigh shaft; but should the speed exceed a safe limit, the governor balls fly out and a brake seizes the rope, and so retards it sufficiently to put in the gun-metal wedges. If this occurs, then the wedges can be withdrawn simply by raising the hoist again.

Automatic arrangements are made to actuate the controlling valve at the top and bottom of the piston movement, so as to bring the cage gradually to rest; but in the event of these adjustments becoming deranged, the water ports in the sides of the cylinder are arranged to gradually increase resistance and stop the movement.

Each rope is capable by itself of carrying easily the maximum load of cage and passengers, and all the fastenings are in duplicate, some even trebled, to minimise the effect of any hidden flaw in any one of them. Thus there are two piston rods, the sheave stirrup is triple, each able to take full load, and all pieces are carefully calculated to secure absolute immunity from danger, even should all the load fall upon one only.

The American hydraulic elevator is an admirably designed and executed piece of engineering work, evincing great mechanical ingenuity and practical skill, which is the result of prolonged experience and much thought. We understand that it is rapidly making its way in this country for passenger work, where safety to life and perfectly smooth running is the primary consideration.

All the ordinary and extraordinary accidents met with in an extended experience have been carefully provided against by this system, and whatever happens in the way of obstruction or breakage, no harm can come to the passengers carried. We hope shortly to describe the peculiarities of this lift as in use at the Paris Exhibition.

ELECTRIC WELDING.

(Concluded from page 414.)

The table following gives analysis made by Mr. P. De la Vieuville :—

	B	A	B	A
Steel.				
Carbon	0·44	0·22	0·52	0·29
Silicon	0·03	trace	0·05	trace
Manganese	0·57	0·14	o·42	0·36
Sulphur	0·041	0·036	0·039	0·035
Phosphorus	0·102	0·100	0·07	0·050
Iron.				
Carbon	0·38	0·15	0·30	0·13
Silicon	0·03	0	trace	0
Manganese	0·53	0·16	0·36	0·30
Sulphur	0·160	0·120	0·110	0·070
Phosphorus	0·137	0·124	0·105	0·087

The B columns have reference to the original metal before electrical treatment; the A columns give the composition of the metal after the treatment. The changes are slight, and appear rather favourable. One of the most valuable and extensive applications of this process is for welding plates of all thicknesses.

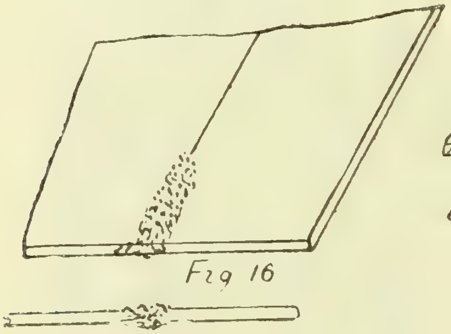


Fig 16

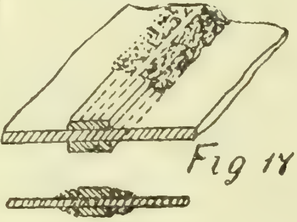


Fig 17

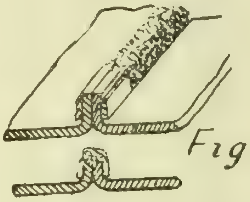


Fig. 18.

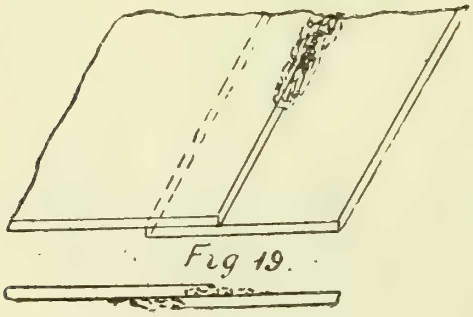


Fig 19.

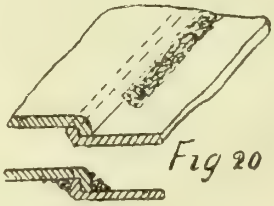


Fig 20

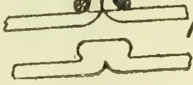


Fig. 21.

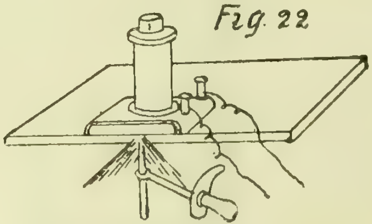


Fig. 22

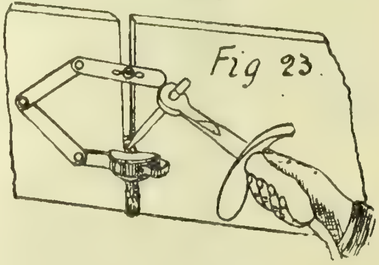


Fig 23.

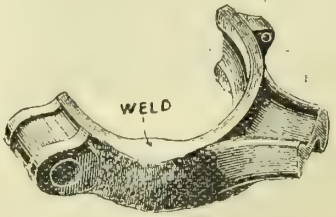


Fig. 24.

For the very finest sheets, of one millimetre and less, the Benardos Company prefer, with commendable impartiality, a modification of the Elihu Thomson process (already described), although it can be accomplished by the Benardos process. All stronger plates are subjected to the arc. To attain this with ordinary plates, the edges are grooved or veed, as shown in fig. 14, butted close together. The furrows are filled up with small pieces of the same material; the arc is then applied, while fresh pieces are added, until the furrow is filled up with the molten mass. The plates are immediately afterwards finished under the hammer. The figures, Nos. 16 to 20, show other ways of joining plates in cases where a perfectly straight surface is not insisted on. Fig. 18 offers some advantages for two $\frac{1}{6}$in. plates; a seam of a yard length can be made in seven minutes. To join two telegraph wires, the ends are bent, as in fig. 21; a little iron ring is pushed over the hooks, and the whole fixed into a sort of button. The joint leaves nothing to be desired as to its conductivity and breaking strength. The operation is accomplished with a few cells in two minutes for four-millimetre wire.

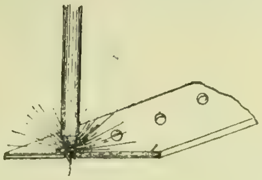


Fig. 25.

In making iron welds the small pieces are always pieces of wrought iron. With iron, a flux of clay is recommended; with copper, borax and sal ammoniac. The double V arrangement (fig. 15) secures great strength, but is only applicable when the lower surface of the metal can be got at. When the plates are to be joined on the under surface, the inventor suggests a powerful electro-magnet, placed as shown on diagram, to prevent the liquid metal from flowing off (fig. 22). This would, of course, not be of any use in the case of paramagnetic material; but as these would be under treatment very rarely, if ever, for all practical purposes the electro-magnet might do. The idea, however, has not yet been much made use of. The apparatus shown in fig. 23 looks more practical. It is intended to be employed when making seams. The pincers carry two pieces of graphite or coke, forming a sort of chamber at the spot where the fusion is to be carried on. As soon as the mass has hardened sufficiently, the carbon pieces are pushed further up. Carbon pieces are frequently employed to prevent the flowing off of the fused material. The arrangement described suggests an application to shipbuilding. The size of the article to be treated is a question of secondary importance, as the arc is brought to the work, and not the work taken to the arc, a great advantage, although for soldering small work and welding easily portable pieces of metal it is an advantage to have a fixed operating table and bring the material to it.

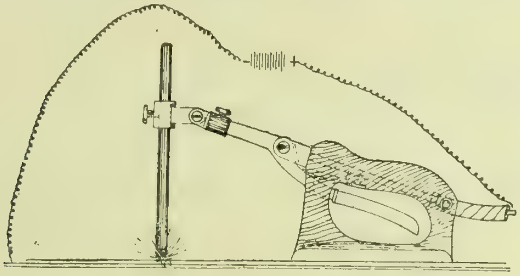


Fig. 26.

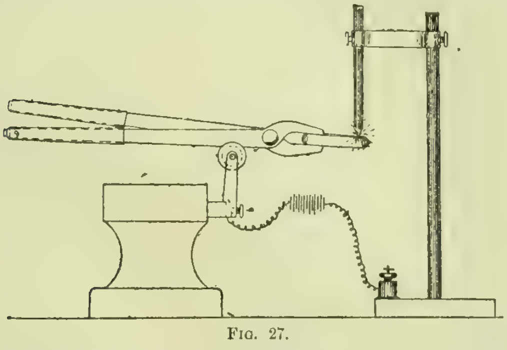


Fig. 27.

An example of the advantage of this process for repairs occurred in the summer of 1887, at the emery works of Messrs. Struve, of St. Petersburg, which directed general attention to the process. The works have a vertical boiler with heaters, some of which had become leaky, and the works were practically at a standstill. The consulting engineer expressed his opinion that the repairs would cost about 1,400 roubles, and would occupy about three weeks time. Mr. Von Benardos was called in, and offered to repair the heaters that day. The boiler was put upon a truck, taken to the Benardos Works, treated by his process electrically on the truck, and wheeled back, all in three hours time. The actual time taken in repairing the heater was one hour. Professor Ruhlmann says he saw the boiler in full working action next working day.

Another case of heavy repairs is mentioned by Professor Ruhlmann. A cast-iron flywheel, of more than five tons in weight, had been broken into several pieces whilst being taken down from the truck. The pieces were fused together within a few hours. The following working day the flywheel was in place and at work. An eccentric strap was welded, as shown in fig. 24. Figs. 25 and 26 show method of boring rivet holes. Fig. 27 shows electric forge, where the work is pushed forward to the carbon forming the arc. Another method is shown in fig. 28, where two carbons are parallel, forming an arc, at which the work is heated, and then transferred to the anvil for forging. The fusion of layers of metal, one on top of the other, in various ways, is effected by introducing into the arc a carbon pencil, prepared with the metal with which the fusion is to be effected. This falls, drop by drop, in a continuous jet. The pencil is insulated (fig. 29); used for soldering, filling up cracks, &c., for armour plates, hermetical casings for projectiles, &c. Fig. 30 represents an iron stay composed of corrugated sheets. The mode of fastening is shown.

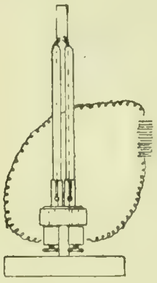


Fig. 28

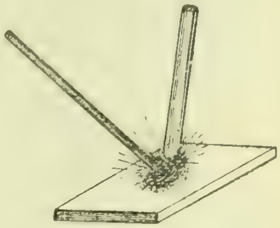


Fig. 29.

The tensile strength tests of joints made electrically show very satisfactory results. Two pieces of charcoal iron, joined together as shown in fig. 16, gave a breaking strength of 28·6 kilogrammes per square centimetre (18 tons per square inch), the iron itself giving 32 kilogrammes; the elongation was 9 per cent. In another instance, 93 per cent of the initial tensile strength was observed. A plate, electrically riveted, tore finally outside the line of rivets. The electrical joining of plates without rivets, as shown in figs. 16, 17, 18, 19, 20, offers material advantages for some purposes.

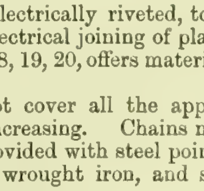


Fig. 30.

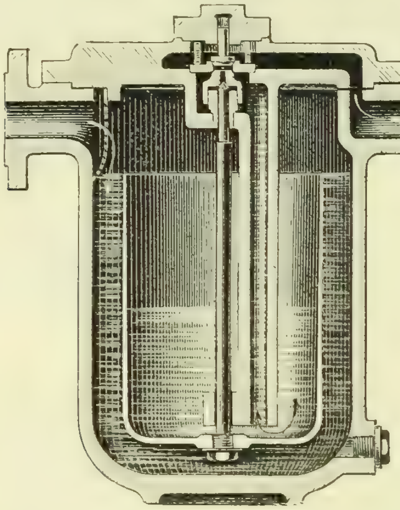
The above does not cover all the applications, they are so numerous, and are increasing. Chains may be produced with welded links, tools provided with steel points and edges, general repairs in cast iron, wrought iron, and steel. Fig. 24 shows a repaired eccentric sheave.

This process is well worthy of the attention of all engineers and shipbuilders. The cost of such a welding plant would not be heavy. The dynamo and accumulators could weld and repair during the day and provide light.

The Electro Hephaestos Co., of St. Petersburg, have taken up these inventions. In Russia the processes have been introduced at the well-known works of Messrs. Struve. For Austria and France, Baron Rothschild has acquired licences, and works have been started at Criel. A Dresden company is about to create works at Berlin. Britons seem to have been slow in appreciating the merits of these inventions.

NEW STEAM TRAP.

We here illustrate an ingenious and sensitive form of steam trap recently introduced by Messrs. Schäffer and Budenberg, engineers, Manchester and Glasgow. It consists of an open bell float, around which water accumulates until it fills and sinks. A spindle attached to it then withdraws and opens a small valve formed by its end. The steam pressure then passes through the aperture, and the main discharge valve, in which the rod end is seated, is no longer held against its seat by the pressure of the steam and float; it therefore falls, and the water filling the float is discharged, as shown in our illustration.



By this arrangement a full discharge area is allowed, with but a small float, and the power required to take the spindle off its seat in the main discharge valve is very slight, as the area is small. So soon as the steam finds it way through the small hole in the main valve the upward pressure is removed, and the valve falls. When the float is discharged it again rises and closes the valve against its seat, while the spindle valve closes the aperture in the main valve. In these days of high steam pressures it is important to have steam traps of moderate dimensions, and this advantage is fully secured in the "Acme" steam trap.

ON THE TREATMENT OF STEEL BY HYDRAULIC PRESSURE.

(Concluded from page 400.)

The mould, having been prepared, dried and warmed, was placed in position on the lift in front of the press, the ladle with the metal was run over it, and the metal tapped into the mould. The ladle was then quickly run back from the face of the press, and the mould with its charge was raised until the platform rested on its top stops. A horizontal hydraulic ram then transferred the mould on its carriage beneath the press, after which the ram was withdrawn and all the workmen retired. The moving head then descended until the top plunger came fairly into contact with the fluid metal. The head, weighing 50 tons, would continue to descend for a few seconds, after which it was locked in position and the compression completed by admitting the water direct from the pumps to the large pressing cylinder. During the first few minutes the ingot shortened rapidly, and a considerable volume of gases escaped and burned from the vents around the top and bottom of the mould. The pressing was continued as long as there was any perceptible shortening. The maximum pressures attained ranged from 4 to 12 tons per square inch on the metal, and were maintained for from 45 minutes to three or four hours, according to the size of ingot and the condition of the metal. The contraction in length during the application of the pressure usually amounted to about 1½in. to the foot of length. The author then referred to the former practice of casting hollow forms under the press, which, owing to various enumerated difficulties, had been abandoned in favour of the solid ingot both in England and in Russia. In the manufacture of trunnions for 6in. B.L. guns from unpressed ingots, the practice was to take an ingot of 65 cwt., reject one-third from the top end, and then to make three trunnions from the remainder of the ingot, after which not unfrequently one of the forgings was rejected for unsoundness. When pressed ingots were taken, however, five trunnions were made from the same ingot, and a rejected forging for faulty metal was unknown. The density of a fluid-compressed ingot as a whole was from 8 per cent to 12 per cent higher than an unpressed ingot. The author's experiments upon sound samples of crucible steel containing 0·54 per cent of carbon gave a specific gravity of 7·8542 for the unpressed metal, as against a mean of 7·8795 for specimens of the same metal after fluid compression. In order to compare the behaviour of the pressed with the unpressed metal, made from similar materials and in the same manner, the two ingots of 8 tons each were cast of open-hearth steel. The unpressed ingot contained carbon, 0·5 per cent, and manganese, 0·35 per cent; it was 30·70in. in diameter, and 82in. long. The second was a similar ingot, but containing carbon, 0·39 per cent, and manganese, 0·4 per cent; it measured 70·5in. in length after fluid compression, or 79in. as cast; it was 34·25in. in diameter. A slab of 4·75in. in thickness, and of the full length and width of the ingot, was obtained from the centre of each by parting each ingot longitudinally into three pieces on the planing machine. The surfaces so obtained presented much unsoundness in the unpressed ingot, while the pressed ingot was quite sound on both faces. The central slab from the pressed ingot was cut up into seven series of test pieces, in such manner that 98 test pieces were prepared from it, but only five series, or 70 test pieces, were obtainable from the unpressed ingot. The centre test of each series was taken directly along the axis of the ingot, and test pieces in each series were cut directly across the axis of the ingot; these were intentionally taken from the very worst part of the compressed ingot. Notwithstanding this, and that the mean results were taken over the whole length of the pressed ingot, as against the best or lower two-thirds of the unpressed ingot, and also that the test pieces from the pressed ingot were taken over the full diameter of the ingot, while the samples from the unpressed ingot were taken only over 24in. of the diameter, the outer and unsound 3½in. at each end of the diameter being rejected—after these and other advantageous conditions were allowed, yet the mean results from the pressed ingot over its whole volume were superior in each detail to those from the five series of tests from the unpressed ingot.

	Mean of the Test Pieces cut Longitudinally.			
	Elastic Limit in Tons per square inch.	Ultimate Breaking Strength in Tons per square inch.	Contraction in Area at Point of Fracture.	Elongation in 4 inches.
			Per cent.	Per cent.
Unpressed Ingot	11·11	29·18	4·41	8·76
Pressed Ingot................	11·45	29·53	7·90	12·51

The results, as derived from the test pieces cut transversely, compared equally favourably. The test pieces were cylindrical, with collars, and the metal was not subjected to any hammering, annealing, hardening, or other treatment, except machining, after it came from the ingots. The pressed ingot gave its highest breaking strength in the upper sections, while the unpressed ingot, on the contrary, was at its best towards the bottom, and showed a rapid falling away at points exceeding one-half of the length of the ingot from the lower end; and, while the elongation amounted to 12·4 per cent in the lowermost of the tests from the unpressed ingot, it fell rapidly away towards the upper part, so that in the fifth series the mean elongation was only 2·02 per cent. The pressed ingot, on the other hand, gave a mean elongation at its lowest point of 13·7 per cent, decreasing somewhat in the succeeding series; but still, at the very top of the ingot, the elongation was represented by 11·63 per cent. The figures further indicated that, in the unpressed (where sound) and also in the fluid-compressed ingots, the mean value of the elastic limit, as also of the ultimate breaking strength of the material, was slightly greater in the metal towards the outer boundary of the ingot, and tended to decrease towards the centre. In the sound portion of the unpressed ingot the mean figure for ductility was much the same, 8 per cent at all radial distances; but, with the compressed ingot, there was a decided superiority in this respect as the outer boundary was approached, the figures being 8 per cent at the centre and 17·61 per cent at the circumference; but the centre approached the high figure of the outer circumference exactly as the pressure applied had been of higher intensity and more effectively applied. The author inferred, from the figures adduced that under mechanical tests the metal from the top, or any other vertical section,

	Mean of Test Pieces cut transversely.			
	Elastic Limit in Tons per Square Inch.	Ultimate Breaking Strength in Tons per Square Inch.	Contraction of Area at Point of Fracture	Elongation in 4 Inches.
			Per cent.	Per cent.
Unpressed Ingots	11·43	28·04	3·61	7·91
Pressed Ingots	12·38	30·07	7·57	12·74

of a pressed ingot was, at least, equal to the unpressed ingot after one-third or upwards of such ingot had been cut off or rejected; that the weakest part of the pressed ingot was along the axis, where the pressure had been least effective, but that this weakness, as compared with the outer layers, arose from insufficient pressure, and could be localised; so that for hollow shafts, tubes, hoops, cylinders, and the like, where the centre was finally removed, either by boring or punching out, it was unnecessary to proceed to the higher pressures required to ensure absolute solidity and uniformity over all parts of any section. With unpressed ingots, on the one hand, the unsoundness was irregularly distributed, and not capable of such localisation, even in the lower end of the ingot. The paper concluded by referring to the effects of annealing and forging upon pressed steel, with tests from various gun forgings, and of shell metal in its soft and hardened states, as also after firing at armour plates.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

BALANCE OF LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—May I be allowed substantially to endorse the remarks of "Dreadnought," in your issue of June 7th, respecting locomotive balance? For a solid road, my own opinion inclines to balancing all the moving parts. If this be done, the fore and aft stability of the engine as a whole will be secured. There is a very prevalent idea that the rectilinear moving parts should only be partially balanced, but there appears nothing in the science of mechanics to warrant this. I have been informed by an experimenter, whose word and observation I can rely upon, that he has found—when testing an engine on friction wheels—that though apparently balanced at one speed, it was very clearly unbalanced at a different speed. This I can only explain on the assumption that the angularity of the connecting rod introduced a disturbing element, which had a sufficient energy at high speeds to make itself felt, and at low speeds was not capable of doing so.

Granting the possibility of practically perfect balance of the engine on a solid road—which, as "Dreadnought" points out, is not affected by the alternating pressure on the rail—there is a very great difficulty to face in what is often termed an "overbalanced" engine. This difficulty is the enormous vibration set up in bridges by the vertical non-balance due to the action of that proportion of the counter-weight which is employed to horizontally balance the piston and other straight-moving parts. The rapid alternation set up has been shown by actual trial to increase the stresses in bridge members as much as 28 per cent, or thereabouts.

For particulars of such trials I would refer to Professor S. W. Robinson's report on Ohio railways. The professor showed, by means of a specially devised indicator, the deflecting of several bridges, and the nature of vibration caused by engine counter-weights, by coincidence of panel length with wheel base of vehicles, &c. And these experiments afford much food for reflection, for they show that with one cause and another bridges may be strained daily or hourly as much as 50 per cent beyond a static load calculation, and that there might be at any time such an unfortunate concurrence of wheel base, panel length, speed of train, diameter of driving wheel, and period of vibration of bridge, as to bring about the destruction of a bridge. Of course, such a complete coincidence of causes is rare, but a coincidence of panel length and wheel base may be common, and is, and may at any time be associated with an unfortunate periodicity of the vibration of the bridge itself, and cause stresses far beyond anything intended by the designer, or even contemplated.

The subject has attracted great attention in America, where the principles of bridge design and vehicle wheel base seem unfavourably connected in respect to stress increment, and a strong feeling has arisen against too great excess of counter-weights above that required for balancing revolving parts only.

My own observations, made at Flixton, near the line of the C.L.C., on the effect of rapidly revolving counter-weights, has convinced me of their effect. There, on good permanent way, engines with wheels of from 6ft. to 7ft. diameter, at 60 miles velocity or over, would set up a very distinct beat in the ground, which communicated itself to the house and to loose fixtures, and exactly corresponded with the period of *visible* revolution of the engine wheels, little or no vibration at all arising from the *train*.

In the early numbers of *The Practical Engineer* there appeared articles on "Locomotive Balancing," which advocated the method now upheld by "Dreadnought." Since they appeared my attention has been drawn—in America—to the violent structural disturbance which may be caused; and now I can only say that full balancing may be a good thing for the engine, but a bad thing for the bridges. Who must decide between the locomotive superintendent and the Permanent Way Department? Will it pay to build all bridges 50 per cent stronger? Is there a reasonable and practical method of introducing a vertically-moving part to counteract the vertical action of the balance weights? At high speeds, especially with small wheels, as used in America, the unbalanced vertical action is more severe than "Dreadnought" seems to indicate. Let us take his own figures with a 5ft. wheel.

Then in place of the centrifugal force of 2·02 tons, as he finds, it will be 2·02 tons × $\frac{7^2}{5^2}$ at sixty miles per hour, or practically four tons, and engines with such wheels run at sixty miles in America. This four tons is sometimes *upwards* in action and sometimes *downwards*. The *difference* of wheel pressure is eight tons, and, therefore, on a wheel loaded statically to say 7½ tons—a very fair load indeed—we get a rail load varying from 3½ to 11½ tons. A cross girder may thus have a load of 23 tons upon it, or at anyrate only distributed one-eighth of a wheel circumference to either side of it in place of 15 tons, an increment of fifty per cent fully above what would be calculated. Similarly the floor longitudinals or track stringers have a central load concentrating fifty per cent in excess, and every rail needs extra strength, for the maximum wheel pressure may fall between any two sleepers.

So long as locomotives are fully balanced no engineer who values his reputation can afford to neglect the counter-weight action in computing the dimensions of floor beams, track stringers, and connections.

It is especially to be noticed that upon the connections of track stringers with floor beams the combined action of *impact* and counter-weight may bring a stress at high speeds from three to four-fold that due to the static wheel load.

Very many of the weaknesses developed in bridge details, and set down to the action of repeated loadings, are more truly attributable to the above causes instead. Such weaknesses have developed at the above-named connections, and in floor beam hangers and hip verticals more frequently than elsewhere, and these are just the parts most likely to be affected. In English express engines with large wheels the action of counter-weight is far less severe, the intensity diminishing inversely with the square of the wheel's diameter, so that a 5ft. wheel has almost double the bad effect of a 7ft. wheel at equal speeds per hour.

"Dreadnought's" example, if taken with a 5ft. wheel, at 80 miles per hour, would just about lift the wheel off the rail.

This, as well as the previous calculation, is on the assumption that the 231lb. is all *reciprocating*, and not revolving, and this does not seem an excessive amount for the piston of an 18in. cylinder, its 3in. rod weighing 71lb. per yard, the cross head, slide blocks, pin, and a proportion of the connecting rod.

A question never appearing to be raised in regard to locomotive balancing is the effect of the eccentrics, rods, and valves.

The two eccentrics are virtually a single weight, balancing or partially balancing the crank and the other parts of the valve gear, and the valve more largely in opposition to the piston.

An investigation may show to what extent the above gear action is to be credited with the good effect of the practical rule of some locomotive engineers, who balance two-thirds or three-fourths of horizontally-moving parts and all the revolving parts. Is it not probable that, after all, they *really* take into account *all* moving parts *fully*, including the valve gear; and may not the variable action of the valve gear, variable because of the movement of the link slider for different expansions, be held to explain the facts often commented upon, that an engine is balanced at one speed, and not at another? This is no doubt due to the position of the reversing lever being varied for different speeds. Such is my own opinion.—Yours, &c., W. H. Booth.

NON-CONDUCTING COVERINGS FOR STEAM PIPES.

[The following letter, which appeared in *Engineering* last week, completes our record of the series of experiments and observations.

Sir,—Referring to my letter of 21st ult., which you were kind enough to publish in your issue of 24th of May, I take the liberty of handing you herewith a copy of another test made yesterday, and trust you may find room for it in your next issue.

I am in this case comparing the fossil meal composition 1½in. thick on No. 1 pipe with the same covering as before, on No. 3 pipe, No. 2 being again bare. All supplementary services have received an additional covering of ½in. of hair felt and canvas. As this day happened to be one of the hottest that occur in our climate, I consider the results a good illustration to the remark which I often hear from steam users during the summer months: "Oh, we do not lose much heat now; we will have the covering done when the cold weather comes."

The result shows that a rise of temperature of 30 deg. or 40 deg. Fah. does *not* reduce the loss of heat so considerably as to make it advisable to postpone covering on that account. As a rule more fuel and labour is lost from such uncovered surfaces during the three or four summer months than the whole covering would cost.

This second test shows further that the small extra saving effected by an additional half-inch thickness is, in ordinary cases, not sufficient encouragement for incurring greater expense by applying more than *one inch thickness* of fossil meal composition, except of course where the steam pressure is considerably higher, as for instance in marine boilers and pipes carrying 160lb. to 200lb. pressure.

June 7th, 1889. Bright Sunshine in Morning, very close. Sultry in the Afternoon, Thunder, no Wind.

No. I. thermometer outside, No. II. inside against wall, No. III. inside between pipes, No. IV. on the main steam pipe, No. V. on fossil meal 1½in. thick, No. VI. on bare pipe, No. VII. on No. 3 pipe.

Time.	I.	II.	III.	IV.	V.	VI.	VII.	Steam Pressure.
								lb.
8-30	69	79	81	102	111	270	98	52
8-45	70	79	82	103	113	278	100	60
9-0	72	80	84	104	116	278	101	60
9-15	72	81	84	104	116	278	102	60
9-30	72	80	84	104	116	278	102	60
9-45	73	80	84	103	116	279	102	60
10-0	73	80	82	105	117	279	102	60
10-15	74	79	81	105	117	278	102	60
10-30	74	81	87	105	118	278	102	60
10-45	74	81	83	105	115	278	103	60
11-0	74	82	84	106	119	279	104	60
11-15	74	80	82	106	119	278	104	59
11-30	76	82	87	106	119	278	104	60
11-45	76	81	86	107	118	279	104	60
12-0	76	80	86	106	117	278	104	60
12-15	76	81	86	107	118	278	104	60
12-30	76	82	86	109	120	280	106	60
12-45	77	82	86	110	120	279	105	60
1-0	77	83	88	110	120	280	106	60
1-15	77	84	86	109	120	279	107	60
1-30	77	85	86	110	122	280	107	60
1-45	77	84	87	111	121	279	106	60
2-0	78	84	86	109	122	278	106	59
Condensed water from No. 2 pipe weighed 30lb. 6oz.								
2-15	76	82	86	112	122	282	108	60
2-30	75	80	86	112	120	279	106	60
2-45	75	81	86	111	119	278	106	60
3-0	74	82	86	110	119	278	104	60
3-15	73	80	85	110	118	277	103	60
3-30	73	80	85	109	118	277	103	60
3-45	73	78	84	108	118	278	103	61
4-0	73	80	85	108	116	280	103	61
4-15	72	80	85	109	116	279	104	60
4-30	72	80	85	109	119	279	104	60
4-45	69	78	80	106	114	277	100	60
5-0	66	79	80	106	115	278	100	60
5-15	66	78	82	106	116	279	101	60
5-30	65	76	80	105	114	276	100	60
5-45	65	77	80	105	115	278	99	60
6-0	65	76	78	105	114	276	98	60
Condensed water from No. 2 pipe weighed 28lb. 14oz.								
6-15	65	77	78	104	114	278	99	60
6-30	65	74	78	104	114	276	99	60

	lb. oz.		lb. oz.		lb. oz.
From No. 1,	16 10	From No. 2,	26 6	From No. 3,	12 2
			30 6		
			28 14		
			85 10		
	16·625lb.		85·625lb.		12·125lb.
	6·481		6·481		6·481
	10·144		79·144		5·644
	12·82 p.c.		100 p.c.		7·13 p.c.
	87·18 ,, saved.		Nothing saved.		92·87 ,, saved.

We recommend in those cases to apply 1½in. to 2in. thickness, and the cool stokeholes of all the new P. and O. boats, beginning with steamship Victoria, as well as a large number of other steamers (City of Berlin, Columbia, Teutonic, &c.), bear witness how very efficiently the covering does its work.—I am, sir, yours very truly,

Albert Haacke.

Kieselguhr Wharf, Hackney Wick, London, E.,
June 8, 1889.

QUERIES AND REPLIES.

44. Resistance of Piping to Water.—Will you kindly permit me through the medium of your paper to ask if any of your correspondents will answer the following question, viz.: In a rising main of 3in. per yard, 400 yards long, composed of 200 yards of 4in. and 200 yards of 2½in. pipes, a pump is required to force through those pipes 30 gallons of water per minute. Will the resistance offered to the pump vary, and, if so, how much in each case, if the pipes were laid in the following order—

1.—200 yards 4in. pipes next the pump.
200 ,, 2½in. ,, delivery end.
400

2.—200 yards 2½in. pipes next the pump.
200 ,, 4in. ,, delivery end.
400

3.—100 yards 4in. pipes next the pump.
100 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
100 ,, 2½in. ,, ,,
400

4.—100 yards 2½in. pipes next the pump.
200 ,, 4in. ,, the above.
100 ,, 2½in. ,, ,,
400

5.—100 yards 4in. pipes next the pump.
200 ,, 2½in. ,, the above.
100 ,, 4in. ,, ,,
400

6.—If the pipes were laid alternately—one 4in. pipe and one 2½in. pipe—throughout the entire range?—Medium.

Answer.—I have a double-acting steam pump working under similar conditions to "Medium's" steam cylinder, 6in. diameter; pump, 6in. diameter by 12in. stroke; 67lb. steam pressure per square inch; suction and delivery pipes, 4in. diameter (inside); length of delivery pipe, about 350 yards; head of water gives 30lb. pressure on main at pump when standing. This pump delivers 53 gallons of salt water per minute; the delivery pipe has numerous bends, two at right angles.—T. M.

49. Proportions of Pipes to Hydraulic Ram.—We have a 10in. ram, with 1¼in. inlet and outlet pipes, pressure 700lb. per square inch. Is this a correct or good proportion? if not, how is the correct proportion calculated? Steam Crane.

Answer.—I have several hydraulic riveters working, made by well-known makers. Rams are 8in. diameter, inlet pipe is ½in. inside diameter, and outlet pipes four times area of inlet, working pressure on inlet 850lb., outlet 5lb. I hope this may be of service.—T. M.

51. Straightening and Bending Angle-iron Bars.—Will any practical man kindly give me a ready method of straightening and bending angle-iron bars about 5in. by 5in. by ¾in.? A sketch or description of suitable machine will much oblige.—Outsider.

Answer.—Machines are now much used for the purpose. One designed by Mr. R. H. Tweddell, the well-known inventor of hydraulic riveters, and made by the Hydraulic Engineering Co., Chester, would suit your purpose.—D. C.

35. Locomotive Driving Wheels.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

41. Hot-water Pipes.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse?—Water-heater.

50. Small Air Pump.—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

52. Details of Oliver.—Can any reader oblige me with details of an oliver, to work by foot, for making bolts from ⅜in. to 1in., with dimensions?—H. C., Egypt.

53. Dash Pots.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made, and what is the approximate cost?—Crank Pin.

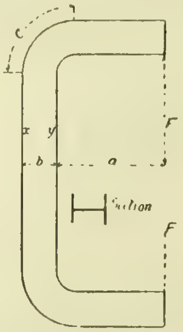
54. Boring Out Crank Pin Hole.—What is the best method of boring out an old crank pin hole, to be most easily done?—Crank Pin.

55. Testing Lubricating Oils.—I wish to know the methods of chemically testing the purity of lubricating oils. Is there any simple mode easily applied by an engineer?—Lubricator.

56. Most Economical Steam Boiler.—I wish to put down a boiler to drive a 12 horse-power high-pressure engine using pressure at 100lb. per square inch. What is the most economical boiler to use? I would prefer one which requires no brickwork. What evaporation per pound of fuel can be obtained with the boiler recommended?—J. T. M.

57. Pumps.—Will some reader oblige with a rule for the sizes of suction and delivery pipes. I have a double-acting plunger pump, 7¾in. diameter, 31½in. stroke, 35 strokes per minute. Suction pipe 11¾in. diameter, and 820ft. long, 16ft. rise. This pump gives me trouble sometimes. Is the suction pipe too large? Delivery pipe 11¾in. diameter, 4,600ft. long, 360ft. lift?—W. H. H.

58. Strains in Frame.—Will some correspondent make clear the following: In the sketch here shown there is a force F acting on the frame in the direction indicated by the arrow heads, a corresponding force, of course, acting in the opposite direction to maintain equilibrium. Neglecting the elasticity of the material, the formula for the strain at x would be



$$\frac{F \times a}{b}, \text{ and at } y \ \frac{F \times (a + b)}{b}$$

But when the elasticity of the material is taken into account, would this formula be correct; more especially when the distance (a) is small as compared to the distance between the arms of the frame? Also how the strains in the curved portion C are ascertained under the same conditions.—Tyro.

TO CORRESPONDENTS.

W. W. Wilton, Blackburn.—The secretary of the West of Scotland Engine-keepers' Association is Mr. John McGregor, 13, Davidson Street, Bridgeton, Glasgow.

J. T. M., Macclesfield.—We have inserted your query. The indicated power of an engine is the power exerted by the steam upon the piston, and is so called to distinguish it from the brake or actual power given off by the engine. This actual power is always less by the friction of the engine than that indicated. Thirty-six pounds of steam per I.H.P. per hour is not at all economical in a high-pressure engine acting expansively. Engines and boilers are now made which give a coal consumption of only 2lb. per I.H.P. per hour, and the engines use about 20lb. of steam per I.H.P. per hour. With such a boiler, and an engine consuming 36lb. of steam per I.H.P. per hour, you would use about 4lb. of ordinary coal per I.H.P. per hour.

R. H. T., London.—In answering any query, kindly address editor, as we do not forward replies direct to querists unless under exceptional circumstances. The answers to queries are intended for the general information of our readers as well as for those particularly interested at the moment.

MISCELLANEA.

THE new Calais-Douvres, a steamer built for the Continental traffic of the London, Chatham, and Dover Railway, seems to be a decided success, making the trip from Dover to Calais in little over an hour. She is 325ft. long, with a beam of 36ft., and a moulded depth of 21ft. 6in., and a rudder at each end. The engines are compound, of the diagonal direct-acting type, with a high-pressure cylinder of 59in. placed over the low-pressure of 106in. diameter, the stroke being 6ft. The paddle wheels have feathering floats. The vessel has accommodation for 900 passengers.

IMPROVEMENTS ON THE MIDLAND RAILWAY.—A further development of the system of lighting railway trains by electricity was tried on Monday in a train which passed over the Midland line between Derby and Manchester. For a short time back trains lighted by electricity have been run between London and Manchester, but this is the first time the experiment has been tried on any other part of the company's system. Each compartment had two lights and the guard's van three. On Saturday, too, the company attached third-class carriages with lavatories to some of their express trains.

LAUNCH OF A LARGE PACIFIC LINER AT BARROW.—On Saturday, June 15th, the Naval Construction and Armaments Company launched from their yard at Barrow another of the magnificent steamers built to the order of the Pacific Steam Navigation Company. She was named the Orotava, and is intended, along with the sister ship Oruba, launched some time since, to run between Liverpool, South America, and Valparaiso. These two vessels will be by far the largest and quickest steamers ever engaged in the South American and Pacific trade.

A MONSTER DRY DOCK FOR BUENOS AYRES.—A dry dock of enormous proportions is at present being made in this country for Zarate, near Buenos Ayres. It is designed for the purpose of dry-docking and floating vessels of 5,000 tons weight, and is to be constructed in such a way that it may afterwards be readily adapted, if necessary, to accommodate craft of twice that weight. The dock is expected to be extremely rapid in its action, and capable of being filled with water in less time than any other dock in the world. It will be the largest and most powerful of its class in the whole of the New World.

LARGE ORDER FOR WAR MATERIAL.—Exceptionally large orders have been received in Birmingham for war material of various descriptions for the British Government. The principal manufactories are engaged to their full capacity, and are employing a large number of extra hands. One of the leading firms of engineers are erecting a new mill for forging steel shell by hydraulic power, and they will then have a capacity for producing ten thousand shells of various sizes per week. With the new plant steel shells will be produced up to the dimensions required for the 110-pounder guns. A new factory has also just been completed for the manufacture of Government revolvers, and there is a large demand for torpedoes, and tubes and fittings for vessels of war, together with the new quick-firing rifle, which is now in course of construction. Ammunition is also being manufactured in vast quantities.

THE ITALIAN IRON AND ENGINEERING INDUSTRIES.—The basic process for manufacturing steel is evidently gaining ground rapidly in Italy. A third Siemens-Martin furnace has been erected at Sestri Ponente, in Liguria, and two others constructed on the old system are to be transformed immediately. The lining of the Siemens-Martin furnaces consists of dolomite, which is found on Mount Gazo, at no great distance from the works. The firm of Ansaldo Bombrini, at Sampierdarena, has just completed the construction of the colossal engine and eighteen boilers which are intended for the Italian ironclad Sicilia. This engine is of 19,500 horse-power, and is the most powerful which has hitherto been constructed in Italy. It is made on the compound principle, with eight cylinders and four surface condensers, the total weight of the engine and boilers being 1,740 tons.

SHIPBUILDING IN THE UNITED STATES.—A New York correspondent says that shortly after the beginning of the next fiscal year contracts will have been let for the construction of new war vessels which will in the aggregate increase the tonnage of the United States Navy by nearly 15,000 tons. Although the majority of the new vessels will be small craft compared with the monster ironclads of Europe, they will embody in their construction the latest approved ideas of high speed and heavy armament, and will be very formidable ships of war. The list includes three 2,000 ton cruisers or gunboats, vessels somewhat larger than the Yorktown just finished, and similar to that vessel in many respects, although embodying many new features. There will be two 3,000 ton cruisers. These new vessels will be 1,000 tons smaller than the new cruiser Newark, but by law they are required to attain the extraordinary speed of twenty knots an hour. If this requirement is met, and the heavy ordnance now in contemplation supplied, these fleet boats will be very effective. A great ironclad of 7,500 tons, a protected cruiser of 5,300 tons, and a small gunboat of 800 tons burden, complete the list. In addition to the vessels above described, Congress, at its last session, provided for the construction of four more cruisers, including the "Thomas" cruising monitor.

TAPPING DROWNED MINES.—With respect to the tapping of the water in the Bilston pound of the South Staffordshire coalfield, the mining engineer to the Mines Drainage Commissioners—Mr. E. Howl—states that it will be necessary for the purpose of drawing off the pound to have at least five or six 5in. bore-holes driven through the rib into the hollow. The pressure will be constantly reducing, and eventually the whole of the "come" of water, equal to over four million gallons per day, will have to be passed through these holes, instead of flowing, as at present, through the perforated rib in the new coalmine 35 yards above. The small trial holes in advance of the main 5in. holes have satisfactorily proved the position of the water at different angles, and two of these 5in. holes are now nearly through, and fitted with taps, which will be closed until the last hole is bored. Consequently no diminution in the height of the pound will take place until this work is completed.

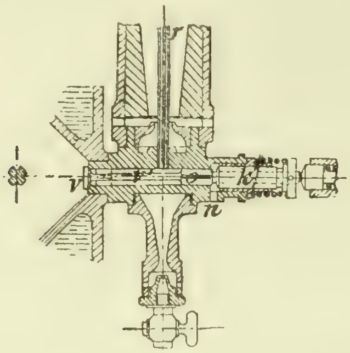
THE NICARAGUA CANAL.—Although the Panama Canal enterprise is dead, or very nearly so at any rate, the Nicaragua Canal project is very much alive. It proposes to begin work at once, and on Saturday, June 8th, sent off a steamship laden with machinery, stores, and hardware, destined to be used in the construction of the interoceanic canal, bound for Greytown, the construction of piers, warehouses, shops, a railroad, and a telegraph line will be undertaken, dredges will be set to work at the beginning of the canal, and preparations will be made for cutting the rocks at the point where the first lock is to be placed. Within a few weeks thousands of labourers will be at work on the line. The company appears to have plenty of money, plenty of confidence, and plenty of energy. The estimated cost of the Nicaragua Canal complete, including an allowance for contingencies, does not exceed 66,000,000 dollars. As there is no line of American steamships running between New York and Nicaragua, the ship which bore the first consignment of this essentially American enterprise sailed down the bay flying the Union Jack. By many this was regarded as an omen that the inter-oceanic canals, no matter whether they are built by French, American, or German companies, are bound in the long run to fall into the hands of the power which furnishes them with the most traffic, namely, Great Britain. The Suez Canal is a striking instance thereof.—*American Notes in the Manchester Examiner and Times.*

MANCHESTER GEOLOGICAL SOCIETY.—A meeting of the members of the Manchester Geological Society was held recently in the rooms of the Literary and Philosophical Society, George Street, Manchester. Mr. John Knowles, president of the society, occupied the chair. Mr. W. Clifford contributed some notes on the Richmond coalfield, Virginia, in reply to certain criticisms; after which Mr. Joseph Dickinson, one of her Majesty's chief inspectors of mines, read a paper on "Carbonic Acid Gas, or Black Damp, as ordinarily met with in mines." He remarked that at a recent meeting of the society, mention was made of carbonic acid gas having been found issuing audibly in the Foxdale Mine, Isle of Man. He stated at once that he had heard of a similar occurrence in Germany, but which he attributed entirely to the effects of some large shots of dynamite which were being fired, and that in all his experience he had never met with such gas issuing audibly, but only firedamp. It was a well-known fact, that in mines the issue of carbonic acid gas was usually, if not invariably, silent; but it occurred to him, that notwithstanding the innumerable number of times such gas had been noticed by him lying silently near the floor of workings, or in shafts, or pouring out of old workings, it might be possible for an issue to be audible if the gas were under certain pressure. He therefore brought the subject under the notice of some experienced mining friends, and he found that their experience agreed with his own, viz., that all the issues met with by them were silent. As the name of Mr. Kitto, the principal agent of the mine, was mentioned as being present when the issue was noticed by a scientific party, they decided to write to him on the subject. His reply was as follows: "I do not think I ever heard the carbonic acid gas blowing, or rather 'singing,' myself, and I have inquired from the other agents and they say not, but we have many times felt it against the back of the hands, very similar to cold air being blown through the stem of a tobacco-pipe. The next time I find any of those little 'pipes,' I will carefully listen. The fact is, we always keep our mouths as far as possible from it." A discussion followed, and a vote of thanks was accorded to Mr. Dickinson for his paper. A communication having been received from Mr. W. J. Bird, relative to a boring at Seaton Carew, Mr. W. Watts, of Oldham, read a paper on "Erratic Boulders in the Castleshaw Valley," and gave the result of some temperature observations at Piethorne and Denshaw. The thanks of the society were accorded to Mr. Watts for his communications. A second meeting was held in the evening, Mr. W. Saint presiding, when one of the hon. secretaries, Mr. Mark Stirrup, read some notes contributed by Mr. Charles Roeder, on the Barton section of the Manchester Ship Canal. Mr. Stirrup subsequently referred to the old canoe which had been discovered in the workings of the Ship Canal at Barton. After describing the characteristics of the "find," he said it appeared evident to him that the boat had been swamped in some heavy flood. On comparing it with similar discoveries in other parts of the country, he was led to believe that it was not one of the oldest types. He did not think that the canoe could claim the title of pre-historic that had been bestowed upon it. His conclusion was, that it was of post-Roman age, and that its years might be measured by a few centuries. Votes of thanks were accorded to Mr. Roeder and Mr. Stirrup for their communications.

ILLUSTRATED PATENTS.

688. Gas Engines, C. D. Abel, 28, Southampton Buildings, London. (*Gas Motoren Fabrik Deutz, Deutz-on-the-Rhine, Germany.*)

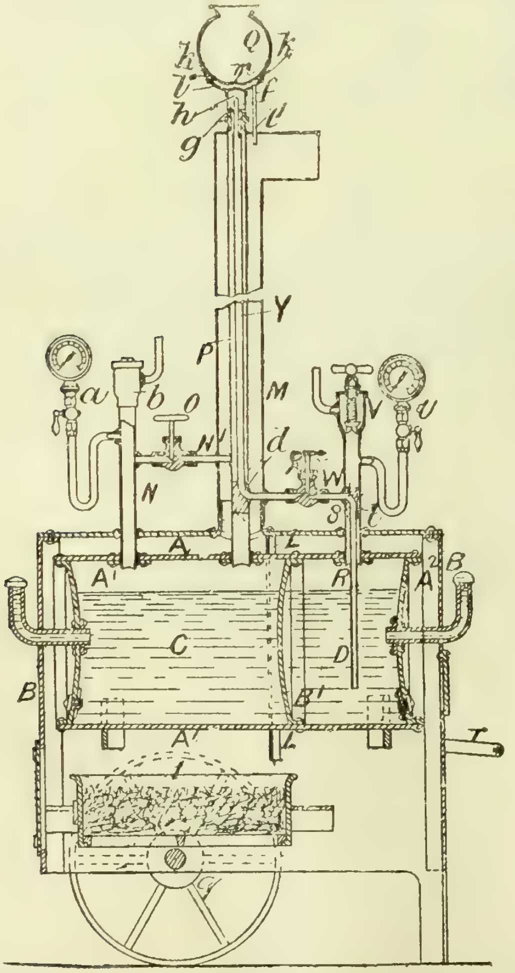
Igniting: For clearing the heated tube igniter, described in Specification No. 11,444, A.D. 1887, of products of combustion, the valve v, which controls communication between the cylinder B and tube r, is provided with a stem v^1 terminating in pistons o and k, the former being grooved as shown in transverse section.



Normally the tube r is open to the atmosphere through the passages in o and the port n, and when the valve is opened, before the piston k can cover the port n, a current of gas from the cylinder clears the passages of products.—January 16, 1888. [8½d.]

359. Spray Lamps and Burners, G. Rose, Springburn, Glasgow.

Oil and steam supplies: Within the casing B is a cylinder A having domed ends A^1, A^2, and divided by a vertical piece B^1 into two compartments C, D, the former containing water and the latter oil. Beneath the cylinder A is a firebox I of such a length as to slightly project beyond a partition L, which prevents the greater portion of the heated products from passing around the chamber D. The steam pipe P, which traverses the flue M, is connected to the chamber C by pipes N, N^1 fitted with a pressure gauge a, safety valve b, and hand-regulating valve O. Sufficient pressure is generated in the chamber D to force the oil up the pipes R, W, d, Y to the nozzle f. A passage t in the gland S places the chamber D in communication with the gauge U, safety valve V, and supply regulating valve X. The



steam ascending pipe P passes through apertures g to a chamber z, where it mixes with the oil from the nozzle f, the mixture ascending through apertures j, m to the combustion chamber Q. This chamber is shown supported above a drip cup l by claws k, which allow air to enter as indicated by the arrows; any condensed oil or steam collecting in l descends the tube l^1. The apparatus is mounted on wheels q, and is provided with handles r to allow of its being wheeled about. The whole of the cylinder A may be used for generating steam, the oil being then supplied by gravity from a reservoir placed above the casing B; or two separate cylinders C, D, with a partition and air space between them, may be provided. The invention is applicable to stationary apparatus. Heating: For heating purposes the burner may be placed horizontally.—January 9, 1888. [8½d.]

Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

May 28th.

8803 Moulds, A. C. Cole, London. (C. H. Wilder, United States.)*
8804 Improved Core, A. C. Cole, London. (C. H. Wilder, United States.)*
8805 Gas Engines, D. Clerk, Birmingham.
8806 Governors, A. C. Pain, Birmingham.
8810 Propellers, R. Buck and S. Read, London.
8827 Water-power Engines, W. P. S. Edwards, Crewkerne, Somerset.
8832 Water Gas, H. Williams, Manchester.
8847 Lubricators, R. J. Threlfall, London.
8858 Bearings, J. Plastow, London.
8863 Saw-sharpening Machines, Esdaile and Co., Limited, and L. C. Tavener, London.
8864 Water Heaters, E. Werdenberg, London.
8877 Railway Rail Joints, C. R. Hastings, London.*
8884 Steam Engines, J. West, London.*

May 29th.

8889 Burnishing Machines, W. P. Thompson Liverpool. (H. Weidmann Switzerland.)
8923 Pressure Gauges, J. Jackson, London.
8929 Valves, F. Ransome, Liverpool.
8930 Carding Engines, F. M. Hetherington, Manchester.
8937 Engine Packing, R. W. H. McDowell and C. L. E. Melsom, London.
8938 Driving Bands, E. A. Parker, London.
8942 Alarum, A. Herts, London.
8959 Windmills, H. P. Vacher, London.
8960 Gas Engines, E. G. Wastfield, London.

May 30th.

8988 Metallic Tube Stopper, H. Whitehead and W. Nevins, London.
8991 Governor, E. Airey, Sunderland.
8996 Rotary Engines, A. J. Thomas-Jésupret, London.
8998 Steam Engines, A. Leckie, London.
9002 Steam Boilers, W. Vorbach, London.
9018 Sheet Packing, R. W. H. McDowell and C. L. E. Melsom, London.

May 31st.

9028 Pipe Joints, A. Ramsden, London.
3034 Electric Bells, W. Pressland and W. T. Pressland, London.
9037 Wire-cutting Machines, T. J. Crossley, Manchester.
9048 Regulator, H. Lee and W. Hilliard, Tipperary.
9053 Brick-making Machines, J. Clarke and G. Clarke, London.
9055 Valve, T. A. Harris, London.
9057 Shuttles, J. Elsas and H. Weissenburger, London.*
9058 Bearings, C. Taylor and G. B. Taylor, Birmingham.
9061 Water Gas, B. V. Steenbergh, London.*
9071 Fire-extinguishing Apparatus, A. F. Nagle, London *
9072 Steel Tires, J. Munton, London.*
9075 Thrashing Machines, E. Foden, London.
9078 Metal Surfaces, F. Wannieck, London.*

June 1st.

9083 Mechanical Stokers, T. Nuttall, London.
9086 Valve Gear, F. J. Burrell and P. Chell, Thetford, Norfolk.
9097 Screw Spanner, E. Reilly, London.
9109 Compressed Air, G. Lansell, London.
9116 Lubricators, C. Wells, London.
9117 Steam Engines, C. Wells, London.
9118 Crucibles, S. Bergheim, London.
9132 Moveable Fire-bars, H. W. Shephard, London.

June 3rd.

9135 Steering Gear, J. C. Wallace and M. P. Campbell, Glasgow,
9140 Iron and Steel, G. Hatton, Hagley, Stourbridge.
9141 Indicator, H. Andrews, London.
9144 Clips, N. Williams, Manchester.
9145 Paper-making Machinery, J. Craig, Cheadle, Cheshire.
9153 Galvanic Battery, D. J. Arnold and H. B. Coryell, London.*
9154 Furnace Fire-grates, J. F. Wake and T. F. Passman, Middlesbrough.
9156 Tubes, T. Campbell, London.
9158 Motors, J. T. King, Liverpool. (J. S. Connelly, United States.)
9159 Piston Valves, M. Douglas and another, Sunderland.
9173 Water Gas, R. Simon and F. Wertenbruch, London.
9178 Steam Crane, J. R. Cotton, London.
9184 Varnish, E. Mourlot, Fils, London.
9190 Dumpling Cars, J. Duff, Liverpool.
9202 Indicator, J. W. Gooch and C. A. Baker, London.
9203 Motors, E. Butler and Butler's Patent Petrol-Cycle Syndicate, Limited, London.

June 4th.

9205 Valve Gear, M. I. Welch and J. J. McDonough, London.
9217 Safety Lamps, W. Patterson, Newcastle-upon-Tyne.
9237 Motors, G. E. Dorman, Stafford, Staffordshire.
9241 Electric Meters, A. A. C. Swinton, London.
9244 Automatic Filter, J. Leslie, Belfast.
9246 Marine Boilers, W. Bramley, Middlesbro'-on-Tees, Yorkshire.
9270 Wood Screws, C. D. Rogers, London.*
9288 Gas, W. Clark, London.*
9293 Steam Generators, J. A. Eno, London.*
9296 Pipe-wrenches, H. H. Lake, London. (J. T. Hawkins, United States.)*
9301 Furnaces, J. Gill, London.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE
PRACTICAL ENGINEER,
JUNE 28TH, 1889.

AUTOMATIC MECHANISM.

IN the earliest days of the steam engine, when it was first applied to pumping water, it was but an incomplete apparatus, dependent upon manual action for its every stroke, until the genius of Humphrey Potter devised a means of making it actuate its own valves, and thus developed it into an automatic prime mover. Whether the inventor thus applied his talents in order to gratify (as is asserted) his own taste for idleness, or whether it arose from his intelligent interest in the machine under his charge, matters little now; but the fact remains that he it was who gave the start to mechanical automatism, which was eagerly taken advantage of by the engineers of the time, and ever since followed up diligently by succeeding inventors.

Automatic action may be defined as that which maintains the continuity of action in running machinery without the necessity of manual intervention, and in other classes of apparatus, such as railway brakes, initiates action under certain contingencies which render promptitude necessary. Where intermittent action at regular intervals is required, it is also obtainable by the introduction of a regulator, of which the cataract of the Cornish pumping engine is a characteristic type.

In common parlance, all movements which are subsidiary to the main action of the machine, but yet brought about by it, are termed automatic; thus, in a planing machine, the motion which brings fresh parts of the work under the tool after each acting stroke is called automatic feed; and the contrivances by which the mutual interdependence of railway signals is secured is described as automatic locking gear.

Without action such as that to which our present remarks refer, many of our machines would be impracticable, and the rapidity of production which characterises our manufactures impossible. From this its paramount importance is evident.

Where certain definite motions are required to take place at regular intervals, as in the case of automatic feeds during intervals of the main action, there is no difficulty in adapting suitable appliances, their duties being strictly limited, and their action uncomplicated by a concurrent movement; but with automatic regulators the circumstances are widely different. Take, for instance, the steam-engine governor. Its duty is to adjust the power of the engine to the work put upon it, so as to maintain a speed as nearly uniform as possible. With the ordinary ball governor controlling the steam valve absolute uniformity of speed is impossible, because that of the governor must vary to vary the opening of the steam valve; but by using a governor of the "Porter" type, but with an automatically varying load, this difficulty may be overcome, and a very close approximation to absolute uniformity obtained. The difficulty in this direction is evidenced by the great number of governors that are or have been in the market. The great point with these appurtenances, however, is to obtain instantaneous action, and against this the inertia of the moving parts militates; time is necessary to communicate momentum to those elements on whose deviation from a normal position the regulating action depends. In this connection it would seem that there is a field for action in developing governors which are actuated by the alterations of load put upon the engine; the variation of resistance will immediately make itself felt, and therefore operate at once. Nor in this case would there be the inconvenience that has been found to attend very delicate governors, in which centrifugal force is the actuating principle, consisting in the tendency—on the slightest increment of speed—to fly to an extreme position; which tendency has led to the addition of subsidiary modifying arrangements of the nature of cataracts, thereby delaying the action of the regulator and complicating the construction of the apparatus. If a governor depending upon the resistance or amount of work put upon the engine be used, the power must be transmitted through it, and consequently the governor must come into action before the variation of resistance reaches the engine.

In connection with the working of railway signals, it was at an early period evident that as traffic increased, and became complicated by junctions, human vigilance was not sufficiently reliable for the prevention of accidents due to misplaced signals. It therefore became the duty of the Government to require the adoption of some mechanical safeguard which should be a protection against human fallibility; in short, it became necessary to have such a mechanical inter-connection between the points and signals that it should be impossible, even intentionally, to place them in contradictory positions. In order to effect this, it is necessary that when any signal or point lever is moved, its first action should be to lock in position certain other levers, and this interlocking must be mutual throughout the system. Thus it must not be possible to lower a given signal until all those which open the same track to other lines are placed at danger, and, being so placed, the first movement of the lever must be to lock them there; and the same remarks apply to the relative positions of points and the signals governing the tracks in which they lie.

The matter of locking a number of levers by the motion of one, through the agency of sliding notched bars and rocking catches, bolts, and other similar contrivances during the motion of the lever, is simple enough; but this is not sufficient. The locking must be done before the main action of the lever—the lowering of the signal or the shifting of the points—commences, and this has led to a great deal of complication and cost, and a really simple form of effective locking-gear for railway signals has long been a desideratum.

In a case like this, where instantaneous action is sought, we should naturally turn to electricity for a solution, the locking and unlocking being effected by electro-magnetic agency, where the making or breaking of a contact immediately sets the mechanism in action. About this, however, there are at present some elements of uncertainty, as electrical apparatus is liable to become deranged, and absolute reliability in locking gear is the first requirement, and this we have with mechanical connections.

A great deal of attention has been drawn to automatic action in connection with railway brakes, and wide differences of opinion have existed as to the advisability of adopting them; but here it cannot be the utility but the reliability of the apparatus that is called in question. The difficulty with the continuous air-brakes has been, that they have sometimes applied themselves improperly, and so placed the trains to which they were attached in danger. This, however, only shows that a defective kind of brake was used, and in no way affects the principle of automatic action in its suitableness to railway purposes, for some vacuum brakes of the automatic class have been run in America for years without failure, and this on the overhead railway, where the stops are frequent.

The extended introduction of automatic action into machinery of all classes must serve to increase its accuracy and promote that rapidity of production already mentioned; and, furthermore, it very materially reduces the cost, as such machines, when in operation, require comparatively very little attention, and are safer from all kinds of accidents due to inadvertence.

The Gold Mining Exhibition.—One of the attractions of the season at the Alexandra Palace is to be the forthcoming Gold Mining Exhibition. This show is to include all the latest improvements in the machinery and appliances used for the excavation and subsequent treatment of gold ore, together with samples of ores from the different mines.

GREASY BOILER FEED WATER.

A number of cases of overheating which have recently come under the writer's notice strongly illustrate the importance of keeping grease of any kind out of boilers. Oil and grease are sometimes introduced direct, with a view to preventing incrustation, and many a damaged furnace crown has resulted from this practice. We have often heard one well-known Lancashire cotton spinner affirm that there was nothing like putting a dead pig inside a boiler, both for keeping down the scale and making the engines run easier, and many engineers hold the opinion that any kind of grease or oil introduced into boilers will prevent the adhesion of hard scale to the plates and loosen incrustation already formed.

The most common way, however, in which grease finds its way into the boiler is by means of the feed water. This is sometimes heated direct by exhaust steam from a non-condensing engine, the vaporised lubricants from which are carried forward with the steam. Where surface condensers are employed and the feed is used over and over again, only a little fresh water occasionally being introduced to supply loss from leakage, &c., as at sea, the water is liable to become exceedingly greasy, and large numbers of furnace tubes have suffered from partial collapse and been seriously damaged through grease in this way.

Some few months ago, a strong, well-made steel Lancashire boiler, working at 150lb. pressure, the furnace tubes strengthened by flanged seams, spaced from 2ft. 9in. to 3ft. apart, was found to be seriously damaged in both furnaces, the plates of which bulged in at the sides and crowns from ½in. to 1in. over considerable areas. There was ample evidence to show that there had been no shortness of water in this instance, and the cause of the overheating which had evidently led to the yielding of the furnace plates was a mystery until an expert was called in by the owners, and found on investigation the interior of the boiler exceedingly greasy about the water level. The engines had surface condensers, and the whole of the condensed steam from the engines, charged with the grease used for lubricating the pistons, valves, &c., was being continually passed into the boilers, re-evaporated, and sent back again, &c. The feed water was not heavily charged with solid matter, but contained from 10 to 12 grains of carbonate of lime per gallon, and this was sufficient, with the excessive amount of greasy matter carried forward with the water of condensation from the engines, to cause thickening of the water in the boilers to such an extent as to interfere with the rapid transmission of heat from the furnace plates necessary to keep them cool enough to resist a high working pressure. Cases of this kind are of far more frequent occurrence than is commonly supposed, and good attendants have frequently been wrongly condemned and discharged for allowing boilers to become short of water, when the supposed evidences of their negligence, in the shape of bulged and distorted furnace plates or melted fusible plugs, have really been due to conditions such as above described, over which they had no control. In some boilers fed by water from surface condensers, the thin deposit or scale which can be scraped from the plates inside the boiler will often blaze like a taper on a light being applied to it. So much greasy matter sometimes adheres to the gusset plates and other parts inside boilers, that the stays, &c., can be lit up and the interior illuminated.

A small Cornish boiler in the South of England some weeks ago was found to leak very freely from the furnace seams when steam was being got up on the Monday morning, and on examination being made, the furnace seams were found severely "sprung," and the crown of firebox slightly depressed. The owner in this instance had attended to the boiler on the previous day, and was sure there had been no deficiency; but a boiler inspector, who was called in, considered he must have been mistaken, and that the defects were such as could only have been caused by shortness of water. The distortion was not so serious as to necessitate the renewal of any furnace plates, but the "sprung" seams were re-riveted, a new fusible plug inserted in furnace crown, and the boiler again put to work. It had not been working more than two or three days, however, when the fusible plug was blown out, and further investigation revealed that the boiler was fed from a tank, the water in which had a thick scum of grease floating on the top. This grease was carried into the water by the exhaust steam from a non-condensing engine, which was utilised for heating the feed, and thus all the conditions necessary to explain the overheating were found to be present.

Many other similar instances could be cited, but the foregoing will suffice to show that the practice of introducing grease into steam boilers, or of heating boiler feed water by direct contact with steam from an engine, is attended with considerable risk. With very sedimentary water, and especially when much lime or magnesia is present, the introduction of grease becomes positively dangerous.

The precise nature of the changes or combinations which occur inside the boiler have not hitherto been explained scientifically, but it would seem as though the mixture of lime and grease—forming probably a lime soap—make with the water a kind of emulsion, the specific heat of which is very much lower than that of clear water. The mixture or liquid in contact with the heated plates has consequently a much lower power of absorbing heat than is necessary to keep down the temperature of furnace plates below the point at which their strength to resist yielding becomes impaired.

That this risk of overheating from grease and deposit is well known to boiler insurance companies is evident, not only from the conditions which have been inserted in most companies' policies exempting them from liability to make good damage brought about in this particular way, but by the circulars which have been issued from time to time to those whose boilers are insured. The following extracts from a circular before us, issued by one of the largest of the English companies, show that the danger we have referred to is a very real one, and is one to which those who have had the most extensive experience in the working of steam boilers are fully alive :—

"It is erroneously supposed by many persons that furnace plates or tubes cannot be distorted or collapsed except from overheating through actual deficiency of water in the boiler."

"The double-cone fusible plugs are a most important safeguard to internally-fired boilers against damage through deficiency of water, and they are also valuable as a means of indicating overheating from deposit."

"It is found where a large quantity of fine flour-like carbonate of lime is deposited from the feed water that in course of working the water in the boiler will become so thickened as to induce overheating of the furnace plates ; or even if the quantity of this deposit is small, and there is grease in the feed water, this grease will mix with the carbonate of lime and render the water like milk, and prevent the free evolution of the steam. The water, in consequence, not being kept in close contact with the furnace plates, these become overheated with ample supply of water in the boiler."

When feed water is heated by the exhaust steam from the engine mixing with it, grease used in lubrication will be carried into the boiler. Even the small quantity in the water taken from the "hot well" of ordinary condensing or compound engines is generally quite sufficient to produce the effects described. Some boiler compositions are very objectionable, and have often induced damage.

The double-cone fusible plugs, being sensitive, are sometimes melted out, or the fusible metal so softened by the high temperature that the cones yield to the steam pressure. When such fusion occurs, it is an indication or warning which should not be disregarded, and the cause of the overheating should at once be sought for, as in many instances this melting out of the plugs has been followed by distortion or collapse of the furnace tubes, through the overheating described. In other cases, the furnace seams have leaked seriously and plates have fractured, or the tube end angle irons have been similarly affected, through the severe strain consequent on the excessive expansion of the furnace plates.

With good water, the fusion of the plugs and the damage, &c., referred to do not occur.

In the working of externally-fired boilers the exclusion of grease is of even greater importance than where boilers are fired internally. Greasy deposit settles on the bottom, sometimes forming large "grease balls." Plates which are immediately over the furnace, and the water being kept from contact with the plates, the sheets become overheated and are bulged down by the pressure. The lower parts of these boilers are unduly strained under the best conditions of working, with good water, &c., but when to these unequal strains are added those due to overheating, caused by thickening of the water through grease and deposit, &c., the dangerous conditions of working become greatly aggravated. It is not an uncommon thing for a mass of greasy deposit to settle on one of the plates immediately over the furnace, and to cause the plate to be overheated locally, and to bulge down in a sort of pocket, forming a receptacle for deposit, greatly increasing the liability to further overheating if the plate is not replaced or restored to shape. The defects known as "seam rents," to which externally fired boilers are peculiarly liable, owing to the straining action to which the seams are exposed through unequal expansion and contraction, are also much more liable to occur where the water in the boiler becomes thickened by grease and deposit.

THE PARIS EXHIBITION.

From Our Own Correspondent.

The Eiffel Tower is undoubtedly the most striking characteristic of the Great Exhibition of 1889. It dominates and dwarfs all its surroundings, and is, we feel, the leading attraction to visitors of every kind. It is visible from a great distance, and is quite unmistakable. We caught the first glimpse from the railway approaching Paris from the north, as it projected high above Montmartre; and, on walking towards the Seine, through the Place de la Concorde, as it came in full view, our first feeling was one of disappointment. The height did not seem overwhelming after all, but the surrounding buildings appeared rather to be diminished.

We do not realise its true magnitude till we get under it, in the open space between the four great supporting columns. Here the vast area bounded becomes more apparent from the great crowds of people within it, numbering thousands, who move freely about without inconvenence. The most pleasing view, however, we obtained from the great gallery of the Palace of the Trocadero ; here the magnificent arch formed by the inclined columns, and the iron work tying them together and supporting the first stage, form a beautiful frame for the Dome and Palace of the Liberal Arts, which glitter in tasteful colours at a considerable distance behind.

After dark, especially, the effect is very fine, as the arches and stages of the tower are outlined with gas lamps, while the whole gardens of the Trocadero and of the Exhibition are brilliant with gas jets. Arc electric lamps are freely used in the grounds and at salient points of the buildings, but the external displays of incandescent electric lights are not to be compared with those of the London Inventions Exhibition of 1885, or the Glasgow Exhibition of last year. The illuminated fountains arranged by the Messrs. Galloway, of Manchester, are, however, quite as beautiful and successful as in the London, Manchester, and Glasgow exhibitions. The Parisian crowds watch the jets and displays of colour with much interest.

While the lifts are at work in the tower a very characteristic sound is caused ; at first it is difficult to trace, as it seems to come from every point, and resembles to some extent the combined whistle and rush of wind through the rigging of a ship in a gale. Each of the lifts to the first stage, four in number, is practically a mountain rope railway, running on an almost vertical incline, and the wheels running on the rails sound through the whole mass of ironwork, producing a most peculiar effect of distributed sound. Entering the Otis lift, which is at work in the north column, we ascended to the second stage, over 370ft. above the ground level, where a magnificent view of Paris is obtained.

The second stage is 30 metres square, equal to about 100ft., and feels as firm and solid as the ground. A covered gallery runs round it, with windows and protecting woodwork, and in the central portion the workmen are still busy on a Vienna bakery, and in fitting up the printing machinery of the *Figaro* newspaper, the first paper published at such a height from the ground. We observed that a two-horse gas engine is used to drive the printing machinery, of the very usual Otto or Beau de Rochas cycle, by a French maker. The lifts from the base to the second stage are very strong and stable-looking structures, which run with absolute smoothness. They are in double stories, and are comfortably seated. The angle of the ascent becomes steeper as we mount, so that when we enter and lean back the seats all incline backwards; this inclination changes, till at the second stage we feel as if seated in a chair which is inclining forward, as if set upon a downward sloping surface. From the second stage we ascended to the summit by two lifts, of the Edoux system, which move upright the whole way.

Although now constantly at work and crowded with passengers, the Edoux lifts are not yet completely finished; workmen being busy glazing and finishing while travelling up and down. The motion, however, is not nearly so steady or agreeable as with the lower lifts; the rate of ascent and descent seems to vary considerably from some cause at different points of the travel, as if something were binding slightly. No doubt this slight difficulty will be overcome when they have been in action a little longer.

From the third platform of the tower, 863 feet high, Paris seems like a map, and the surrounding country can be seen for nearly 60 miles distant with great clearness. Looking over the edge of the balcony immediately below, the enormous base of the tower seems to extend but little beyond the platform upon which we stand, owing to the great distance, and the Seine seems close at our feet, while the numerous smart screw-steamers plying on it look but toys. The railways and cars also can be plainly seen moving apparently slowly, while Montmartre, Mont Valerian, and the highest buildings and elevations in Paris, seem reduced to a level. The views from the first and second platforms are in some ways more agreeable, because more detailed, and do not blot out so completely the variations in height, which form part of the beauty of any scene.

The machinery hall is a magnificent building, but here also we find it difficult to realise the great magnitude. It is so thoroughly proportioned both in length, height, and span, that it is only when we have walked about for some time within its limits that we begin to realise the vastness of its dimensions. A hall over a quarter of a mile long, covered by a circular glass roof of 360ft. span, exceeds anything the world has yet produced ; but in some way we fail to feel the great difference in dimensions till we examine in detail the multitude of machines collected within it, some of great dimensions, but all dwarfed by the containing case.

In future articles we shall deal fully with the principal exhibits, but in all large exhibitions there are necessarily great numbers of exhibits of no particular merit or novelty, so we have carefully to examine a mass of uninteresting or common-place engineering before discovering the really valuable.

English engineers, though represented by good firms and good work, are few in number this year, and the engineering exhibit accordingly quite fails to give any adequate idea of the present relative position of English engineering. The French, and even Swiss and German exhibits, far outnumber ours, so that any one depending wholly on an examination of the Paris Exhibition for information as to our position in the engineering world would form a very erroneous conclusion.

Messrs. Greenwood and Batley, Leeds, are busy fitting up a magnificent specimen of a heavy lathe, which, however, will take some time to complete. Messrs. Smith and Coventry, whose stand adjoins, are quite complete, and have a fine show of specialties. Messrs. Davey, Paxman, and Co. appear most creditably for England in steam engines, and Messrs. Crossley Brothers, Manchester, have a splendid exhibit of the Otto and Crossley gas engines, with their latest improvements. The American engineers are represented in considerable force ; but we shall leave details to future articles.

ROYAL AGRICULTURAL SOCIETY'S SHOW, WINDSOR.

ONE of the most attractive features at the above show is to be found in a huge Pulsometer steam pump, slung on poles, showing the method of using it in sinking operations. This odd-looking but now well-known appliance only requires the addition of a boiler and steam-pipe to enable it to lift to a considerable height 80,000 gallons of water per hour. The convenience and portability of this pump have ensured its adoption by contractors and others throughout the civilised world, over 12,000 being already in use.

By an ingenious modification of the steam inlet, a great economy has *this year* been introduced into the construction of the Pulsometer, and the steam is by the Grel arrangement now cut off at the proper moment, just as by the expansion slide of a steam engine, thus allowing the steam to act expansively, and saving nearly half its volume. This arrangement is shown on a small Pulsometer in action.

A large volume of water is thrown by a "Deane" patent direct-acting pump, of which the Pulsometer Engineering Co., Limited, are the sole makers in England. This pump is distinguished by the clever mechanical construction and certainty of action of its steam valve.

Duplex pumps, now so generally in use, are also manufactured in all sizes by this firm, and are also to be found at their stand.

The Pulsometer Engineering Co., Limited, are manufacturers under various patents of the "Regenerative" ice-making machines up to 100 tons of ice per diem, and claim that their system produces ice at a lower cost than any other ; but they only exhibit here their domestic ice-making machines, "The Champion," on Fleuss's patent. This machine may find a fit place in every household where ice is consumed, and for £8 8s. and £12 respectively a machine is supplied which will ice water or make ice in three minutes. The convenience of these machines in country places, or in any country where ice in large quantities is not accessible, can hardly be overrated.

The "Sirenette," also exhibited by this firm, is an instrument for producing a uniform sound audible at long distances, and is adopted by the Admiralty for signalling purposes.

Mr. E. S. Hindley, of 11, Queen Victoria Street, and Bourton, Dorset, exhibits no less than fourteen steam engines on his stand, No. 348, in addition to others working in the showyard driving different exhibits. These are of a variety of sizes, and are adapted for a number of purposes, and it is probable that no class of engine has hitherto been applied to such a variety of uses as the above, from the small ½ H.P. engine to the large condensing engine which pumps the water supply for some town or city. Recognising the fact that engines suitable for one particular purpose are not so suitable for another, these engines are made of different designs, and specimens of each are exhibited. They appear to combine the greatest simplicity with good finish and moderate cost.

Dairy engineering has received at the hands of Mr. Hindley a large share of attention, and as the result he can point to dairies of his erection in the United Kingdom of the most complete and efficient kind, one of which especially has received considerable praise, both from competitors and users, for its great completeness in labour-saving contrivances and arrangements for securing the greatest cleanliness. Mr. Hindley's exhibits in dairy machinery include the following: A milk lift and automatic tipping machine, which effects the greatest possible saving of time in emptying, at the required height, the churns of milk as they are brought to the factory by the farmer's cart ; also a weighing machine, into which the milk runs from this lift, and which gives at one operation the weight and number of gallons of the whole of the delivery from one farmer ; and a centrifugal pump, which, although only a few inches in diameter, will lift the milk at the rate of 1,000 gallons an hour after it has passed through the separator and scalder.

At the working dairy in the showyard, Mr. Hindley's horizontal engine, with vertical boiler, has been selected to drive the machinery, and one of the above-named milk lifts is also employed.

A number of saw benches are also shown in the same exhibition, and may be had in all sizes from the small hand-power bench, costing not more than £6 complete, to the elaborate machine capable of cutting large forest trees into boards or planks.

There are also five different sizes of donkey pumps for feeding steam boilers, or pumping water into cisterns ; also a very compact hoisting gear, and another working by friction and combined with a vertical boiler, the whole being portable.

Messrs. Priestman Bros., Limited, of Holderness Foundry, Hull, and 73A, Queen Victoria Street, London, exhibit three types of their new oil engines (Priestman, Humes, and Eteve's patents), using common mineral oils. It will be remembered that this engine secured the Royal Agricultural Society's highest award (a silver medal) at the Nottingham show last year, and it is now becoming well known as an example of the latest motive power.

The types of oil engines exhibited include the following: A 6 H.P. nominal portable type, the special feature of this exhibit being the application of this motive power as a portable engine ; and the makers claim it to be the first introduction as such to the public. In this form it is useful for many purposes, especially for farms, and in all cases where the portable steam engine has hitherto been used ; and as the engine requires no driver and but little attention, it is likely to answer its purpose well.

A 4 H.P. nominal horizontal engine, driving a 50-light dynamo, showing the utility of the engine for this purpose. The general design has been much improved upon, both as to compactness and otherwise, and the engine is now so constructed that every part is easily accessible.

A 3 H.P. engine, horizontal type, similar in construction to the foregoing, but having an air compressor mounted upon sole plate at end of engine, and connected directly with same by gearing. This shows another application of the engine, which arrangement can be carried out for other purposes, such as pumping, &c. An improved method of supplying electricity for ignition purposes is also shown with the engines exhibited, by means of a small storage cell. The advantages of this improvement can be readily realised when it is considered the cell will last for about three months without being recharged.

In connection with the dynamo before mentioned, are exhibited some electrical plant provided by Messrs. Lear, Sons, and Co., of Shrewsbury. Messrs. Priestman also exhibit models of their patent dredgers, excavators, &c., as manufacturers of which their name is well known.

AIR RESISTANCE TO TRAINS.

According to a writer in the *Railroad Gazette*, insufficient attention is paid to the element of air resistance as the average speed of trains increases. This, he states, acts seriously both in front and at the rear of a train, retarding its speed or consuming power. The flat front of a locomotive and its projecting cab are highly unsuitable for rapid movement through an atmosphere which has a pressure so great as 15lb. per square inch, and, therefore, considerable inertia. The remedy for this, he thinks, is simple, and head resistance would be much reduced by conforming, approximately, an engine front to the well-known shape of a boat or ship. It is very much easier, however, to reduce the air resisting at the rear of the train. A marine architect who made his ship's stern absolutely rectangular and flat, would be counted a worse man than he who made a bluff bow, and yet railway engineers have for fifty years been dragging flat-stern vessels at 60 miles per hour through the atmosphere at an immense expenditure of power, and no one of them has cared to test the effect of adding a light tapering frame to the rear end of a train and noting the decreased resistance, although everyone is familiar with the rush of air which follows a train in its attempt to fill up the vacuum formed. As in water, so in air, the formation of eddies means loss of power, and the application of the tube of a draught gauge just outside the rear end of a fast train would convey some idea of the folly of the practice of to-day. Supposing such a gauge showed an inch of water. This equivalent to a vacuum of about $\frac{1}{26}$lb., and the end surface of a car being about 80 feet, implies a total pull of say 432lb., which at 60 miles per hour is equivalent to 60 horse power. A mere tenth of an inch, therefore, would imply one or two tons of coal every 100 hours' run, all of which would be saved by a light frame of parabolic plan attached to a rear car. This theory may be entirely wrong, but reason points to its being correct, as does also the practice of shipbuilders who deal with a denser fluid, which, being visible and ponderable, has forced consideration of its properties earlier than the lighter fluid, air, the eddies of which are visible only by dust in dry seasons, and are generally unseen and unfelt.

H.M.S. MAGICIENNE.

The new cruiser Magicienne, which is engined by Messrs. R. and W. Hawthorn, Leslie, and Co., Limited, of Newcastle, went out of Portsmouth Harbour on Saturday, June 15th, for another trial of her machinery. The trial took place off the Isle of Wight, and was successfully accomplished without a hitch of any kind occurring. At the previous trial, under the same conditions, the total collective power developed was 8,780 horses, over 200 below the contract, while the mean speed realised was 18·851 knots. In the meantime, the pitch of the screws was reduced from 17ft. 9in. to 17ft., with improved results both as to power and speed. The trim of the ship was 16ft. 3in. forward and 18ft. 9in. aft, and at the end of the four hours' run the following data were worked out: Pressure of steam, 148lb.; vacuum, 23·28in. starboard and and 24in. port; revolutions, 144 and 143·2; indicated horse power, 4,516 starboard and 4,746 port, giving a collective power of 9,262 horses, or 262 in excess of the contract. The maximum power recorded at any time was 9,607, and, had it not been for a falling off in the steam during one half-hour, the mean results would have been even more satisfactory. The main speed attained during four runs on the measured mile was 19·126 knots, and as the patent log showed that a distance of 76·6 knots had been travelled while the ship was under way, it would appear that the speed was maintained throughout the trial. The Admiralty was represented by Messrs. Butler and Goodwin, and the contractors by Messrs. Marshall and Milton. Both the Magicienne and her sister ship, the Marathon, have received their armaments, and will be at once coaled for the naval manœuvres.

THE THEORY OF AQUA-AMMONIA ENGINES.*

From general considerations the author concludes that there is nothing in the science of thermo-dynamics which precludes the possibility of obtaining a less wasteful medium than water for the conversion of heat into mechanical energy. He then gives a description of a plant for the utilisation of ammonia in engines, and of experiments made with it. The boiler is of the horizontal return tube type, with a superheating surface. A division plate is introduced in the back connection, so that the products of combustion pass forwards through the liquid, and return above through the vapour. The boiler was worked with artificial draught. The feed liquid is supplied by a fly wheel pump discharging through two heaters and a coil. The motor is a Porter-Allen engine, unjacketed; diameter of cylinder, 11·5in.; stroke, 20in. The load on the engine consisted of two Edison dynamo machines of 225 ampéres capacity each. The engine also drove the fan and feed pump. The absorbing apparatus consists of a jet of spray from the boiler introduced into the exhaust pipe. The liquid forming the spray is first cooled in the heaters. After leaving the spray jet the exhaust vapour passes to the first absorber, which is practically a surface condenser with five hundred ⅝in. tubes, 41in. long. The vapour then passes into the second absorber with one hundred and fifty tubes, 40 inches long. Here the vapour is nearly or wholly converted into liquid, which overflows into a well, from which it is returned to the boiler by the feed pump. The absorbers are cooled by a current of water supplied from the city hydrant, and partly by a small centrifugal pump fed with sea-water. Tests showed that the piston of the engine was tight, but that the exhaust valves leaked, and this operated against the efficiency of the engine.

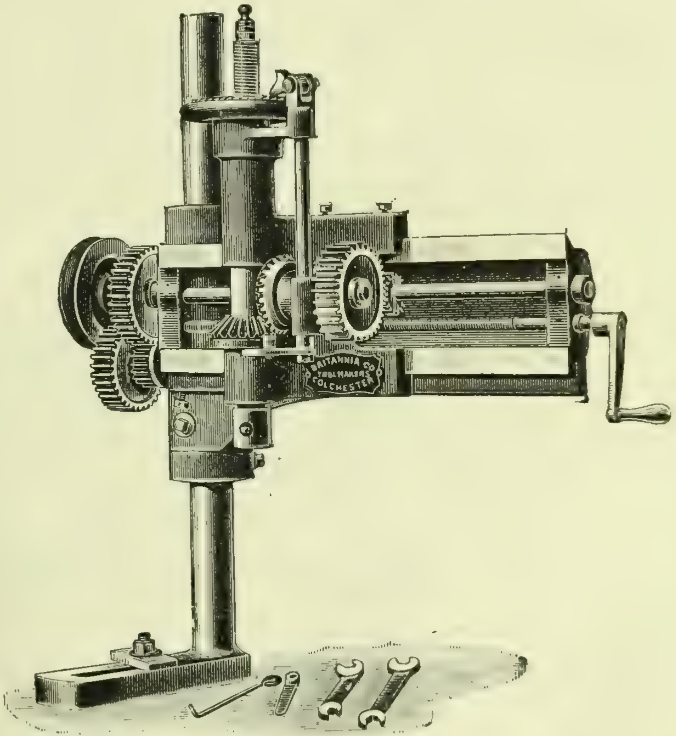
Experiments were made in this way. The apparatus was worked first with steam and then with ammonia, and the results compared. With steam only 32·26 H.P. could be obtained, but with ammonia used in the same boiler 58·14 H.P. were obtained at a lower rate of combustion.

With steam the consumption of coal was 5·626lb. per H.P. per hour; with the ammonia the consumption fell to 2·974lb. per H.P. per hour. The poor boiler performance affected the results of both fluids equally. The author believes that much water is evaporated in the boiler with the ammonia.

A PORTABLE RADIAL DRILLING MACHINE.

We here illustrate a new form of portable radial drilling machine, as manufactured by the Britannia Co., Colchester.

This machine has been specially designed to take the place of the old ratchet brace, and is adapted for bolting to locomotive frame plates, or similar work, for drilling and rimering holes up to 1½in. diameter by 4in. deep.



It consists of a strong steel tubular pillar forged on to a wrought-iron slotted foot, and is capable of being turned to any desired angle. When bolted in position, it is capable of drilling all holes within a radius of 18in. from the centre of the pillar. The spindle is of steel 1½in. in diameter, driven by strong gearing, and arranged to drive from either a swinging countershaft, as used in locomotive shops, or from a fixed countershaft if desired. There is also a variable self-acting motion as well as hand feed, and the drill will rise and fall on the pillar through a range of 18in. The weight of the machine is about 4 cwt.

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* By E. E. Magovern, Inst.C.E., Foreign Abstracts.

This is an exceedingly handy and useful tool, which will be found very convenient for a great variety of purposes. It is very desirable to use properly made adjustable slide-rest tools whereever possible, as their great convenience and accuracy in work more than compensates for the extra first cost as compared with hand tools.

THE CAPACITY OF AIR PUMPS.

(*Continued from page 273.*)

The curve AB, fig. 8, represents the solubility of air at atmospheric pressure in water at different temperatures. The curve is carried on to C, representing a temperature of 112 deg. Fah. If 5 per cent be dissolved at D, representing 59 deg. Fah., then 5 per cent × $\frac{1{\cdot}5}{1{\cdot}8} = 4{\cdot}17$ per cent would be dissolved if the temperature were 103 degs. Fah. But if the air pressure in the condenser be ½in. and the atmospheric 30in., the fraction of the air which will remain in solution will be $\frac{41{\cdot}7}{5} \cdot \frac{\frac{1}{2}}{30} = {\cdot}014$. This is such a small fraction that for practical calculations it may be assumed that the whole of the air separates from the water in the condenser. Thus for every cubic foot of water which has to be removed from the condenser there are $\frac{5}{100} \cdot \frac{461 + T \text{ deg.}}{461 + 59 \text{ deg.}} \cdot \frac{30}{P}$ cubic feet of air, where it is assumed, as before, that the temperature of the atmosphere is 59 deg. and its pressure 30in. of mercury, T being the condenser temperature and P the pressure of the air in the condenser in inches of mercury. If T be 102 deg., as before, and P = ½in., then for each cubic foot of water $\frac{65}{20} = 3\frac{1}{4}$ cubic feet of air would have to be removed.

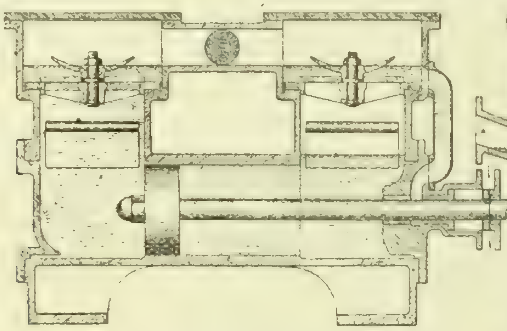


Fig. 1

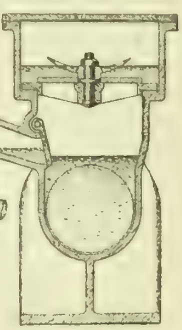


Fig. 2

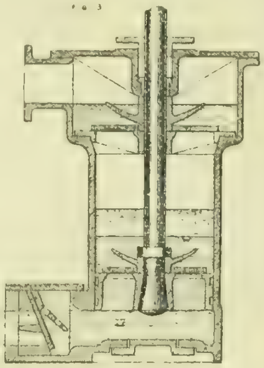


Fig. 3

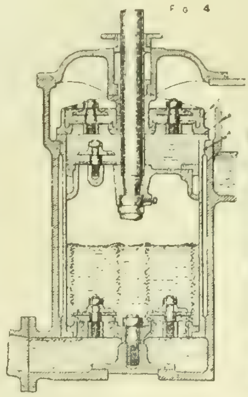


Fig. 4

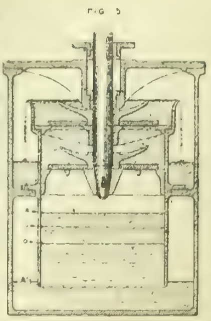


Fig. 5

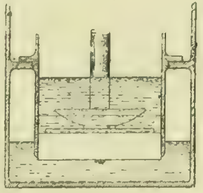


Fig. 6

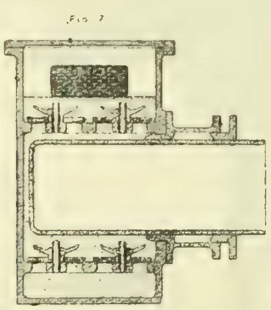


Fig. 7

In most types of air pump the air pressure is still further reduced in the barrel of the pump; but we can conceive a type of pump in which the air and vapour pressures will be the same as in the condenser. Such a pump is shown in figs. 1 and 2.

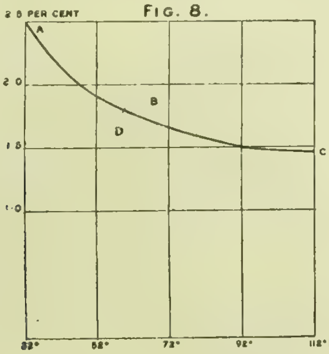
The passage A, leading from the condenser, is closed by a flap valve, which readily yields to the pressure of the water that accumulates in the passage during the delivery stroke. The water flows into the pump at the bottom of the valve, while towards the end of the stroke of the piston the vapour and air pass in through the upper corners of the valve opening. As the pressure of the water in the passage is supposed to be sufficient to open the valve, the distribution of air and vapour pressure above the water level in the pump is the same as in the condenser. The top of the valve must be at such a level that, on the return stroke, the water surface rises above it before the air above the water has increased much in pressure, otherwise some of the air would be liable to leak back. As the piston comes back the the vapour above the water condenses, so that its pressure is constant; but the pressure of the air increases under the isothermal compression till it is in excess of the air pressure above the delivery valve by an amount depending on the pressure required to lift the valve with the head of water above it, and at this point the discharge commences. Water takes a considerable time to absorb air unless the latter is violently shaken up with it, and the absorption of air due to the increasing pressure as the surface of the water rises will be very slight, if any. If there is any solution at all, it will take place at the surface; and as the water at the surface is discharged through the delivery valve, there will be no disengagement of air from the water when the latter descends in following the piston. All the air that is in the pump enters directly from the condenser. It is usual to express the capacity of an air pump as a fraction of that of the low-pressure cylinder, and to calculate the capacity of this pump so as to maintain a given vacuum it is necessary to make some assumption as to the quantity of steam in the low-pressure cylinder.

To be on the safe side, assume that if the expansion curve were carried to the end of the indicator card it would show a terminal pressure of 10lb. per square inch absolute. Further, there may be 10 per cent of the steam condensed in the cylinder, which will re-evaporate during the exhaust. The loss from clearance may amount to 3 per cent, so that if V be the volume swept by the low-pressure piston per stroke, the volume $2{\cdot}\frac{113}{100}$ V of steam at 10lb. pressure absolute would require to be condensed per revolution. The specific volume of the steam at this pressure is about 2,300, so that the volume of condensed steam will be $\frac{2{\cdot}26V}{2{\cdot}300} = {\cdot}000983$ V. The total heat of this steam will be 1,140 thermal units per pound, and if the condensing water rises in temperature from 59 deg. to 102 deg., the volume of injection water will be 24 times as great as that of the condensed steam. The volume of water to be removed per revolution will thus be 25 × ·000983 V = ·0246 V, and if the air pressure in the condenser be ½in. and barometer 30in., as before, the volume of air will be 3¼ times that of the water. Thus the pump must be capable of removing a volume of water and air equal to $4{\cdot}25 \times {\cdot}0246\ V = {\cdot}1045\ V$; that is to say, since the pump is double-acting, its capacity must be $\frac{1}{10}$th that of the cylinder.

In most air pumps, however, the suction valves are covered with water, and the pressure of the air in the condenser must be higher than in the pump before any can be transferred from one to the other. Such would be the case for pumps like those shown in figs. 3 and 4. As the same reasoning applies with slight modifications to each, it will be better to take the common form, shown in fig. 4, as a case to work out. Suppose the bucket full down and immersed in the water which covers the foot valve. The whole space between the bucket and foot valves is filled with water, and when the bucket begins to ascend there would be a perfect vacuum below the bucket valves if it were not for the evaporation of the hot water and the fact that the water enters through the foot valve. Unless the speed of the pump is very low, the water will not enter the pump as fast as the bucket rises, as the difference in pressure between the condenser and the pump will not be sufficient to produce the acceleration required. Suppose, for instance, that a pump with 2ft. stroke is running at 60 double strokes per minute, and that the effective area through the valves is the same as that of the cross section of the passage from the condenser, both being one-fourth of the area of the bucket. The acceleration of the bucket at the commencement of its upstroke will be (when upstroke corresponds to forward stroke of engine and $\frac{\text{crank}}{\text{connecting rod}} = \frac{1}{5}$) 47·5ft. per second, and the acceleration of the water through the passage and valves would be $47{\cdot}5 \times 4 = 190$ft. per second; that is, nearly $= 6\ g$, if the water were to follow up the bucket.

Thus, if the passage between the condenser and air pump were a foot long, the pressure required to put the water in the passage in motion, with an acceleration of $6\ g$, would be equal to that of a column of water 6ft. high, which corresponds to 5·4in. of mercury. To this would have to be added the pressure required to force the water through the valves, and that required to put the water below the valves in motion, and the sum of these pressures would represent the difference which would have to exist between the pressure in the condenser and that in the air pump, in order that the water should commence to enter as fast as the bucket rises. This pressure difference is much greater than any which generally occurs in practice, so that the conclusion is inevitable that as soon as the bucket begins to rise it leaves a continually increasing space between it and the water below. This space fills with vapour, and the pressure of the vapour depends on the rate of evaporation in relation to the rate at which the space between the bucket and the water increases. But the rate of evaporation is itself a function of the difference between the actual vapour pressure and the pressure corresponding to the temperature of the water; it is very rapid if this difference is large, and is very slow when this difference is small.

FIG. 8.



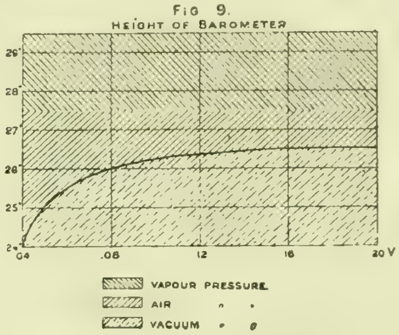
The vapour pressure below the bucket then is less than that corresponding to the temperature of the water; but, having regard to the agitation to which the water is subjected, and the extensive evaporating surfaces exposed by the ribs of the bucket and wall of the pump, and also bearing in mind that the evaporation of one cubic inch of water suffices to fill a cylinder 30in. diameter by 30in. long with saturated vapour at a pressure of 2in. of mercury, it would seem that the pressure of the vapour below the bucket will not be much short of that due to the temperature. The water which accumulated in the passage from the condenser during the downstroke of the bucket has meanwhile been flowing slowly through the valves into the pump, and if the pressure difference be sufficient, so much will have passed into the pump that the level of the water in the passage falls till it touches the top of the passage, where the latter enters the pump, as represented in fig. 4.

The momentum of the water passing through the valves helps to keep them open, and air and vapour pass along the top of the passage, mixing with the water, which has still some onward motion, the vapour being condensed and the air bubbling up through the water above the valves. This air carries up some vapour with it, and the agitation increases the evaporation, so that when the bucket has arrived near the top of its stroke, at which point it is moving very slowly, the vapour pressure cannot be much less than that due to the temperature. If the water were at rest, the condition that the air should pass up through it would be that the pressure of the air below should be greater than that of the air in the barrel of the pump by an amount equal to the pressure due to the column of water through which it has to pass.

Just before the air first begins to pass through the valves there is a water current in the same direction, owing to the greater air pressure in the condenser; but immediately the level of the water falls below that of the top of the passage and the air passes along the pressure below the foot valve becomes almost equal to that in the condenser, and the water comes gradually to rest, since the head of water above the valves checks the flow. A reverse current downwards through the valves sets in, and the valves close, preventing further entrance of air. From this it would result that the last portion of the air will have entered about the time when the water is at rest, and the pressure of the air in the barrel of the pump will be less than that of the air in the condenser by an amount due to the head of water above the valves.

The capacity of a pump required to give any vacuum which may be fixed on will, on the assumption that the action is somewhat as above described, be as follows. For the sake of comparison, the temperatures will be taken the same as before, viz.:—

FIG 9.



Temperature of injection water .... 59 deg. Fah.
„ „ discharge to hot well... 102 „
Barometer .... 29·5 inches.
Air dissolved in water at 59 deg. and 30in. pressure = 5 per cent by volume.

Then the volume of water to be removed per revolution will be as before, ·0246 V. where V is the volume swept out by the low-pressure piston per stroke. If p be the pressure of the air (in inches of mercury) in the barrel of the pump when the bucket is full up, then the volume between the surface of the water and the bucket should be

$$\cdot 0246\ V \times \frac{5}{100} \times \frac{461 + 102^\circ}{461 + 59^\circ} \times \frac{30}{p} = \cdot 04 \frac{V}{p}.$$

Thus the capacity of the pump should be $\left\{ \cdot 0246 + \frac{\cdot 04}{p} \right\} V$.

To find the vacuum in the condenser corresponding to this capacity, the height of the water over the foot valve when the bucket is full up must be known. This height is the sum of the height due to clearance and that due to the quantity of water which enters at each stroke.

The former may be taken at 6in. for a medium-sized pump, and the latter will depend on the diameter of the pump in relation to that of the low-pressure cylinder. If the diameter of the pump be one-half of that of the low-pressure cylinder, the water which enters at each stroke will raise the level by $\cdot 0246 \times 4\ S$, where S is the stroke of low-pressure piston. If S be 4ft., this becomes $\cdot 0246 \times 16 = \cdot 3936$ft. $= 4{\cdot}72$in. The total height of the water will then be 10·72in., giving a pressure equivalent to ·78in. of mercury, or say $\frac{3}{4}$in.

(To be continued.)

THE DIFFERENTIAL POSITIVE WATER METER.

CONSTRUCTED BY THE LONDON WATER METER COMPANY, LIMITED, LONDON.

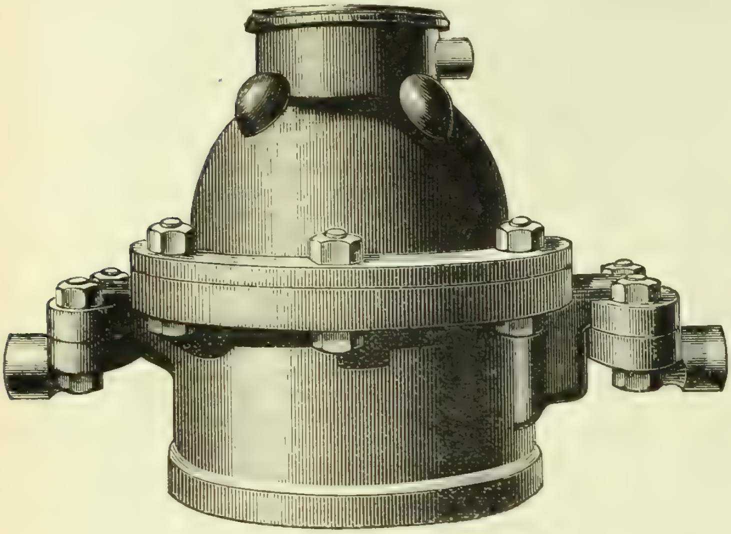


Fig. 1

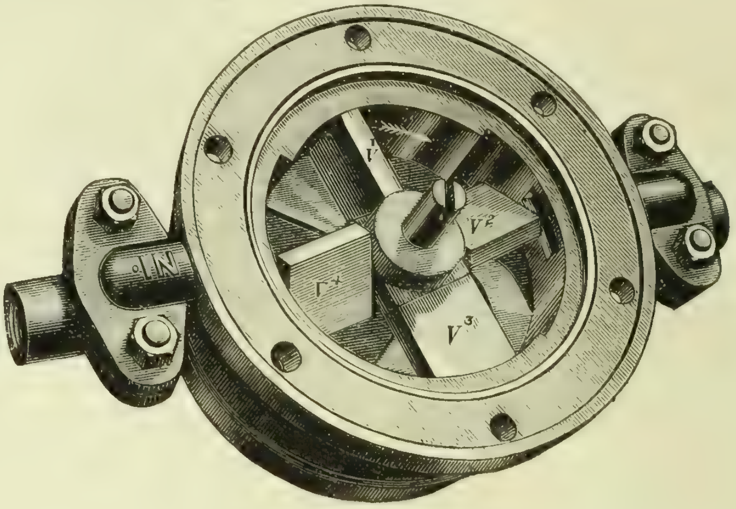


Fig. 2.

The majority of the water meters at present in use are of the well-known reciprocating piston type, which no doubt answers very well in practice, but has very objectionable features. The cumbrous form and complicated valve gear, together with the noisy action of the valve weights when thrown over by the piston movement, are undoubtedly bad points; the first because of the considerable expense involved in first cost for each meter, and the second because of the added wear and tear. A noisy machine is very rarely an economical one in repairs, as noise always means some hammering action, which is bound to cause deterioration in time. The sole advantage of this kind of meter has been considered its absolutely positive action, and the reliability with which it measures out one cylinder full of water at every stroke.

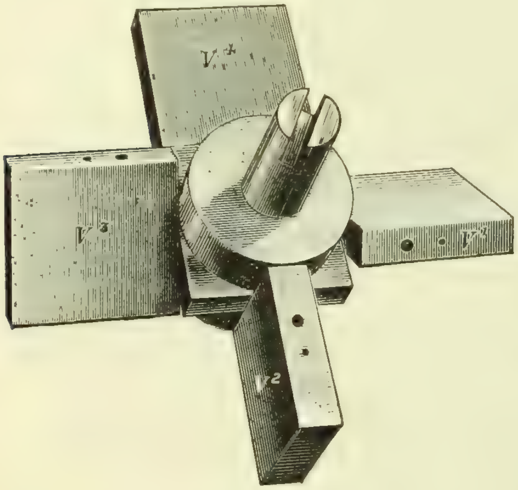


Fig. 3

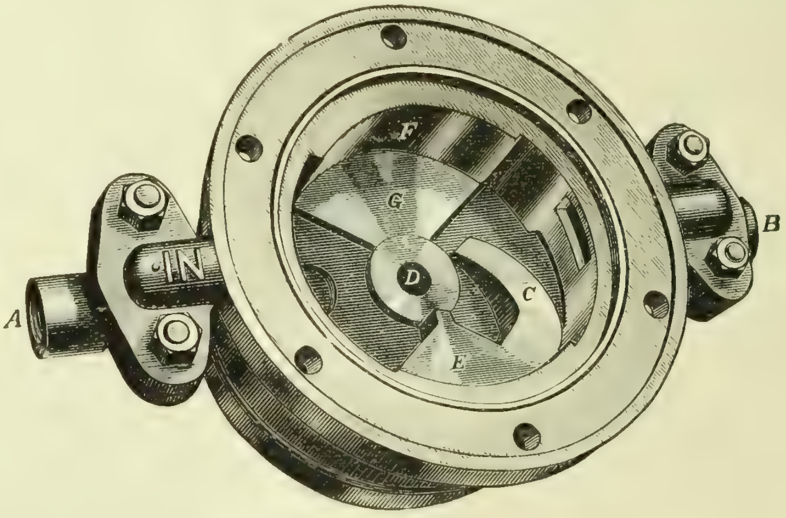


Fig. 4.

Rotary water meters are much more compact and simple, but their disadvantage hitherto has been due to a want of positive measurement, and consequently a dependence on a constant friction of parts for uniformity in results.

The London Water Meter Co., Limited, of Chancery Lane, London, have produced and manufactured largely a most ingenious form of rotary water meter, which, in our opinion, completely overcomes the objections hitherto held to such meters, and combines most effectively the advantages of compactness and simplicity, while securing effectively a measurement which is absolutely as positive as that of any cumbrous reciprocating piston meter. Essentially it consists of a cylindrical case, within which revolves a spindle carrying four vanes. Each vane is attached to the opposing one by a spindle passing through the main boss, and so set that one vane is at right angles to the other; at one segment of the cylinder a projection from the side fills it up completely, except a slot just wide enough for the vane to pass edgeways. An incline piece leads up to this slot, so that the edge is gently turned round and entered into the slot.

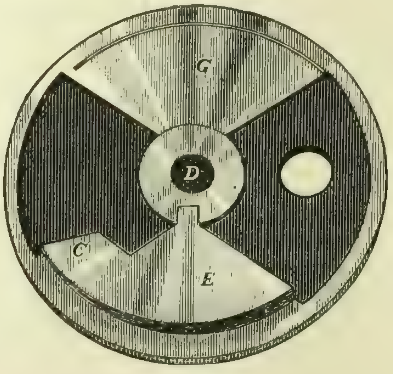


Fig. 5.

Suppose water admitted under pressure while in this position; then the area of the flat of the vane being much greater than the area of the edge, the main boss is rotated and the water is measured into the space formed, which is accurately known from the difference between the areas of the edge and flat. Referring to our illustrations, fig. 1 is an external view of the meter; fig. 2

is a view of the interior, with the vanes, boss, and main spindle in position, the exterior cover only being taken off; fig. 3 shows the vanes, boss, and main spindle taken out of the meter; fig. 4 shows the meter, with vanes, &c., removed to show the construction; and fig. 5 represents the top plate or cover (interior view).

The vanes V^2 and V^4, and V^1 V^3, are at right angles to each other, and each pair on one spindle, and the inner edges fit closely to the surface of the boss, while the exterior edges fit the surface of the meter cylinder. An incline piece C, fig. 4, and a corresponding piece C, fig. 5, in the cover guides the vanes so that each as it touches is gradually inclined till it assumes the horizontal position, and passes through the slot formed by the position E in the meter cylinder, fig. 4, and E in its cover, fig. 5. In fig. 2 the vane V^2 is on the incline piece, and is being turned to the horizontal position, while its opposing vane V^4 is by the connecting spindle through the central boss being turned to the vertical position. In the position of V^1 and V^3 of the same figure, they are respectively vertical and horizontal. The water enters at A, marked in fig. 4, and the pressure acts upon V^1 and V^3 flat and edge, so that the movement takes place in the direction of the arrow. The water on the discharge side B, fig. 4 (not marked in fig. 2) is forced out by the outlet port seen. Only a segment of the cylinder fits the edges and flats of the vanes, so that while any pair is having its position changed, or feathering, the water has free passage by the front edges, as in V^2 and V^4, fig. 2. The vane V^2 becomes horizontal and enters its slot just as V^4 becomes vertical and fits the turned segment upon which V^1 is seen moving in the figure. The volume entering by A is measured by the difference between the area of the edge of V^3 and the flat of V^1, as the first passes through the slot and V^1 passes the fitting portion of the meter cylinder. Two vanes are always acting during the revolution, while two are changing positions preparatory to action, so that the meter is perfectly positive, and there is no dead point.

We are much impressed with the obvious ingenuity and great simplicity of the arrangement, which has cost, we can readily see, a very considerable amount of thought and experiment.

The annular chamber or cylinder is lined throughout with gun metal, and the hub and vanes are of ebonite of low specific gravity, which gives floating power, and the spindles connecting the vanes through the hub are of phosphor bronze. The horizontal connecting flanges allow the meter to be taken to pieces and put together with great ease and rapidity, and a special ebonite bushed joint with a flexible washer renders the main spindle passing to the counter diaphragm perfectly tight.

Owing to the large waterway the hub movement is comparatively slow, even when working at full force, which fact, joined to the floating power of the ebonite, makes the movement practically frictionless; and as the pressure is always acting on a perfectly uniform area, the action is absolutely uniform and noiseless. The parts marked G, figs. 4 and 5, fit the edges of the vanes. The obvious advantages of this method should find it in greatly increasing demand. In large meters for measuring a heavy flow through mains, the capacity and compactness are undoubtedly a great convenience. If, as is sometimes urged, the want of a reliable meter is the principal bar to an extension of the meter system, this carefully worked out design will no doubt prove a stimulant in the right direction.

COMPOUND LOCOMOTIVE ON THE NORTHERN RAILWAY OF FRANCE.*

On the advice of M. du Bousquet, an eight-coupled wheel goods locomotive, on the Northern Railway of France, was converted into a Woolf tandem compound locomotive, comprising a pair of tandem engines. In making this conversion, the application of additional wheels was not allowed, and the maximum weight on any one axle was not to exceed 14¼ tons (14½ tonnes), the maximum weight allowed for high-speed engines on the railway. The distribution of the weight of the locomotive before and after conversion was as follows :—

	Before Conversion.		After Conversion.
	Tons.		Tons.
1st axle	12·00	....	13·24
2nd ,, ...	10·92	....	14·01
3rd ,, ...	11·91	....	13·76
4th ,, ...	9·15	....	9·86
	43·98	....	50·87

Showing an augmentation of 7 tons weight, of which 3 tons is the weight of a platform of cast-iron, at the back of the firebox, to counterbalance the weight of the cylinders.

The cylinders of the original engine were 19·68in. in diameter, with 25·59in. of stroke; and wheels 51·18in. in diameter. As compounded, the first and second cylinders, in tandem, were 15in. and 26in. in diameter, with the same stroke as before, 25·59 in.; the capacity ratio of the cylinders being 3. These dimensions are the result of elaborate calculation based on indicator diagrams taken from the cylinders of the original engine. The cylinders are placed outside the frame-plates, and the second or larger cylinder is placed at the front. They are joined together, forming a diaphragm partition common to both; and the second piston is provided with two piston rods, which pass back, flanking the first cylinder, and are, with the piston rod of the first cylinder, fastened to a cross head common to both. The two cylinders have but one valve chest and one slide valve, worked by the link-motion. The valve is formed double to provide passage ways between the cylinders, and for the exhaustion into the chimney. For the second cylinder the Trick principle of double entry is provided. The steam ports are unusually wide, 17¼in., for ready ingress and egress of steam. The valve is balanced, for the most part, by the removal of the pressure on the back by a packing ring for a circular area 19in. in diameter. Through an automatic piston valve, air is admitted into the cylinders when the steam is shut off. Steam can be admitted direct into the second cylinder when required.

During the month of January, 1888, the compound locomotive was tested daily with regular coal trains of sixty wagons (900 tons), from Lens to Longueau, 106 miles going and returning. The gross consumption of fuel was at the rate of 50lb. of coal per mile. By the results of comparative trials of the ordinary and the compound locomotive, given in detailed tables, it is shown that a saving of fuel of from 13½ per cent to 26 per cent, according to the weight of the trains, is effected, in favour of the compound system. These results, deduced from the actual performance of the engines, are corroborated by analyses of the indicator diagrams, which show an economy of from 3·20 per cent to 26·4 per cent; with speeds of from 10 miles to 13 miles per hour on levels and ascending inclines for the ordinary machine, and from 8 miles to 22 miles per hour for the compound machine.

SIX YEARS' PRACTICAL EXPERIENCE WITH THE EDISON CHEMICAL (ELECTRICITY) METER.*

This paper, read before the American Institute of Electrical Engineers, commences with a detailed description of all the meters devised and patented by Mr. Edison, and which are deemed more or less practical and adapted for commercial requirements. The special subject is, however, the electrolytic meter, consisting of two glass cells containing zinc electrodes, immersed in a 10 per cent solution of zinc sulphate. These cells, shunted by small German silver resistances, are introduced in the main circuit, the resistances being adjusted so that one cell receives $\frac{1}{975}$ of the current, and the other one-third of that amount, one cell being adapted for a monthly account, and the other for a trimensual. In localities where the solution is likely to freeze, the precaution is adopted of introducing into the case containing the cells a thermostat and a glow-lamp, the circuit of the latter being closed by the former when the temperature falls below a certain minimum. The positive plates are removed once a month, and weighed, the loss since the previous weighing serving, by a simple calculation, to give the amount of current which has traversed the circuit controlled by that meter, and the consumer's account made out accordingly.

The different objections which have been raised against electrolytic meters are discussed *seriatim*, and the principal of them are obviated by ordinary care in cleaning the plates and the use of pure chemicals; these latter, it may be noted, are supplied from a specially appointed bureau of the Edison companies. The effect of temperature, as well as the variation of the electrical quantities involved, are diagrammatically exhibited, from whence it appears that these variations may be neglected in commercial practice, the ultimate limit of error being less than 2 per cent.

Finally, the experience of the different subsidiary Edison companies has been obtained in answer to definite questions circulated among them for the purpose, and their replies are extremely satisfactory as to the reliability of this meter, as well as to the advantage for both supplier and consumer of adopting payment by meter, instead of by time contract.

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* By G. du Bousquet, Inst.C.E., Foreign Abstracts.

* By W. J. Jenks, Inst.C.E., Foreign Abstracts.

THE SKILLED LABOUR MARKET.

THE following memorandum on the state of the skilled labour market has been prepared for the *Board of Trade Journal* by the labour correspondent of the Board of Trade: "The monthly reports of the principal unions of skilled trades again show that the recent activity in the labour market is being sustained, although it cannot be said that any improvement has taken place upon the conditions of the last few months, except in the building trades, which seem to be expanding remarkably just at present. In all, 19 societies have sent in returns as to the state of their respective trades. These organisations have a total membership of 194,097, of whom 3,952 were out of work, as against 3,798 for last month. This is an increase in the unemployed list of 154. The change for the worse exhibited by these figures is, however, due to special causes rather than to any slackening of the general current of trade. In some districts there have been stoppages of work in support of requests for improved rates of wages, and to these disputes any increase in the number of unemployed men is due. The increase is, in fact, entirely confined to the shipbuilding and engineering branches. The former trade has been disturbed by an extensive strike of riveters on the Clyde, while the latter has had its list of men on benefit swelled by a dispute at Hull. On the other hand, the building trades are better employed than for some years. The carpenters and joiners in particular are well employed, and during the month the percentage of unemployed has gone down from 3·7 to 1·9. This change for the better has in some districts had the effect of increasing rates of remuneration, and many local advances of wages are reported. The general proportion of unemployed is about 2 per cent, and, judging from appearances, this percentage is not likely to be much reduced. Summarised generally, the reports show five trades to be very good, ten good, and four moderate."

INSTITUTE OF MARINE ENGINEERS.

A MEETING of the Institute of Marine Engineers was held on Thursday evening, 6th inst., in the Langthorne Rooms, Stratford, when the discussion on the paper read by Mr. Manuel at the previous meeting, on "Shafting in the Mercantile Marine," was continued.

In the absence of the president, the honorary secretary occupied the chair, and introduced the subject of the evening by referring briefly to several noteworthy points in the paper, with a view to court discussion and invite members to give their experiences or views. The first point referred to was the original lining up of the shafting by the engine-builders, and the importance of having the utmost care and attention bestowed upon this, as well as having ample bearing surface in the blocks. Mr. Manuel had instanced cases where, owing to want of attention to these details, much trouble had been experienced with steamers from the time of leaving the builder's hands. In connection with the original lining off, the chairman referred to the good practice of marking the bearing blocks and making accurate gauges, so that at any time it could be seen at a glance how much the shaft had fallen. Cases were cited illustrative of the want of sufficient bearing surface, where the use of water was almost a constant practice to the detriment of the whole work of the engine-room, and of others where the bearings had not been touched for eight years even with hard driving. The need of more surface in the after than the forward bearings, and the fact of the greater strain on the former, were touched upon; and reference was made to a shaft which developed a flaw in the after crank-shaft bearing, and where, as a safeguard, the shafts were reversed and the after bearing shifted forward. The exceedingly interesting description, illustrated by diagrams and samples, of the process of manufacture and testing the material was next referred to, and the surprising amount of accuracy with which the forgeman completed the shaft-forging, leaving little to be done by the turner except smoothing the bearings. Mr. Manuel had referred to the paper on the subject of shafting read before the Institute of Naval Architects by Mr. Milton in 1881, but there was a later and most interesting paper by Mr. Hector McColl, read before the Institution of Engineers and Shipbuilders in Scotland, session 1886-7, which contained valuable data, and would repay perusal. The difficulty experienced with regard to the propeller boss was mentioned as due largely to improper fitting at first, which opened the way for the action of the sea water to have effect on the bearing surface of the boss, involving fitting the boss higher up the shaftcone, and occasionally, when the action had been going on too long, and the cast iron of the boss softened, this had to be done time after time until the necessity arose of having a new boss or shaft, or both.

Discussion being then invited, Mr. F. W. Shorey questioned if much or any damage was done to the shaft forging by the process of extra finish put on it by the forgeman, as he had not found in his experience when turning large shafts that the outer skin was so much different from the inner section as the diagram illustrating the broken shaft seemed to show.

Mr. D. Greer was of opinion that the breaking of this shaft was due to other causes.

Mr. J. R. Ruthven spoke at some length on the subject of the undue strains to which, in these days of almost instantaneous-acting hydraulic reversing gear, the shafting of steamers are subjected. He considered that if records were kept showing the number of times the engines were reversed from full speed ahead to full speed astern—often by orders given from the bridge thoughtlessly by the navigation officer—it would prove that the shafting was not treated altogether with justice. He gave an instance of a small steamer which put into port with a broken shaft, and where a large shaft was turned down to suit, there being no facilities to forge a new one in time, and, although the diameter was kept much larger than the original, it gave way, showing that the inner section of the forging is not so reliable for strength as the outer skin.

Mr. J. H. Thompson referred to the paper read by Mr. McColl, a copy of which had been shown to him by the honorary secretary, whose remarks as to its value he endorsed, and spoke on the subject of the crank pins in built shafts, and the different opinions that were held as to shrinking on the webs, keying them or fitting pins to prevent the tendency to work slack, cases of which had been referred to by Mr. Barringer at the previous meeting.

Messrs. J. Stewart (Orient Line), W. Wilson (P. and O.), J. Simpson (National Line steamship Erin), and J. Bruce (City Line steamship City of Cambridge), and others continued the discussion, referring to the breaking of propeller shafts, galvanic-corrosive or mechanical action on these shafts, the fitting of the bosses on the shaft, and causes leading to the bosses becoming slack; after which Mr. Manuel explained his own views more fully, and illustrated the several matters which were brought forward in the course of the discussion by the various speakers.

The proceedings were brought to a close by votes of thanks to Mr. Manuel and to the chairman of the evening respectively, moved by Mr. J. Bruce and Mr. R. Leslie, which were heartily responded to. The chairman, in closing, stated that the members who had not yet received their copies of the first paper and discussion could obtain them now. He also announced that the samples of steel, &c., illustrative of the recent paper, could be inspected at leisure by members in the reading-room any evening, by the kindness of Mr. Manuel. It had been considered advisable to close the present term for the reading of papers for the summer months. Arrangements were being made for the reading of a paper during the first week of September by Mr. W. J. Craig or Mr. Newall; other papers had been promised by Mr. J. M. F. Gray and Mr. Manuel, and others, and by a few of the honorary members. The reading-room and library would remain open as usual for the use of members of all grades. The council would meet during the recess, on the first and third Fridays of each month, unless summoned for special business.

ELECTRIC ENERGY FROM CARBON WITHOUT HEAT.*

THE second law of thermo-dynamics states that when mechanical energy is obtained from a hot body by cooling it, a fraction $\frac{t}{T}$, where T is the higher and t the lower temperature on the absolute scale of the total heat, is transferred. If the energy of carbon could be converted electrically into mechanical energy without first converting it into heat energy, this fraction of the energy would be utilised.

Jablochkoff has constructed an electric battery having plates of iron and carbon immersed in fused potassium nitrate (nitre). The carbon is oxidised to CO_2. There is strong local action in the battery.

The author has experimented on plates of platinum and carbon in sulphuric acid (sp. gr. 1·81, temperature 75 deg. Fah.), in which potassium chlorate is dissolved with the following results.

The electro-motive force varied with the quality of the carbon used. With lump graphite, 0·8 volt; gas carbon, 0·5 volt; carbon produced by the action of sulphuric acid on cane-sugar, 0·3 volt. Other forms: Animal charcoal, wood charcoal, coke, gave 0·3 to 1·24 volt. Finely divided carbon in a porous cup gave 1·24, due apparently to the presence of the oxygen of the air. The chemical action appeared to be due to the action of chlorine peroxide on the carbon, the result being the formation of chlorine and carbonic acid. The experimental cell had an internal resistance of 2·7 ohms. The cell polarised rapidly when giving current.

Another form of cell used experimentally by C. S. Bradley consists of a carbon and platinum pair in a solution of manganate of potassium, through which air is forced to re-oxidise the salt as it is reduced by the carbon. Coal was the form of carbon tried. The electro-motive force was nearly 1 volt. The resistance of the cell was very high.

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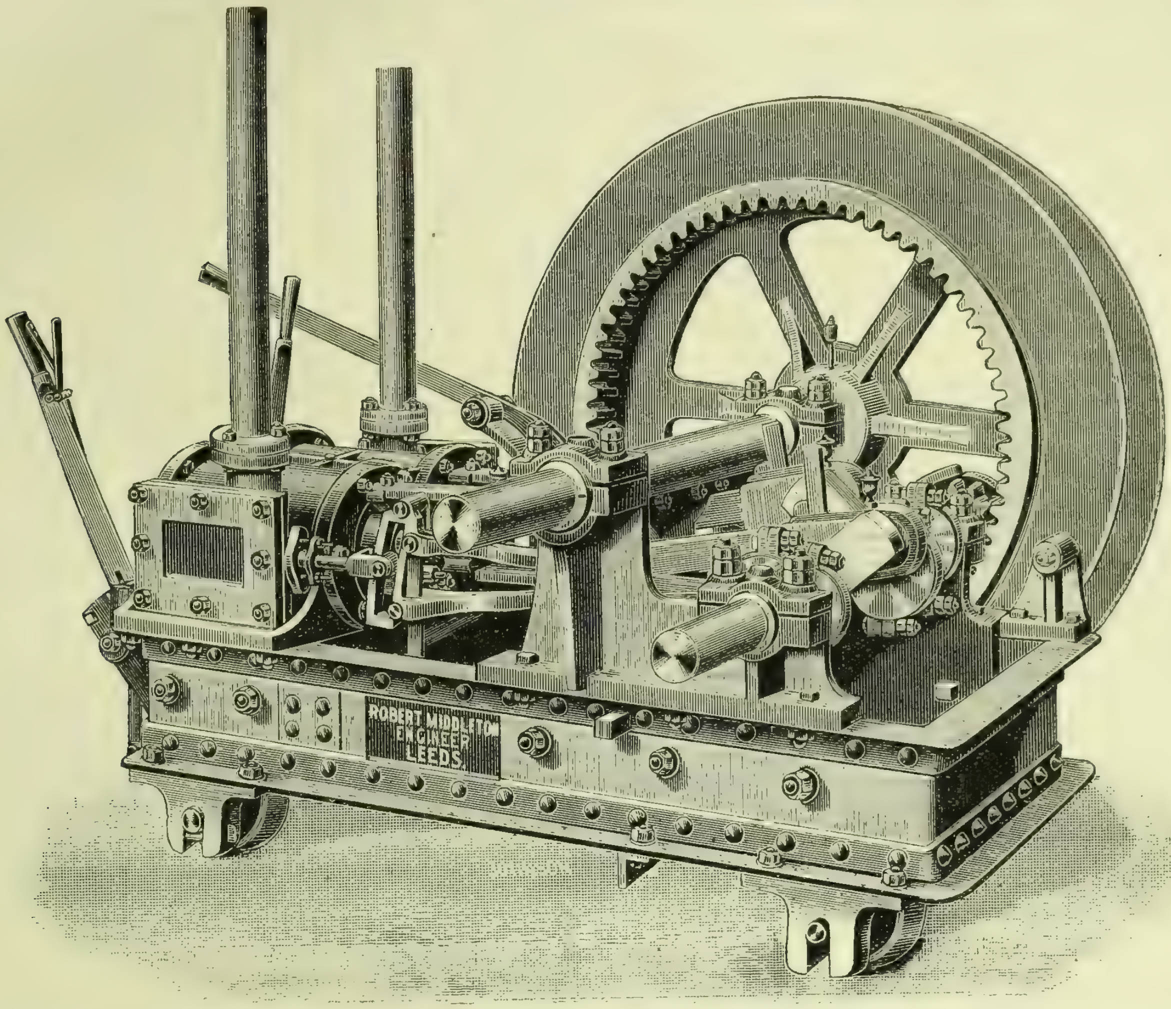
* By Willard E. Case, Inst.C.E., Foreign Abstracts.

IMPROVED HORIZONTAL HAULING ENGINE.

CONSTRUCTED BY MR. ROBERT MIDDLETON, ENGINEER, SHEEPSCAR FOUNDRY, LEEDS.



IMPROVED HORIZONTAL HAULING ENGINE.

WHERE extreme lightness is to be combined with considerable power, the liberal use of wrought iron in framing and other engine parts is very desirable, and is now very generally adopted by good makers. We here illustrate an improved form of hauling engine for underground work, designed and made by Mr. Robert Middleton, engineer, Sheepscar Foundry, Leeds. It is entirely self-contained, and designed to occupy as little space as possible in the works, great strength and lightness being given by the wrought-iron girder bed. It is exceedingly useful for colonial purposes, and can be readily moved and refixed either on rails or road. The whole machine is very creditable indeed, both in construction and design.

THE NEW DEE RAILWAY BRIDGE.—This important work is so rapidly approaching completion, that Sir Edward Watkin, in the presence of other directors of the Manchester, Sheffield, and Lincolnshire Railway Company, by whom the bridge has been constructed, recently successfully rotated it, and the party travelled over the new portion of the line, some eight miles in length, from Chester to the bridge. The section of the railway to Hawarden is being pushed forward with great rapidity. A little beyond Mr. Gladstone's residence, the line joins the main track of the Buckley, Mold, and Connah's Quay Company, giving it direct connection with the Welsh system of railways which the bill now before Parliament proposes to amalgamate, for through working to Cardiff and South Wales. The railway bridge over the Dee is constructed of three girders, two of which are fixed, while one swings. This latter, which was easily moved by Sir Ed. Watkin, is 243ft. in length, while the fixed girders have each a span of 133ft. During the proceedings a general hope was expressed that the Queen would consent to open the bridge during her visit to North Wales in August.

THE NATIONAL BOILER INSURANCE COMPANY.

THE annual report of the chief engineer of this company for the past year has just been issued, and, as usual, it contains some interesting remarks on the subject of boiler legislation and inspection, and many useful hints to steam-users on the management and inspection of their boilers. After referring to the increase in the number of boilers insured by the company, and the comparatively large number of minor claims for damages owing to deficiency of water, caused generally by a want of care or by positive neglect on the part of the attendants, Mr. Hiller goes on to remark that "It has almost become the fashion, in each session of Parliament, for some one to propose legislation in reference to the working of steam boilers; but the schemes submitted in recent years would materially interfere with manufacturing operations, and subject to arbitrary and unnecessary regulations the bulk of steam-users, who are careful and anxious to secure safety, consequent on the neglect of a careless minority. The reports issued by the Board of Trade, under the 'Boiler Explosions Act, 1882,' are liable to lead to erroneous conclusions in reference to this matter. The statistics based thereon are most misleading, and the object of issuing such returns is not apparent, but it should only require to be pointed out to secure their correction. At the present time the explosions of drying cylinders, stills, and any kind of steam apparatus, or any occurrence which can, by straining of terms, be designated an explosion, are included in the official list, as though all were steam boiler explosions. Numerous occurrences connected with the use of steam could with equal consistency be so designated; and if all such were to be made known, and counted as boiler explosions, the list might be increased at least one hundredfold, compared with the numbers hitherto returned. If such simple occurrences have to be investigated, they should be separated and described accordingly; whilst the explosions or failures of apparatus which are not steam boilers should also be given separately, the actual explosions of steam boilers only being so designated.

"The only legislation which seems necessary in face of the great diminution of destructive explosions, consequent on the large number of boilers which are now placed under voluntary inspection (which probably exceeds 60,000 in the United Kingdom), would be to intimate to all steam-users that it is their duty to have their boilers periodically thoroughly inspected by competent persons, and that they will be held responsible if due precautions are neglected; and there should be powers obtained by which anyone proved guilty of gross negligence may be duly punished, even though the explosion of the boiler might not be accompanied by fatal results. The minority whose negligence might cause the whole of steam-users to be subjected to stringent regulations could, without doubt, be dealt with as above indicated; and a few examples would have such a deterrent and healthy effect, that explosions from gross negligence or recklessness would soon almost, if not entirely, disappear. Steam-users should be on the alert and oppose unnecessary or arbitrary legislation, which would inevitably seriously interfere with their operations."

Mr. Hiller again calls attention to the great comparative reduction in the number of explosions in the United Kingdom, which he rightly ascribes to the efficient service rendered by the National and other first-class insurance companies. He therefore solicits the earnest co-operation of insurers, in order that the inspection provided for by the company may be attended with that success which it is to the interest both of insurers and insured to attain. With this object a number of practical suggestions are thrown out as to the time and manner in which inspections should be conducted.

The report also contains a number of practical observations upon the causes of some of the explosions which have taken place during the year, which will no doubt be read with considerable interest by every steam-user.

LAUNCHES AND TRIAL TRIPS.

THE steamship Pocasset, built and engined by Messrs. Robert Stephenson and Co., Limited, of Newcastle, was taken on her trial trip on Saturday, June 1st. Her principal dimensions are: 300ft. between perpendiculars; 39ft. breadth; and 27ft. 6in. depth, moulded; with a carrying capacity of 3,750 tons. She has been built for the Mediterranean and New York Steamship Company, Limited, for whom Messrs. Phelps Bros. and Co., of Liverpool, are the managers, and is intended for the Mediterranean and New York trades. She is fitted with triple-expansion engines of the latest type, having cylinders 25in., 39in., and 62in. diameter, with a stroke of 42in., and supplied with steam from two extra large steel boilers, working at a pressure of 155lb. per square inch. Four runs were made on the measured mile, when a mean speed of 12½ knots was attained. The engines worked without a hitch, and the owners' representatives on board expressed themselves as highly satisfied with the ship's performance.

ON Saturday, June 1st, the new screw-steamer Talavera, which has been built by Messrs. W. Dobson and Co., Low Walker, for Messrs. H. Scholefield and Son, Newcastle, went to sea for a trial trip. The vessel is of the following dimensions: Length, 265ft.; breadth, 37ft.; draft 17½ft. She is fitted with every modern appliance for quick and economical working of the steamer. The machinery, which has been built by the North-Eastern Marine Engineering Company, Limited, Wallsend, is of the tri-compound type, with cylinders 20in., 33in., and 54in., with a stroke of 39in. During the trial the engines worked with perfect smoothness and regularity, and the speed of the vessel on the measured mile was equal to 10 knots, which was considered highly satisfactory.

ON May 28th there was launched from the Low Walker Shipbuilding Yard of Messrs. Sir W. G. Armstrong, Mitchell, and Co., a steel screw-steamer, which is the pioneer vessel for the German-Australian Steamship Company, of Hamburg, who are about to inaugurate a new service between Hamburg and Australia direct. The vessel, which is named the Elberfeld, is one of 3,500 tons burthen, built to the highest class at Lloyd's and Veritas, and has large poop extending to midships for the accommodation of emigrants. After the launch the vessel proceeded to the works of the Wallsend Slipway and Engineering Company to receive her machinery, which will be of the triple expansion type, with boilers working at 160lb. pressure, fitted with all the most recent appliances. The engines will be capable of indicating about 1,400 horse power. The vessel will be fitted with the electric light, and, generally speaking, finished in the most complete manner for her intended service. Messrs. Armstrong, Mitchell, and Co. have a sister ship to the vessel now under construction.

THE steel screw-steamer, Italia, built by Sir W. G. Armstrong, Mitchell, and Co. for the Hamburg-American Packet Company, of Hamburg, has just been tried at sea with the most satisfactory results. The vessel is 359ft. long, 43ft. 6in. beam, and 31ft. 9in. depth, moulded. She is built to the highest class at Lloyd's and Veritas, and has two ranges of 'tween decks fitted up for emigrants, of which she will carry about 1,200. The vessel has been built exclusively as an emigrant and cargo ship, and her emigrant berths are of iron, all being portable and interchangeable, and can be very readily stowed away on the return voyage, so as to allow the carriage of cargo in the emigrant space. The vessel is fitted in the most complete manner, including fire service throughout, and has also steam pipes, so that any part of the hold can be filled with steam. The Italia is fitted with triple expansion engines by the Wallsend Slipway and Engineering Company, which indicated 2,100 horse-power, and gave a speed of over 12 knots. The trial was entirely satisfactory, and the vessel at once proceeded to Hamburg to load for New York.

THE steel screw-steamer, Holme Eden, built to the order of Mr. Wm. Wright, of South Shields and London, by Messrs. John Readhead and Sons, was taken to sea for her official trial trip on May 28th. The steamer made a series of runs over the measured mile off Whitley, when an average speed of 11½ knots was made, although the vessel was light and the propeller partly out of water. The Holme Eden is the fourth steamer built by Messrs. Readhead and Sons for Mr. Wright, and is 290ft. long, 39ft. broad, and 20ft. depth of hold, her dead-weight carrying capacity being 3,450 tons. The engines are of the triple expansion type, and worked smoothly during the trial. The vessel has been built under special survey to class 100 A1 at Lloyd's, and is of the improved well-deck construction. She is fitted with shifting boards to comply with the Grain Cargoes Act, and has all the most modern improvements for the rapid loading and discharging of cargoes. The building of the hull was superintended by Capt. G. W. Freeman, and the construction of the engines was under the supervision of Mr. W. Menzies, of Newcastle. After the trial, the vessel was taken into Tyne Dock to load.

THE screw-steamer Crown left Blyth recently for the purpose of proceeding on her official trial trip. The Crown is 260ft. in length, and has been built to the order of Messrs. Dent and Co., Newcastle and Blyth, for the Crown Shipping Co., of Newcastle. The machinery, which has been supplied by the North-Eastern Engineering Co., of Wallsend, gave the greatest satisfaction. After several successful runs on the measured mile and a run south, the Crown returned to the mouth of the Tyne, where the company was taken on board, and the Crown proceeded to Middlesbrough to load.

ON Saturday, May 25th, the new screw-steamer Vesta left the Tyne for a trial trip. This vessel, which was built to the order of Messrs. Fisher, Renwick, and Co., of Newcastle, has been sold to the Finnish Steamship Navigation Co. of Helsingfors. She was built by the Tyne Iron Shipbuilding Co., Limited, Willington Quay, and is of the following dimensions: Length, 210ft.; breadth, 31ft.; draft, 14ft. 10in. The vessel is fitted with all modern appliances. The engines, which have been constructed by the North-Eastern Marine Engineer Company, Limited, Wallsend, have cylinders 17, 28, 46, and a stroke of 30in., and are fitted with all the latest improvements. During the trial, they worked at 94 revolutions without any hitch, and indicated 750 horse power. The vessel was tried over a measured mile, and showed a mean speed of nearly 10½ knots, which was considered very satisfactory.

FLYWHEELS.

THE necessity of the attainment and maintenance in steam-engine working of a uniform, or nearly uniform, velocity in cases where the work is given off from a revolving shaft was early recognised, and the requirement practically met by the flywheel and governor. These two appendages of the steam engine, although both are concerned in regulating the speed of the machine, have distinct duties to perform: that of the governor is to accommodate the supply of steam to variations in external load, which are independent of the construction of the engine itself; the duty devolving upon the flywheel consists in absorbing the work done, in constantly varying quantity, upon the crank shaft, and giving it off with the closest practical approximation to uniformity, the whole work done in each revolution being rendered again during that revolution, with the exception of course of that part expended upon prejudicial resistances. When the engine is working against a uniform resistance, any position of the crank being taken, the velocity of the flywheel will be constant for that position, because the whole work received in one revolution is also given off during the same, the normal velocity having already been obtained.

The question of adapting the flywheel to the duties required of it is one of very great importance, not on account of any difficulties, either practical or theoretical, so far as the regulating element itself is concerned, but because it has been a practice to give rules for determining its dimensions, which are not based upon the actual conditions under which it is required to act. It is also of importance that, while the necessary proportions to ensure the variations of velocity against exceeding the prescribed limits in any particular case are given, the wheel should be made as light as is consistent with its duties to avoid placing any unnecessary load upon the main bearings, which would increase the always considerable amount of friction on those parts.

At the angular position of the crank, corresponding to the least maximum velocity of the flywheel, there will be a quantity of work stored up in the latter to be given off between that position of the crank and the one corresponding to the least velocity, and the amount of this stored-up work being known, the ratio of velocity to weight corresponding to it can be ascertained.

The accumulated work varies on the weight multiplied by the square of the velocity $\left(\frac{Wv^2}{64{\cdot}5}\right)$. It is therefore evident that for lightness the flywheel should be as large in diameter as possible, as for a fixed number of revolutions per minute the velocity of its rim will vary as the diameter of the wheel.

The resistance at the working point being uniform throughout the revolution, the quantity of work given off during the passage of the crank through any given angle will be directly in ratio to the extent of such angle, each degree traversed corresponding to an equal amount of work. The work done upon the machine in passing from one position to the other, will be measured by the distance travelled through by the piston in the same time, multiplied by the mean effective steam pressure upon it while passing through that distance.

If the steam pressure were constant throughout the stroke, the only variations to be compensated would be those due to the difference between the angular and rectilineal velocities, and these always varying according to a fixed law, one formula would be of general application; but the fact that engines cut off their steam at different parts of the stroke renders such a rule useless. The higher the rate of expansion used, the greater will be the difference in the work done upon the crank shaft at the commencement and termination of the stroke, and this is a poin- which seems to have been generally neglected in note-books and treatises hitherto published. For engines in which the governor acts by varying the rate of expansion, the flywheel should be designed for the highest rate of expansion at which the machine is to be run.

By making a hypothetical indicator diagram for a proposed steam engine, and dividing its length up by ordinates, the positions of which represent those of the piston in relation to known divisions of the crank path, the work done on the piston during any portion of the stroke can be calculated and compared with that given off, and where the greatest difference occurs, there will be the maximum velocity of the wheels.

This excess of work, which is accumulated during one portion of the stroke and yielded up during another, furnishes the datum for determining the weight of the wheel. There is, when the engine is running steadily, a normal amount of accumulated work in the flywheel corresponding to its velocity, and from the relation of that quantity, which is constant to the fluctuating quantity, the result will be obtained for any fixed limit of variation of speed.

Let U = the accumulated work in the flywheel at the normal speed; U^1 = the same at the maximum speed; n = normal number of revolutions per minute; N = maximum number; d = diameter of wheel in feet measured at centre of section of rim; W = weight in pounds; v = velocity of rim in feet per second; then

$$v = \frac{3{\cdot}1416\, d \times n}{60} = 0{\cdot}052\, d\, n$$

and the ordinary formula for accumulated work—

$$\frac{W v^2}{64{\cdot}4} = \frac{W d^2 n^2}{64{\cdot}4} \times 0{\cdot}0027 = \frac{W d^2 n^2}{23{,}815}$$

and

$$U = \frac{W d^2 n^2}{23{,}815};\ U^1 = \frac{W d^2 N^2}{23{,}815};\ U^1\, U = \frac{W d^2}{23{,}815}\{N^2\, n^2\}$$

and

$$W = \frac{\{U^1\, U\} \times 23{,}815}{d^2\ (N^2 - n^2)}.$$

In determining the amount of variation of velocity to be allowed, some thought must be given to the sensitiveness of the governor, and the limit of the flywheel be made rather less than that of the governor, otherwise the latter will be kept constantly on the change, which should not be the case when the former does its duty properly.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

THE STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

SIR,—In reply to the criticism of "Boiler" with respect to my statement anent cross tubes in flue tubes, perhaps I ought to have written they had "no *useful* effect" in stiffening a flue.

In the case of a badly-built flue—by which I mean one having a lack of true circularity in cross-section—I do not deny that a cross tube may prevent distortion; but with truly circular flues, in which the collapsing strength approximates to the crippling resistance of the plate, an interposed strut is useless, as proved by experiments, which show that a flue strutted against collapse in one direction at once fails on another portion of the diameter at a very few pounds more pressure. Such experiments are referred to by Nicholls in his book on steam boilers.

In a column of great length failure occurs by banding, and long columns are stiffened by introducing ties, as in bridge work, to hold the column at its middle point. This halving may be continued until the lengths unsupported are so short that the material of the column fails by crushing, and a truly circular flue approximates to the condition of the short column, while a non-circular flue resembles a long pillar, and to some extent may fortuitously be strengthened by a cross tube. But of what avail is the addition of a ⅝in. link in a ½in. chain? Let us grant for the occasion that cross tubes do stiffen a tube, and even then can it be proved they do so usefully? Why do flue tubes collapse? Usually, I believe, because they first become weakened and distorted above the furnace, where cross tubes are inadmissible. Hence the weaker portion of the tube is left, not only to take care of itself, but also to provide the elasticity for the natural movements of a boiler which the now stiffened rear position is restricted from giving by the (assumed) action of the cross tubes. I believe also that if a flue does collapse, the cross tubes are liable to cause the plates to tear round the tube, and so give rise to an outburst of water; but granting even that they have no bad effects, they are at best but the odd strong link in a weak chain, and have not even the merit of standing in the place of the weakest links of such chain; they but replace the strongest links, and the ultimate strength of the whole is left as before, that of the weakest link. Is "Boiler" prepared to place cross pipes in the furnaces?

My chief objection to water pipes is their bad effect on combustion. That they cause accumulation of soot in the flues I believe none will deny who have had good opportunities for comparison of boilers with and without them.

It is argued that they promote circulation of water, but if they do so it cannot be very great; and I believe that a Lancashire boiler, properly set with bottom flue leading, is fairly well arranged for the establishment and steady continuance of circulatory currents of the mass of the water, and that the leading bottom flue is essential to the action of the water pipes also. I am very much inclined to doubt the advisability of alternate inclination of the cross pipes. If those act well which incline outwardly, is it not very probable that the inward inclination of the remainder is negative to circulatory action? Should not all cross tubes incline outwards? Again, if cross tubes do aid circulation, it appears that their proper position would be, as suggested by me, towards the back end of the flues, where the boiler bottom receives most heat, and where usually the thick deposit of mud or scale seems to indicate the circulation is the wrong way.

As the flue tubes of the Lancashire and Cornish boilers have to do duty as combustion chambers, it is obviously improper to choke them up with cross pipes, whose chief action is to arrest combustion. The enormous combustion chamber of the Galloway type of boiler is thus completely spoilt as such, by the introduction of the struts necessary to keep apart the crown and bottom of the oval tube. It appears to me wrong practice to use water pipes in the capacity of struts for combustion chambers of the Galloway type. As struts are necessary to preserve the oval flue against immediate collapse, the correct method of construction for such cases would be to use much smaller water pipes, encased in good refractory firebrick tubes, to protect not the cold water pipes against the hot gases, but the hot gases against the cold pipes.

The erroneous idea that the combustion of fuel is completed in the grate is at the bottom of nearly all the patents for water-tube and fire-tube boilers, whose great and universal claim to exist is that the gases on their way to the chimney are kicked and buffeted about, and worried through tight places to make them disgorge their load of heat, in utter disregard of the fact that unburnt gas has very little heat to disgorge.

For stationary work in the greatest number of situations the Lancashire boiler is essentially the common-sense type of boiler, and would never willingly be fitted with cross tubes by many who profess to understand the subject as well or better than W. H. BOOTH.

To the Editor of "The Practical Engineer."

SIR,—Your correspondent, "Practical Man," seems somewhat hard to please. He objects to one formula because it is not sufficiently easy of application, and to mine because it cannot be reconciled with what has been told him about a second-hand boiler.

My formula ought to satisfy him, as it is both simple and accurate, or at least as nearly accurate as possible. Any boiler, working at a pressure which the formula would give as that of collapse, is in a state of imminent danger, as the records of exploded boilers will show.

I have not yet seen any other that gives even approximately accurate results, and I think it would be advisable that "Practical Man" should have better grounds to go upon than the statements of others, presumably not even practical, who have old boilers to sell, before he attempts to throw discredit on calculations that have been well considered by their authors.

I should not have noticed his letter but for the fact that in it and other letters I think I have observed a growing impression that boilers made many years ago, with flues of large diameter and thin plates, are capable of working at much higher pressures than are justifiable by an accurate calculation of their strength. Such boilers were not constructed to sustain pressures now common, and the danger of attempting to use them with increased pressures should not be ignored.—Yours, &c., W. J. Ellis.

TURBINES.

To the Editor of "The Practical Engineer."

Sir,—In your issue of the 14th inst., I have read with pleasure your account of the "Victor" turbine, and agree with you that turbines, when carefully designed and constructed, are by far the most efficient motors for the utilisation of water power. There must, however, be something wrong with the design or construction (or both) of the one you refer to, for the following reason: You say, "From the published results, we observe that with a head of 18·06ft., and making 368 revolutions per minute, a 15in. wheel developed 30·17 H.P., or an efficiency for the water used of 89·32 per cent." You also say, "We are informed that even at lower powers, with partial gate, proportionately good results were obtained." Now, I have before me the detailed published results referred to, from which I notice that this identical turbine, during the same experiments, with the slightly increased head of 18·19ft., made 350·5 revolutions per minute, but only gave out 18·69 H.P.; the quantity of water used in the test quoted by you being 990 cubic feet per minute, and in the latter test 775 cubic feet per minute, an efficiency of only 70·18 per cent. Or, in other words, when the quantity of water supplied to the turbine was diminished by 21 per cent, the power given out was crippled to the extent of 38 per cent; and the users of the Victor turbine now know to their cost that even the above results are not realised, as these experiments were made at a time when the testing apparatus was defective (another turbine of a different make getting results as high as 96 per cent), and since the testing apparatus was remodelled the Victor has not been again presented for experiments.—Yours, &c., John Turnbull, Junr.

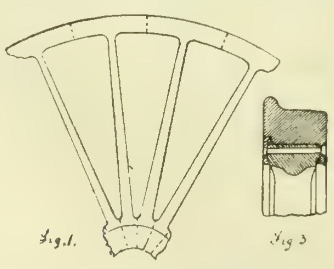
QUERIES AND REPLIES.

51. Straightening and Bending Angle-iron Bars.—Will any practical man kindly give me a ready method of straightening and bending angle-iron bars about 5in. by 5in. by ¾in.? A sketch or description of suitable machine will much oblige.—Outsider.

Answer.—I have seen many machines for the purpose, but have often found that, when angles are not too heavy, a really good angle-smith, with three useful mates capable of using hammers, more efficient than any machine. If "Outsider" has a great quantity of repetition work to perform, the best plan will be for him to consult a machine-tool maker, who will no doubt be able to design him a suitable machine without putting him to a great cost, as all that is wanted is a ram and supports. I have several times seen old punching machines used for this purpose.—Chalkline.

35. Locomotive Driving Wheels.—Will some reader please inform me of what material the large 8ft. 6in. driving wheels on the new locomotives are made, and if the wheels are solid, or in how many pieces they are made?—J. T.

Answer.—If your correspondent, in asking for information, had stated where these locomotives with 8ft. 6in. driving wheels are being made, I have no doubt he would have had a reply much sooner. I am not aware of any locomotives being made with wheels of that diameter. The largest driving wheels made at present on a few of the principal railways in this country are as follow, viz., the Great Northern, 8ft., built at Doncaster; the London and North-Western, 7ft. 6in., built at Crewe; the North-Eastern, 7ft. 7¼in., built at Gateshead. Until recently the two first-named companies made their wheels of forged iron; each spoke was forged separate, and welded together in segments, as shown in fig. 1., then bolted together, and a boss welded on each side; the V's were afterwards welded in rim, as shown by dotted lines in fig. 2. These railway companies are now using cast-steel wheels for all their locomotives, and the North-Eastern are at present building some which will have cast-steel wheels 7ft. 1¼in. in one casting, tires 3in. thick, making diameter across thread 7ft. 7¼in; cast-iron balance weights fitted in between spokes, and secured by rivets, with a wrought-iron plate on each side. Fig. 3 shows the most modern and safest way of fastening tires on wheels.—Loco.



57. Pumps.—Will some reader oblige with a rule for the sizes of suction and delivery pipes. I have a double-acting plunger pump, 7⅞in. diameter, 31½in. stroke, 35 strokes per minute. Suction pipe 11¾in. diameter, and 820ft. long, 16ft. rise. This pump gives me trouble sometimes. Is the suction pipe too large? Delivery pipe 11¾in. diameter, 4,600ft. long, 360ft. lift?—W. H. H.

Answer.—In reply to "W. H. H.'s" question, I may say that the largeness of the diameter of the suction and delivery pipes (11¾in.) as used in his pump is not the cause of the trouble he complains of, but is of real advantage. The trouble may arise from one or more leaky joints admitting air into the suction pipe, to which, from its great length and numerous joints, it will be very liable, and the ingress of air at such joints is not so readily detected as the escape of water from a bad joint in the delivery pipe above. It may be, also, that the 16ft. of rise in the 820ft. length of pipe is not a continuous rise, but that one or more falls may take place in that length, in which case air will lodge at the highest point or points of the pipe, and so intercept the flow of the water to the pump. Under the circumstances, as the action of the pump is intermittent, and the inertia and momentum of a column of water 820ft. long, to be alternately put in motion and arrested 70 times per minute by the force of a partial vacuum equal to about 16ft. of a water column, or by a force less than one fiftieth of its own weight, we may expect frequent difficulty with it. There ought to be a partial vacuum vessel on the suction pipe, as near as possible to where that pipe enters the bottom clack box of the pump, of a capacity not less than about three times that of the pump barrel, by which means a continuous flow may be maintained in the suction pipe, and the shocks to which the pipes and joints are subjected be thereby greatly diminished.—W. A.

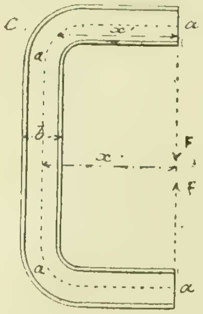
58. Strains in Frame.—Will some correspondent make clear the following: In the sketch here shown there is a force F acting on the frame in the direction indicated by the arrow heads, a corresponding force, of course, acting in the opposite direction to maintain equilibrium. Neglecting the elasticity of the material, the formula for the strain at x would be

$$\frac{F \times a}{b}, \text{ and at } y \ \frac{F \times (a + b)}{b}$$

But when the elasticity of the material is taken into account, would this formula be correct; more especially when the distance (a) is small as compared to the distance between the arms of the frame? Also how the strains in the curved portion C are ascertained under the same conditions.—Tyro.

Answer.—Your formula will not apply, as one flange will not form a *fixed fulcrum* in relation to the other. The resistance of the whole section about its centre of gravity must be taken in opposition to the moment of force acting in an opposite direction about the same point. In the annexed figure the dotted line $a\ a\ a\ a$ represents the neutral axis passing through the centre of gravity of all the cross sections of the frame. In any section it is about this neutral axis that the forces act. Thus, in the straight vertical part of the frame, the moment of force will be $= F \times x$; in the curved part c, the moment will be $= F \times x'$; and in the straight horizontal parts it will at any section be equal to F × horizontal distance of section from the line of force. In this case the centre of gravity is in the centre of section, the flanges being equal; hence, if b = breadth of frame from centre of gravity of one flange to that of the other, and S = the resistance of one flange (and therefore, of course, the strain upon it), the moment of resistance of each flange $= S \times \frac{b}{2}$, and that of the two flanges $= S \times b$. From this $F \times x = S \times b$, and $S = \frac{F \times x}{b}$ for either flange, neglecting the web. If the web is taken into the calculation, let W = width of flange, W_1 = width of flange less thickness of web, b = breadth over all, and b_1 = breadth between flanges. Let also s = the maximum stress per sectional square inch on the outer edges of the flanges, and the dimensions be taken in inches, then the moment of resistance $= \frac{s(W.\,b^3 - W_1.\,b_1{}^3)}{6.\,b}$, and from this $s = \frac{6 \times F \times x \times b}{W.\,b^3 - W_1.\,b_1{}^3}$.

F. C.



41. Hot-water Pipes.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse?—Water-heater.

50. Small Air Pump.—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

52. Details of Oliver.—Can any reader oblige me with details of an oliver, to work by foot, for making bolts from ⅜in. to 1in., with dimensions?—H. C., Egypt.

53. Dash Pots.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made, and what is the approximate cost?—Crank Pin.

54. Boring Out Crank Pin Hole.—What is the best method of boring out an old crank pin hole, to be most easily done?—Crank Pin.

55. Testing Lubricating Oils.—I wish to know the methods of chemically testing the purity of lubricating oils. Is there any simple mode easily applied by an engineer?—Lubricator.

56. Most Economical Steam Boiler.—I wish to put down a boiler to drive a 12 horse-power high-pressure engine using pressure at 100lb. per square inch. What is the most economical boiler to use? I would prefer one which requires no brickwork. What evaporation per pound of fuel can be obtained with the boiler recommended?—J. T. M.

59. Power of Winch.—A wagon loaded, weighing one ton, is to be drawn up an incline 1 in 5 with a winch, by two men. If some reader of *The Practical Engineer* will give me a formula showing how to get the diameter of the gears, also the diameter of drum and radius of handles, and the power each man would have to exert on the same, he would greatly oblige.—Chatham.

MISCELLANEA.

New Method of Separating Minerals.—Mr. Carus-Wilson has devised an effective dry method for separating the denser minerals from sand for analytical purposes. A piece of cardboard about 2ft. long is bent in the form of a shoot or trough (it must not be allowed to break), and held in this form by elastic bands at either end; this must then be held or fixed at angle sufficiently inclined to allow the sand to travel slowly down the shoot on being gently tapped. A small quantity of the sand to be treated is now placed at the head of the trough, which is then tapped with the finger. When the trough is tapped the sand travels slowly down, and in doing so the denser grains lag behind, forming a dark mass in the rear of the stream; this dark mass increases as the sand flows on, and must be collected and placed in a receptacle just the moment before the last tap would cause it to fall on the trough. When a sufficient quantity of this denser sand has been thus collected, it should be placed in the lid of a cardboard box (about 12in. by 6in.), and gently shaken to and fro at a slightly inclined angle, the mass being at the same time gently blown upon with the breath The finer quartz grains will thus be blown away, and hardly any but the denser grains will remain.

Mr. Edison's Latest.—Mr. Edison, who has become more deaf than ever, is engaged at the present moment in making experiments in connection with his projected invention of a far-sight machine, by which he hopes to be able to increase the range of vision by hundreds of miles, "so that," to use his own words, "a man in New York could see the features of his friend in Boston with as much ease as he could see a performance on the stage. That would be an invention worthy of a prominent place in the world's fair, and I hope to have it perfected long before 1892." The idea is not new by any means. A description of an electric telescope invented by Herr Nipkow, is given in the November (1885) number of the *Electrical World*, which states that the system is a "means for maintaining the synchronism of the mechanisms, and in means for transforming intermittent light into intermittent electric currents, and in the retransformation of the latter into light." Meanwhile Edison is working night and day at the matter in his laboratory, frequently spending a week there together without going home. His meals are sent to him, and he sleeps on the floor with his clothes on, and with a block of wood under his head for a pillow. He seems to think that by acting thus he can better preserve the nervous tension after he has started to work.

Another Explosive—Grisontite.—We hear, through a Berlin correspondent, that the new form of explosive called grisontite lately discovered or invented by Mr. E. Müller, of Cologne, has been experimented with in Germany, and has yielded most satisfactory results. Grisontite, the name of which is derived from the French grison (fire-damp), fulfils two conditions, viz., efficiency and entire freedom from danger. Chemists have long had an idea of the utility which would result from the union of water with an explosive in the direction of cooling the flames resulting from deflagration. It occurred to Mr. Müller to introduce water in a solid form into the explosive in this case. Certain salts of course have the power of holding in combination, in the state of water of crystallisation, a portion of the liquid in which they form and are deposited, the quantity of the water varying with the salt. When heated such salts dissolve in their water of crystallisation, and that, too, usually at quite a low temperature. Upon being further heated they lose this water very easily, and in most cases without the salt being altered. In the present case, the inventor incorporates one of such salts, in a very finely divided state, with a proper explosive, which he calls "gum grison," or "grisontite," in which the proportion of water may be graduated at will by varying the salt or the mixture. The salts best adapted for this purpose are carbonate of soda, which has ten equivalents of water; and sulphate of magnesia, which has seven. Grisontite with 50 per cent of salt, contains, with carbonate of soda, 31 per cent of water, and with sulphate of magnesia 25½ per cent. The invention is rendered complete by a special apparatus for firing, and by what are called safety matches, these being surrounded by wire gauze, which performs the same office as the wire gauze of a miner's safety lamp. With these matches there is no danger of setting fire to the gas which may be in existence in the surrounding atmosphere.

Open-hearth Steel.—The growth of the production of open-hearth steel in the county of Durham has been rapid beyond precedent. An official statement shows that in 1884 there were only 16,400 tons produced in the North-Eastern district. Year by year the quantity has grown until last year there was produced the enormous quantity of 352,000 tons. The cause, of course, is the transfer of the demand from iron to steel in shipbuilding and in marine engineering; and it is quite probable that a continuance of the growth will be seen this year.

A Large Pendulum.—The largest pendulum on the American Continent, by means of which the earth's motion is demonstrated, has been set up in the technical school at Atlanta, Georgia, by Dr. J. S. Hopkins, president of the school. The pendulum is a heavy pear-shaped piece of iron attached to a brass wire 42ft. long. The upper end of the wire is pivoted in a steel point, which rests on the centre of a steel plate so as to cause the least possible friction. The swinging of the pendulum gradually describes a circle on the floor in a direction following the sun, showing in this way that "the earth does move." Directly underneath the pendulum is a large circle divided into twenty-four parts of 15 degrees each to correspond with the hours of the day. The North Pole is placed directly under the pendulum, and the meridians of longitude meet there. The parallels of latitude make smaller circles inside the first. The experiment is performed as follows: The iron is brought to the edge of the circle in the meridian of Atlanta and let swing across. Apparently it goes straight across, but gradually it traverses the circles in the direction taken by the sun, and opposite to the revolution of the earth. The pendulum, not being directly over the axis of the earth, does not move in exactly the same time as the sun, but falls behind some hours a day. It is said that, if it were at the North Pole, where it would be immediately over the axis, it would traverse the circle in exactly twenty-four hours, and at the Equator it cannot traverse it at all, the gravity operating to prevent it.—*Iron.*

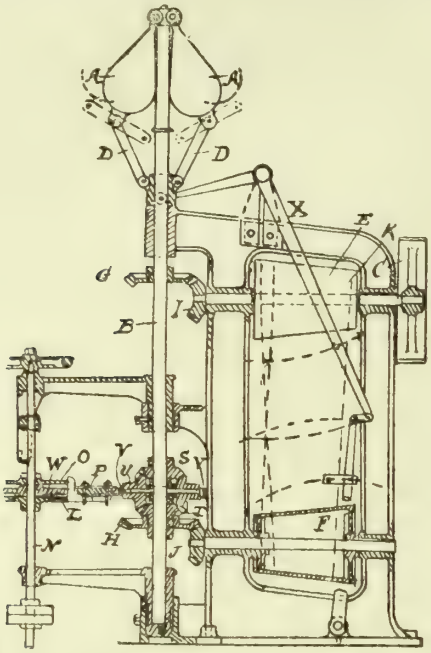
An Automatic Sewage Leak Detector.—A useful device, intended to automatically detect leaks in pipes in hotels or private houses, and for preventing the escape of foul gases from passing from one room to another through the waste pipe, has been patented by Mr. Andrew H. Brown, of 229, West Twenty-second Street, New York. It consists essentially in the employment of a valve held in a closed position until sufficient leak water accumulates on the valve to open it, when the valve closes an electric circuit connected with an annunciator. The water-pipes of one or more rooms are passed over a drip-pan, so that in case any of them leaks the water will accumulate in the pan. In the bottom of the pan is held a head, which is provided with a strainer on its top and in the pan, and which is connected at its lower end with a pipe terminating preferably a short distance above the cellar floor. In the head is held an apertured partition, forming a valve-seat for a valve, held on the under side of the partition and secured on a stem passing upwards through a bridge. This valve is pivotally connected to a lever fulcrumed on a suitable post. The lever plays in a saddle, and is provided with an insulated contact point, adapted to be thrown in contact with a set screw screwing in the saddle, the two points being connected by wires with an annunciator. When a pipe leaks, and sufficient water accumulates in the head on the top of the valve, the latter in opening establishes an electric circuit by the wires with the annunciator, giving an alarm to attract attention.

New American Ideas.—A rail joint has been invented by Mr. Edmund M. Cooke, of Brooklyn, New York, in which a jacket is formed to receive the meeting ends of the rails, and wedges are driven between the jacket and the base of the rails, goffers, or corrugated portions forming the walls of the wedge recesses, while side plates extend up and bear snugly under the base of the rail. Another patent has been granted to the same inventor for a rail joint of different construction, in which ways or recesses are provided between the upper side of the base of the rail and the jacket, the wedges fitting these recesses being formed of sections having each a straight and an inclined face, one section being inserted in the way and the other section being driven upon the first one. A bricklayer's plumb level, consisting of a frame to which is applied angle castings or guides, the frame also having graduated plates, while at each side of the frame is a plumb level or bob, and also a spirit level, the whole making a convenient and accurate instrument, which can be expeditiously handled, has been patented by Mr. James Smith, of Centerville, Md. An improved radial tube boiler which the inventors, Messrs. John Clark and Robert W. Savage, of Tyler, Texas, claim can be used in practical work without any deposit of scales, mud, and so forth being made in the tubes, has been patented. It is designed to make more and drier steam than has hitherto been found possible in boilers of this class. It has a horizontal steam reservoir at its top supported by standards firmly secured to the foundation, while suspended from this steam reservior above the firebox is a vertical steam-generating chamber with radial tubes extending therefrom. A firebrick casing surrounds the firebox and the radial steam-generating chamber, while a firebrick arch partly surrounds the horizontal steam cylinder, a metal covering surrounding the firebrick and extending above it to the smoke pipe or flue. As deposits are generally found in those parts of a boiler where there is the least commotion, the design of this boiler is that such parts shall be in the ends of the horizontal reservoirs, from which the deposit may be readily removed by blow-off cocks on the manhole.

ILLUSTRATED PATENTS.

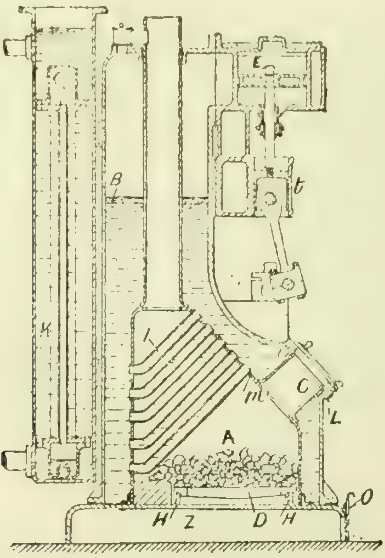
461. Turbine Governors, C. L. Helt, Ancholme Ironworks, Brigg, Lincolnshire.

The sluice is actuated by a "jack in the box" arrangement, the direction of whose motion is controlled by the governor. The cone pulley E is driven by the pulley C from the prime mover. A cross belt K drives the cone F from E. The belt K is traversed along the cone pulleys E and F by the lever X, which is actuated by the governor A, D. The position of the belt K controls the relative speed of the pinions I and J, and hence that of H and G, and T and S. When the belt is in the centre of the cone pulleys, T and S move uniformly in opposite irections, and consequently no motion is imparted to the differential wheels U or the spur wheel V which is fixed to them, but when, by the movement of the belt to one side or the other of its central position by the governor, the speeds of T and S become different, V rotates in one direction or the other about the vertical axis B and actuates the wheel W, which is connected to the sluice shaft N by a clutch L and catch P, which will slip when the gates are full open, and which can be thrown out of gear by means of the plate O for stopping.—January 11, 1888. [6½d.]



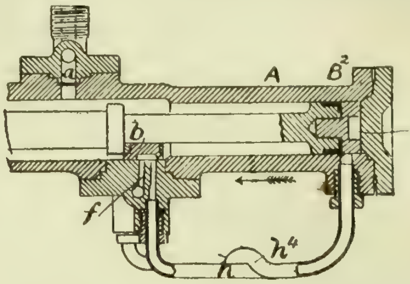
1160. Steam Generator, H. Davy, Westminster.

Relates to that class of low-pressure boilers which are used for supplying steam to domestic motors. The inner and outer shells, of the shape represented, are secured to the bed-plate Z which, by means of the upturned portions H, also carries the fire-bars D. The fire-box A is traversed by water circulating tubes I. Leakage between the firehole ring C and the outer shell of the boiler is prevented by a packed joint at L. A damper at O in the bedplate regulates the air supply. The cylindrically-shaped body K is the condenser for the steam engine. It is similar to that described in Specification No. 15,185, A.D., 1884. In connection with this form of generator there is shown, although not claimed, the engine cylinder E and guide *t*, formed in one piece. The cylinder is formed with a steam jacket opening into the boiler as shown. In a modified form of generator, to which the engine is not attached, the external shell is cylindrical while the fire-box is supplied with fuel through a capacious hopper, opening out at the top of the boiler, which, when filled, is sufficient to keep the fire-box supplied for a lengthened period.—January 25th, 1888. [6½d.]



1,015. Hydraulic Pumping Engine, E. Barnes, Parchfields, Handsworth, and Tangyes, Limited, Cornwall Works, Soho, both in Staffordshire.

Relates to engines having two cylinders as A, the pistons of which are of different areas on their opposite sides, and in which the piston of one actuates the distributing valves of the other. The motive fluid is supplied continuously through the pipe *a* to the side of the piston with the smaller area. The slide valve *b* is the position shown, exhausting from the larger end of the second cylinder through the pipe *h* to the exhaust port *f*. At the same time the second slide valve is supplying motive fluid through h^4 to the larger area B^4 of the piston B^2, and at the end of its back stroke B^2 strikes the slide valve *b* and sets it so that motive fluid is supplied to the larger area of the second piston through *h*, and so on. Various arrangements of distributing valves and actuating mechanism are described, such as "Corliss" valves actuated by levers, D valves reciprocated transversely by inclined slots in the pistons, slide valves in one piece with the pistons, and different arrangements of piston valves.—January 23, 1888. [1s. 2d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

June 5th.

9311 Ball Valves, H. J. Burgess, Sussex.
9316 Gas Motor Engines, J. Fielding, Gloucester.
9320 Piston Rings, A. T. Allen, Sheffield.
9336 Steam Generator, J. J. Meldrum and T. F. Meldrum, Liverpool.*
9339 Rope Clips, J. W. Glover, Liverpool.
9340 Packing Rings, M. Husbands, Middlesex.
9349 Pumping Engines, Tangyes, Limited and E. Barnes, Middlesex.
9354 Separating Machines, F. J. Brougham, London. (S. Jönsson, Denmark.)
9367 Lubricators, H. Hamelle, London.
9377 Fluid-pressure Engines, J. Mayson, Cockermouth, Cumberland.

June 6th.

9388 Cranes, J. T. King, Liverpool. (J. Kennedy and H. Aiken, United States.)
9426 Valves, D. Joy, London.
9431 Mountings, Sir N. Barnaby, London.

June 7th.

9433 Explosive Compounds, W. B. McGavan, Essex.
9437 Jointing Plates, W. Thomlinson-Walker, York.
9454 Combustible Gas, G. Love, Durham.
9468 Pump Rods, A. A. Rickaby, London.
9469 Soldering Tool, L. Thies, London.*
9478 Fire Extinguisher, H. N. Morgan, London.
9497 Chain Cable, J. F. L. A. Larroque, London.*

June 8th.

9500 Mechanical Stokers, W. Leach, Halifax.
9503 Reeling, T. Rivett, Manchester.
9525 Spirit Engines, C. Wells, Middlesex.
9526 Ventilating Fans, W. Matthews and J. Yates, Manchester.*
9527 Hydraulic Power, H. Roberts, Clynnog, Carnarvon,
9528 Telephony, H. Coles, London.
9538 Coiled Springs, I. A. Timmis, London.*
9542 Fire Escape, J. Cross, London.
9554 Wheel Tyres, W. Firth, Glasgow.
9568 Blast Elevators, F. W. Allchin and J. Walker, London.
9575 Lifting Water, W. Hargreaves, Birmingham.

June 11th.

9581 Safety Lamps for Mines, R. W. Moore, Newcastle-on-Tyne.
9587 Fire-bars, R. Robson, Leeds.
9595 Valve Gear, J. W. Melling, Manchester.
9598 Dredging Cranes, S. M. Cockburn, Westminster.
9615 Steam Engines, H. Bleasdale, London.
9617 Hydraulic-press Engine, J. E. Newton, Surrey.
9619 Water Gas, G. Hatton and F. W. Harboard, Hagley, Stourbridge.
9623 Surface Condensers, E. W. Tucker, Califonia, United States.*
9648 Change Gearing, H. Coppinger, Middlesex.
9649 Sprinklers, J. Clapp, London.*
9650 Rack-rails, H. E. Ludwig, London.
9651 Filtering Apparatus, C. B. Davis and E. H. Riddell, London.*
9655 Oil Lamp, J. Lyle, London.

June 12th.

9677 Shuttle Guards, P. H. Marriott, Manchester.
9685 Motors, E. Hunt and J. Howden, Glasgow.
9690 Locoms, W. P. Thompson, Liverpool. (J. Papleux and E. Persil, France.)
9694 Wood Pulp, F. J. Cheesbrough, Liverpool. (H. Pataky and W. Pataky Germany.)*
9702 Tires, W. Colclough, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE

PRACTICAL ENGINEER,

JULY 5TH, 1889.

RECENT ADVANCES IN PETROLEUM ENGINES.

THE Paris Exhibition and the Royal Agricultural Society's Show of the past week indicate clearly the strenuous efforts which are being made both by English and foreign engineers to overcome the difficulties of applying petroleum to the production of motive power by explosion. To the uninitiated it will seem no doubt but a small matter to obtain an explosive mixture from hydrocarbon vapours, and to compress that mixture and ignite it, as is done in gas engines,—to work a gas engine, in fact, with inflammable vapour instead of with permanent gas. The difficulties, however, are very serious, and by no means readily overcome, notwithstanding the fact that inventors very generally assume—at least in their patent specifications—that a gas engine may also be used as a petroleum engine, with but trifling modification. To a certain extent this assumption is no doubt true. When a very volatile oil or spirit, such as gasoline or benzine, is permissible, then it is only necessary to cause the engine to take in air through a series of trays, or over a series of surfaces, upon which the volatile spirit is dropped, and it becomes so charged with inflammable vapour that upon compression it can be exploded within the engine cylinder, just as with coal gas.

With such light oils there is no danger of separation during explosion when at ordinary work, because the heat of compression added to the heat of the sides of the explosion space and the face of the piston sufficiently counteract the tendency of compression to liquefy and separate the vapour. But with heavy and non-volatile oils the case is very different. The tension of the vapour at ordinary temperatures is far too low to form an explosive mixture with air by simple evaporation, and it is accordingly necessary to raise the temperature very considerably. Not only must the temperature of the oil itself be raised, but also that of the whole body of air entering the cylinder. The reason of this is obvious. When the oil is heated considerably, although not necessarily to so high a temperature as its boiling point, the pressure of its vapour increases, and air passed over or through it can take up a sufficient proportion to become explosive; but if the air be cold, then it speedily cools the vapour, which is at once condensed and deposits upon the passages admitting to the engine. If the air, however, be also heated, then the temperature of the oil is not reduced by mixing with it, and the whole mass remains inflammable or explosive.

For very obvious reasons it is most desirable that heavy and non-volatile oils should be used in such engines, as experience with lamps burning spirit has proved the dangerous nature of very volatile hydrocarbons, and accordingly an Act of Parliament regulates the maximum inflammability allowable in oil to be stored in private houses, and handled by the general public for illuminating purposes. To those who have never experienced the rapidity of ignition of very inflammable oils, the present laws defining the minimum allowable flashing point may appear to be unduly severe, but one experimental test in a safe way will speedily convince of error. Ordinary paraffin oil, or petroleum, as used in lamps at atmospheric temperature, is exceedingly safe in this respect, and a burning taper or match is at once extinguished on plunging into either, much as is the case with water. To be safe, petroleum engines should use oil of this kind, and not gasoline, benzoline, or benzine. We regretted to observe, during a recent visit to Paris, the number of engines at work in the Exhibition, using light oils of highly inflammable character, and in our opinion such engines, by the accidents certain to accompany their use, will greatly tend to discredit petroleum engines and damage their reputation for safety in the eyes of the public.

Many English and foreign engineers fully appreciate these facts, and are striving to render heavy petroleums and paraffins commercially successful in explosive engines. Several engines in the Paris Exhibition we had the pleasure of examining at work with quite heavy and safe oils, and at the Royal Agricultural Society's Show of last week two types of such engines were at work, one the well-known petroleum engine by Messrs. Priestman, of Hull, and the other designed by an inventor as yet unknown in the gas-engine world—Mr. Knight, of Farnham. Both engines worked exceedingly well, but so far as we can judge neither are sufficiently clear of the experimental stage to be of any immediate commercial importance. Messrs. Priestman's engines are fired by the electric spark, generated by primary batteries or storage cells and induction coil—a method, in our opinion, far too complex and troublesome to be of genuine and extended practical service. The electric spark is one of the easiest modes of ignition for occasional or experimental use, but is far too delicate and easily deranged for the rough handling of daily work under the care of ordinary attendants.

The respective lines of advance upon the Continent and in Britain supply an interesting subject for study. Here it has been found that even the ordinary flame ignition slide is rather delicate for every-day use, and the best gas-engine makers here now use metal tubes, heated to incandescence by a Bunsen burner, for firing the explosive gases. On the Continent inventors have sought to adopt the electric spark, and many gas engines we inspected were running with electric spark igniters, some with and some without primary batteries. We purpose describing the details fully very shortly; but meantime we may say that some generated a single spark by rapidly removing a wire wound armature from contact with the poles of permanent magnets, and others generated the current by a small dynamo, and obtained sparks from an induction coil. Such modes of ignition, no doubt, will act quite efficiently while the engines are running in the care of their makers, and everything is in first-class order, but under the ordinary conditions of daily work they are sure to give trouble to their users. The simple methods now in use here are much preferable, both for gas and petroleum engines, and we strongly advise the firms using or contemplating the use of electrical ignition to modify their designs to suit flame or incandescent igniters.

Heavy petroleum engines are under considerable disabilities because of the necessarily high temperature of the explosive charge even before admission and compression, and accordingly their valves require more care in design and arrangement than gas-engine valves. The igniting arrangement used by Mr. Knight is similar to that designed by Clerk, and used in a gas engine exhibited at the Royal Agricultural Society's Show held at Kilburn in 1879, and it consists of platinum raised to incandescence by a forced flame, and then quickly transferred to the cylinder while at a white heat by the movement of the slide valve containing it. The ignition, although very suitable for one type of engine, is not adapted for the one to which it has been applied.

Heavy petroleum engines have undoubtedly a very considerable future of usefulness before them, and the object to be attained is well worth the continued effort and expenditure of firms and inventors, but much yet remains to be done before they will rank with the gas engine in freedom from small but very annoying troubles in daily use.

It is the business of the practical engineer to master these troubles, and there is no doubt but that in the near future it will be thoroughly and completely accomplished. Matters which seem of small moment to the theoretical or purely academic engineer are of vital importance in daily work, and it is the business of the practical man to understand completely the general laws which govern his subject, and simultaneously conquer all those innumerable little troubles which conspire to prevent him carrying his theories into practice.

MR. WILLANS ON SPIRIT ENGINES.

Mr. Willans, well known in connection with his clever single-acting steam engines, and his experiments upon the efficiency of steam in compound engines of his central-valve type, has addressed a letter to our esteemed contemporary the *Engineer*, in which he criticises the errors in statement made by that journal upon heat-engine theory. He takes the same position and points out the same errors as we did in our issue of the 14th ult., when we showed that the *Engineer* had mistaken entirely the correct mode of applying the laws of thermo-dynamics. Part of Mr. Willans' letter is well worth quoting:—

"You are simply fighting a bogey of your own creation. Before denouncing theorists who have done, in spite of what you say, enormous services to modern steam engineering, we ought to be sure that we are able to make a proper use of their formulæ, and I am confident that I am only expressing the feeling of all thinking engineers when I say that such an article as yours of last week is calculated to do great harm, in that it draws a distinction between theory and practical experience, and condemns the former, whereas the two should be looked upon as inseparable. Able thinkers have shown practical engineers what is the greatest possible return from heat supplied to any heat engine, and it is for practical engineers to bear in mind this theoretical limit, and come as near to it as they can. They cannot go beyond it. It is frequently stated that it is impossible by mathematics to calculate the amount of steam a given engine is going to use; it is also impossible by mathematics to determine how much water a man will carry home in a pail: mathematics will tell him how much the pail holds, but experiment only can prove how much he spills on the way.

"No theory can possibly tell an engineer how bad an engine he is going to make, nor is it its province to do so. I am not sufficiently acquainted with the results obtained from spirit engines to be able to say anything about them, but I have no doubt that the facts will easily be reconciled with the thermo-dynamic truths named above; if not, it will be very 'awkward for the facts.'"

We quite agree with Mr. Willans, and our immediate corrections of our contemporary's errors were prompted by the knowledge of the grievous injury which such indiscriminate condemnation from a journal of standing was bound to cause. All the leading inventors and discoverers have been theorists as well as practical men, and the greatest inventions of the day have been the result of a careful and diligent comparison of theory and practice. Correct theory is the result of careful observation and experiment, while the best practice is attained by skilfully approaching as closely to theory as the mechanical conditions will allow.

We are all aware that the leading scientific discoverers are not constructors of engines, and the nature of their work makes it almost impossible that they could be so. But the leading practical inventors have always understood and been guided by the proved laws of nature. Without some knowledge of this kind advance would have been impossible. Our contemporary answers Mr. Willans in last week's issue; but as precisely similar errors are made as those to which we have already called attention, we think it undesirable to trouble our readers further to follow them.

THE ROYAL AGRICULTURAL SOCIETY'S SHOW.

The Royal Agricultural Society has now held its jubilee show, and we are pleased to say with brilliant success. This important society has influenced the application of engineering and science to farming in an almost incalculable manner, and nothing we can say could give so just an idea of the magnitude of the results produced mainly by its influence, as the inspection of the very numerous ingenious appliances and special types of machine and engine designed expressly for farming use.

The number of mechanical exhibits at Windsor exceeded that of most previous shows, the principal exception being London, held at Kilburn in 1879, at which 11,878 exhibits were upon the ground, while 7,446 only were to be seen last week. However, in quality the Windsor show was admirable. Correct design and good sound workmanship were everywhere evident. In steam engines and boilers, as there was no competitive test this year, no new results are before us for discussion, but many interesting novelties of design and arrangement were shown. No startling or very novel departure was made, but a general attention to the construction of high-speed engines for electric lighting was very evident. The use of wrought iron in the framing of engines seems also on the increase. A wish to promote economy of fuel is proved by the fact that all the leading makers exhibit engines compounded or using automatically variable expansion gear.

The fifty years of the society's existence have seen the adoption of the steam-thrashing machine instead of the time-honoured flail. Steam ploughing has been made possible, and reapers and binders have largely displaced the scythe and sickle. Nearly every part of farm work is now assisted by mechanism. Even the operations of the dairy have been made mechanical in points where one would hardly have thought that mechanism was applicable. The centrifugal separators at work, rapidly and certainly extracting cream from milk, are now in most extensive use, and have been the subject of much care and thought. The society also has been the means of developing the science of farming and applying chemistry to the needs of the farmer, so that the average production per acre of our land has been much enhanced.

Artificial manures and the proper drainage of land have been developed and introduced within the period of the society's existence. The analysis of manures, feeding stuffs, and farm products has been completely understood in that time, so that the exact commercial value of both farm necessaries and products can now be determined with great accuracy. This result is largely due to the invaluable researches of Messrs. Lawes and Gilbert, of Rothampstead, as well as to the society.

Notwithstanding these important advances, the agricultural industry of to-day is said to be in a state of adversity, and competition has greatly reduced agricultural prices. This, of course, may be a disadvantage to the farmer, although we may question the reality of this so-called depression, but it is a gain to the general public, and cheap food is an absolute necessity if we are to sustain our very large population in anything like comfort and contentment. In so far as the society has assisted in this, it is useful to the great mass of our countrymen.

ENGINE PATTERNS.—III.

Figs. 11 to 14 show the casting of the high-pressure cylinder of the compound engine whose low-pressure cylinder was illustrated in the previous article. The principal differences in this and the low-pressure occur in the dimensions. The diameter being much smaller (14in. bore), there are fewer lagging pieces in the circle. To maintain some appearance of symmetry in the two cylinders, and to give sufficient width for crossheads and guides, which are of the same size as those on the low-pressure, and to give width for the main and cut-off slide valves, the casting is very wide (fig. 11) in proportion to bore, instead of having the squat appearance of the previous example. The passages are therefore brought in diagonally (fig. 13) instead of being much curved like those in the low-pressure. This necessitates quite a different construction of steam chest and passage-core box in this case. In figs. 11 to 14, A is the steam chest, B the valve face, C the guides for the main valve, D those for the cut-off valve, E is the steam pipe, F the exhaust to the low-pressure, G the flange for bolting the cylinder to the base plate, H H the feet by which it is fitted to the low-pressure, I the indicator boss, J drain cock boss, K K bosses for auxiliary starting pipe. The same reference letters are used to indicate the corresponding parts in the succeeding figures.

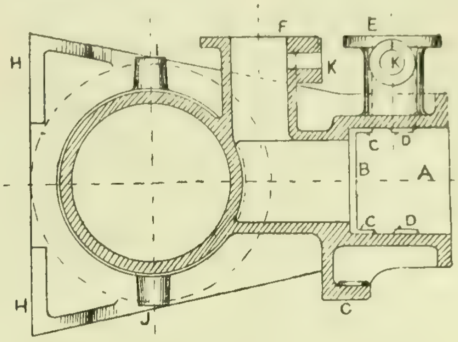

FIG 11

Section through X—X Fig. 12.

Fig. 15 shows the cylinder pattern in two half sections, and fig. 16 the same in plan. The lagging and boxing up is explained in the previous example, but since the cylinder is smaller, the number of lagging pieces is less. The prints M and the head metal N are similar, and the flanges O, with their hollows and facings, are fitted similarly. The pattern body P and Q, for the steam chest and for the metal flanking the passages, is boxed up in two pieces P and Q, and the flange piece R and print S abutted. This print is small by comparison with that on the low-pressure cylinder, and instead of boxing it up, as in that example, we make it of solid stuff. The branches E and F are fitted with loose flanges, as shown, clipping over the prints, and

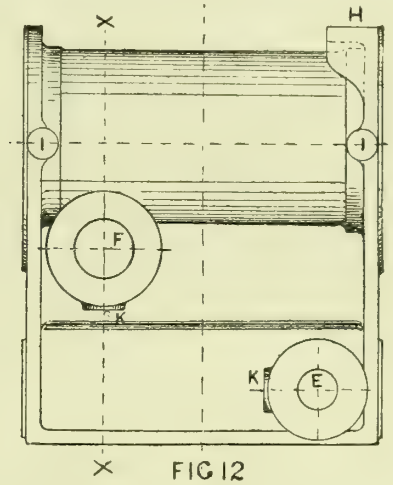

FIG 12

PLAN

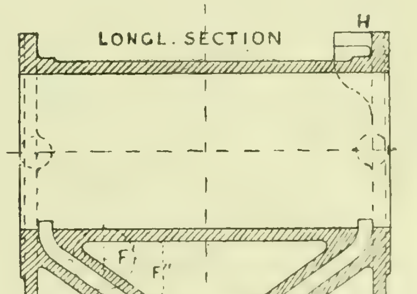

FIG 13

the bosses K K for the auxiliary starting pipe may be either screwed to the flanges and deliver with them, provided they are not under cut, but made as at K (fig. 15), or if circular, they must be skewered on as at K^1 (fig. 15). Between the foot G in fig. 15, by which the cylinder is bolted to its bedplate and the steam-chest body there is an open space (see fig. 11). This overhanging mass of sand will not deliver without making use of a drawback, or of a core box. A core box is the more convenient alternative in this case, and we put a print T to carry this core. The spaces underneath and at the back of the flanges H H are cored out similarly to those in the last example, and U are the prints. The facings at V V are to receive valve stuffing boxes and guides for the valve rods.

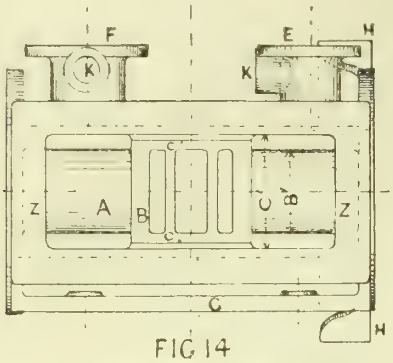

FIG 14

ELEVATION - STEAM CHEST

SECTION X-X FIG 16

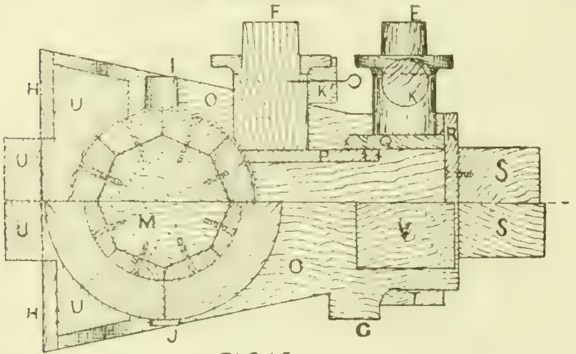

FIG 15

END VIEW FROM Y FIG 16

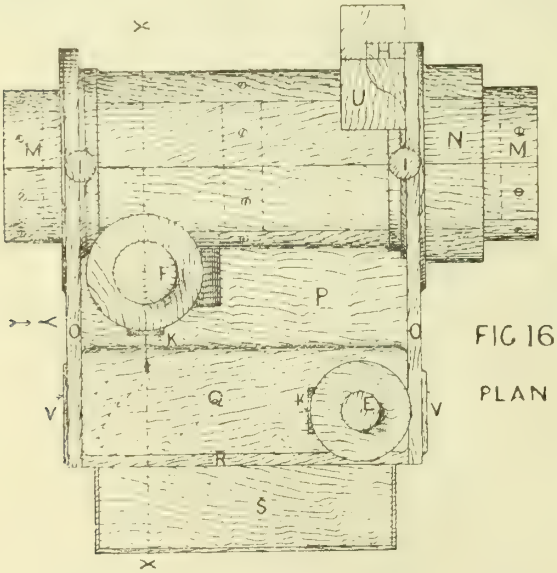

FIG 16.

PLAN

Fig. 17 shows the steam chest and passage core box. The steam chest and passages are, therefore, made in one core, and not separately, as in the high-press cylinder. When the passages take a diagonal direction, as in fig. 17, there is an advantage in making them in one with the steam chest, because then the stiffening rods can pass from the grid of the main core into the passages, so rendering the entire core very rigid, and there is no trouble experienced in fixing the passage cores, and no risk of the metal getting into the vents at the point of junction.

The blocks A A in fig. 17 form the internal steam-chest flanges Z Z in figs. 13 and 14, and also the ends of the print S in figs. 15 and 16. The width B corresponds with the width B^1 in fig. 14, and the width C in fig. 17 with C^1 in fig. 14. Hence it is necessary to have a bottom board D, with its thickness piece E, and also the corresponding shouldering down of the top edges. A portion of these shouldered-down top edges is covered with a strip F, whose edge F^1 is cut to correspond with the edge of the bottom piece E (the edge X in fig. 13). Upon F are screwed two battens G, which carry the strips $H_1 I_1$, corresponding with the guides C and D in figs. 11, 13, and 14. Similar strips H I are nailed on the bottom board. By comparing the curved pieces J K with fig. 13, their correspondence with the thickness of metal between the passages is apparent. These pieces are dowelled upon the piece E below, and secured at the top by means of screws passing through F; and J also by confinement between the pieces L M; and K likewise with a screw passing into it through the box ends.

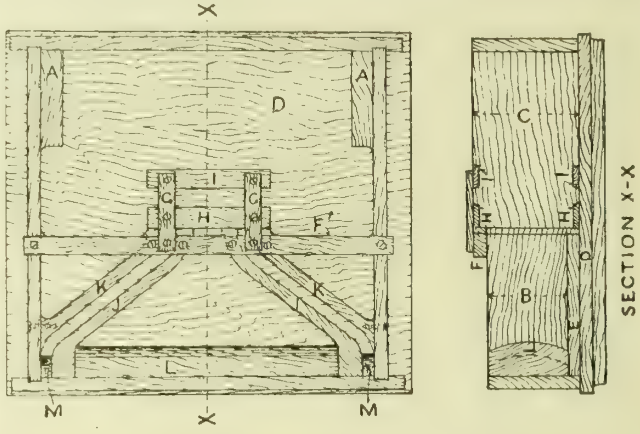

FIG 17

The piece L gives the thickness of metal round the bore of the cylinder, and the pieces M correspond with the curvatures of the circular body core, against which the passage cores abut.

Fig. 18 shows the core box for the recess over flange G in fig. 11, fitting print T in fig. 15, and the bosses A A are for holding down bolts. I need not illustrate the box for the prints U in figs. 15 and 16 for coring underneath and behind the lugs. Its shape is the same as fig. 10 in the last article, dimensions only being different.

The core for the steam branch E in fig. 11 is a plain straight piece of circular section, and requires no box. The core for the exhaust branch F, though circular in the greater part of its length, requires a box, because the circular portion of the core has to merge into the exhaust space seen in fig. 13. To illustrate this, the position of the branch relatively to the space is shown at F^1 in fig. 13, and the dotted line F^{11} shows where the core is enlarged into a kind of bell mouth to maintain the area of entry intact. The box is, therefore, simply of circular section, with a bell mouth cut to one side. The metal around this portion is seen in the plan view of the branch F in fig. 16.

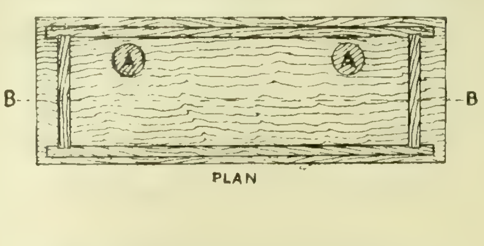

FIG 18

Taper, in patterns like this, is almost neglected. The circular parts deliver freely, and all the taper necessary for the flange can be given by removing two or three extra shavings. J. H.

STEAM ON COMMON ROADS.—I.

We purpose in this series of papers to trace the history and progress of steam transport on common roads during the last fifty years, dividing the subject under the three following heads :—

1. Road locomotives for the conveyance of passengers, &c., at quick speeds.
2. Road locomotives for heavy haulage and conveyance of goods at slow speeds.
3. Agricultural locomotives for use on farms.

For the present we shall only illustrate and describe the machinery belonging to the first division, the examples of this type of steam carriage not being very numerous, reserving the other types for future articles in due course.

Previous to the introduction of railways in this country numerous individuals had turned their attention to the subject of steam transport on common roads. Some of these steam carriage promoters possessed little or no knowledge of the requirements of such engines, and had received no practical acquaintance with machinery, and, as might be anticipated, in attempting to solve such a difficult engineering problem they miserably failed. Several abortions of such schemes which we could name were brought out for a brief airing, and soon displayed some irritating traits of character on the highway, not unfrequently ending the performance very abruptly with a breakdown. These steam carriage exploits were invariably witnessed by a member of the press, who had by invitation accompanied the sanguine inventor during the trip. The account of the trial formed a theme for a commendable article in the daily paper.

These carriages, after acting their part in running one or two short experimental trips on a level and smooth road, were mysteriously disposed of; so they and their novel manœuvres were speedily forgotten.

Some of the early locomotionists produced a fairly good plan, in the working out of which considerable ingenuity and mechanical skill were displayed, but good workmanship could not be obtained; consequently during each trial some hitch occurred traceable to defective workmanship. But most of the steam carriage projectors were not to be turned aside by trifling breakages, and by the application of an indomitable perseverance they out of repeated failures eventually achieved a mechanical success. However, after surmounting constructive difficulties, and in possession of an engine that worked fairly well, they were met by a still more formidable obstacle, to which they one after another succumbed. Public opinion was against them; the influential people who opposed railways about this time, but in vain, did their utmost to put a stop to steam locomotion on the highway, and in many cases succeeded in their design. The steam carriages of the early days were hooted and hissed at by road authorities, coach-drivers, publicans, and men who delighted in horses, which perhaps was not to be wondered at, seeing that their interests were at stake; but engineers and others who ought to have known better have joined in the crusade against steam on common roads, from the celebrated James Watt, who actually put a covenant in the lease of his house, Heathfield Hall, that "no steam carriage should on any pretence be allowed to approach the house."* He also discouraged Murdock when busy with steam carriage schemes. Could his prejudice against steam locomotion have gone any further? Such were the facts, and the antagonistic spirit displayed by Watt, when penning the foolish provision respecting his house, is in keeping with the feelings evinced by succeeding generations of steam locomotion obstructionists, who placed loose stones 18in. deep on the Cheltenham and Gloucester Road, for the purpose of disabling Sir Charles Dance's steam carriages, and thus preventing their running. The same determined opposition, accompanied by similar treatment, was extended to Scott Russell's carriages on the Paisley and Glasgow Road; and an Act of Parliament was speedily passed to levy prohibitive tolls on steam carriages.

Bearing in mind the combined forces that have barricaded the path of steam power on roads during its history from the earliest times, we cannot be astonished that its growth and development has been so slow. In passing we may mention that the origin and early history of steam locomotion on common roads dating from 1618, and giving particulars of the work of about fifty advocates, has recently appeared in a contemporary and is now accessible. Our object is to bring the account down to modern times.

Fifty years ago steam locomotion on common roads was at a very low ebb. Railways were quickly spreading in all directions, and the attention of inventors and capitalists was attracted by this new and rapid system of railway locomotion. Moreover, some of the road locomotionists had brought an amount of discredit upon their cause by attempting to rival the railway, their extravagances tending to retard progress. Their one aim appeared to be to outrun each other; whereas, had they been satisfied with a reasonable speed, say eight or ten miles an hour, instead of boasting of having run twenty-five miles an hour; and had they looked upon their road conveyances as feeders to the great railway system, good would have resulted from their introduction in many districts. "Redivivus," who in those days wrote much on steam carriages, said in 1839: "There can be no rivalry between railways and highways; each have their appointed purpose to fulfil. Railways carry cheaper and faster; but there is plenty of scope for the slower speed of the road locomotives. Let a company be formed and offer a premium for the best road engine, and when the best is chosen let the company have one made at their expense in the best style; because," he says, "the poor inventors have to make shifts, and use improper materials because of their lack of funds—are apt 'to spoil the ship for a hap'orth of tar.'"

At this period very few carriages were in working order. The names of the proprietors of these will now be embodied in our narrative.

Gurney.—Sir Goldsworthy Gurney had ceased to build steam carriages at his own expense; he had just completed two "perfect" steam drags with other people's money, and refused to run them unless more money could be raised to build a third. He was very busy at this time attempting to float a company to introduce and run his improved carriages. One project was mooted of forming a joint concern of all the steam carriage proprietors, viz., Hancock, Maceroni, Redmond, and others, but this idea failed also. Gurney then petitioned the House of Commons to sanction a grant for the expenses he had incurred in attempting to introduce steam carriages, and to repay the heavy losses he had sustained through these numerous experimental trips. Sir George Cayley supported the prayer of the petition in Parliament. "He considered Mr. Gurney a very ill-used man. On the faith of our patent laws, Mr. Gurney had given up, to pursue this noble invention, a lucrative profession. Five years' toil, and an expense of £30,000, brought it into practical use; yet he is now deprived of receiving any remuneration—not from any want of success in his experiments, not from any failure in his carriage, but by Act of Parliament: by our act and deed has he been wronged, and by our act and deed ought he to be, and I trust ultimately will be redressed." A select committee of the House of Commons' recommended a grant of £16,000 and the repeal of the injurious Turnpike Acts. The Chancellor of the Exchequer refused the grant. The Steam Carriage Bill was twice referred to a select committee, had passed the House of Commons but was thrown out by the Lords. Mr. Gurney says: "When the repeal did not pass, I sold all my materials for manufacturing, and gave up my factory, feeling that injury had been done to me."

After Mr. Gurney quitted the steam carriage business he turned his attention to many other useful subjects—the production of the Bude light, the ventilation of mines, &c.—and in most of them he succeeded. By these inventions his name was kept prominently before the public, and we are enabled to trace his career down to the time of his death; but in the case of many succeeding steam carriage projectors we lose sight of them for ever when they cease to build and run carriages.

Hancock.—Walter Hancock, of Stratford, London, was undoubtedly the most successful of all the steam carriage makers; his labours, however, have so often been referred to, and particulars of his steam coaches being given in several modern works, it is only necessary for us to refer to one or two incidents which occurred during the latter part of his career, that have been overlooked by writers, and describe the Enterprise and the successful little steam carriage, his last achievement in this direction. Hancock's experiments in steam locomotion commenced as far back as 1824, and extended to 1841. His first carriage was a failure; his second was very defective, but it ran many miles, and was used for experimental purposes; but all the rest were more or less successful. At the time of our writing he was the only steam carriage proprietor who had ventured to run a locomotive along the crowded streets of London at the busiest periods of the day. These somewhat hazardous journeys were performed by two of his carriages—the Autopsy and the Era—from the middle of August, 1834 to the end of the following November, running several times each day from Moorgate Street to Paddington, and from Moorgate Street to Islington. These hard roads were a severe test for the wheels and the gearing, but few accidents happened. The motion of these carriages was easy; they made no noise, and produced no smoke, and did not frighten horses.

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*"The Steam Engine," by Mr. E. A. Cowper, M.Inst.C.E., 1884.

The Enterprise is represented by fig. 1, below. It was built for the London and Paddington Steam Carriage Company, and commenced to run for hire under Mr. Hancock's personal superintendence between the city and Paddington for sixteen successive days, doing two or three journeys a day "to prove its capability of proceeding through crowded thoroughfares without inconvenience or liability to accident to the persons in the coach or others."

Mr. Hancock says, respecting these preliminary trips: "It is not intended to run this carriage more than about a week longer; partly because it was only intended as a demonstration of its efficiency, and partly because my own occupation will not admit of my personal attention to the steering, which I have hitherto performed myself, having no other person at present to whose guidance I could, with propriety, entrust it." The Enterprise ran from Cottage Lane, City Road to Paddington, and from Paddington to London Wall, and back to Cottage Lane, nine or ten miles, in less than an hour, exclusive of stoppages, performing the trips in an exceedingly satisfactory manner, and the carriage was more under the control of the driver than the best driven horse coach; it ascended Pentonville Hill with ease at six miles an hour. This steam omnibus, of course, was opposed by the drivers of horse vehicles. We quote the following from one of the daily papers: "In watching, as I have done, the early operations of the new steam coach, the Enterprise, on the Paddington Road, I have been pained, though not surprised, to see the malignant efforts of some of the drivers of the horse conveyances to impede and baffle the course of the new competitor. They must be taught not to endanger the lives of the passengers, who have entrusted themselves to their guidance, by a wanton courting of collision with a vehicle so vastly more weighty, more strong, and more powerful than their own frail vehicles, and feeble, staggering beasts of draught. One of these infatuated men, to-day, crossed about the path of the steam coach, palpably with a mischievous design, which was only rendered abortive by the vigilance and prompt action of Mr. Hancock."

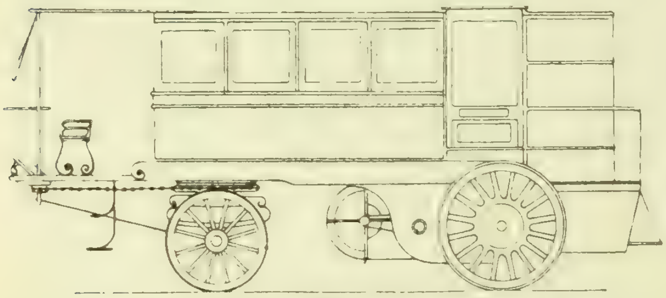


Fig. 1.

The London and Paddington Steam Carriage Company behaved very shabbily to Hancock. He had built the carriage to their order, had run it for several weeks over the course to test its powers at his own expense. Mr. Redmund, the engineer for the company, was satisfied with its performance after it had been running a week, and wrote a flattering report to the directors and shareholders respecting it. After the Enterprise had been delivered to the company Mr. Hancock expected to receive directions to proceed with two more carriages upon the same plan, as per contract entered into by the company. "Various pretexts were, however, resorted to for delay, which subsequent proceedings proved were merely employed by the engineer as feints to conceal a design which for dishonesty has seldom been exceeded." During a delay which lasted for nearly six months, when a voluminous correspondence took place, Mr. Redmund had meanwhile taken the Enterprise to pieces, and was making a carriage of his own on the same lines. This we shall refer to in due course. Mr. Hancock at length caused the Enterprise to be put together and returned, and thus ended the unprofitable and unpleasant business. We must briefly refer to the last and perhaps the best steam carriage built by Mr. Hancock in 1838, which is illustrated by fig. 2 on this page. It will be seen from the illustration that the engine was of the vertical type, placed about the centre of the carriage. C is the cylinder; the crank shaft works in bearings fixed to each side plate, on which is keyed a chain pulley, while a similar pulley of larger diameter was fitted to the driving axle; a strong pitch chain communicated the motion from the crank shaft to the axle; the up and down motion of the axle, which was hung on springs, not interfering with this method of driving. The boiler was situated at the back of the conveyance, the stoker's place being in the middle of the carriage. T represents a water tank and seat for two passengers. The steering arrangements are clearly shown by the illustration. The action of the little locomotive was most creditable to its builder.

In May, 1838, Mr. Hancock and two friends rode through the principal streets of the city in this steam carriage, caused it to run round the open space in front of the Guildhall, turn in any direction, run at any speed desired by its conductor, to the delight of a number of onlookers, after which Hancock threaded his way through the crowd of carts, omnibuses, cabs, and other vehicles in Cheapside, Leadenhall Street, and other busy thoroughfares, stopped at the bank for a few minutes, where Hancock alighted, leaving his friends in charge of the gig. One of the bank porters pompously ordered the gentlemen to "move on," but having had no experience with machinery they were placed in a dilemma, so they were obliged to confess their inability to comply with the order, to the great amusement of the bystanders. When its master arrived the locomotive moved off in good style and returned to Stratford. On the 22nd of June Hyde Park presented an unusually gay appearance in consequence of a crowd of fashionable people being assembled to witness the trial of this little favourite steam carriage, which ran about among the splendid equipages for three or four hours without the slightest failure. Mr. Hancock guided it, caused it to turn in its own length, repeatedly stopping and starting it, then ran a distance at the rate of twelve miles an hour. The nobility who had met for the purpose of seeing it were delighted; their horses, too, were not frightened, because it was noiseless, and it emitted no smoke or steam. In the early part of 1839 Hancock stated by advertisement that he had prepared his largest steam carriage, the Automaton, for traffic, and was ready to enter into engagements with responsible parties to run on any turnpike roads. An old inhabitant of Stratford, in June, 1839, said: "I have repeatedly noticed the performance of Hancock's carriages from the first of his experiments up to his present state of perfection in steam locomotion on common roads. A few days ago the Automaton ran from Stratford, through Ilford, and thence back through Stratford to the city, at fifteen miles an hour. Meeting the procession of the Lord Mayor and other city authorities going to hold a Court of Conservancy at the Swan Inn, Stratford, Hancock headed the procession to their destination, and in front of the house caused the carriage to perform a number of short trips and masterly evolutions, carrying at one time no less than thirty-two of the conservancy jury, quite to everyone's satisfaction."

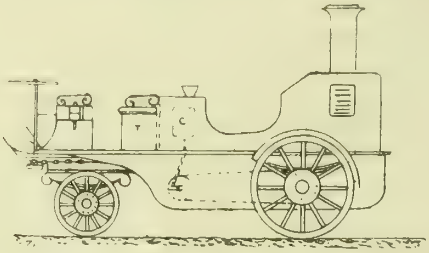


Fig. 2.

The last trip we shall record is a novel one, performed as late as July, 1840. A cricket club borrowed the Automaton of Mr. Hancock to convey eleven of the Stratford Club and twenty-one visitors to the Forest. The run was a pleasant one, the carriage went properly with thirty-two people on board, although there were seats provided for only twenty-two passengers. The game was played, the Stratford team won, and returned to the factory gate at the rate of fifteen miles an hour. Numbers of persons who went to see the match occupied their time in viewing the conveyance that brought the players to the field, rather than the players themselves; but this personal neglect was good humouredly put up with by the club. Mr. Ogle says Mr. Hancock, for want of support, was obliged to withdraw his carriages from the most difficult road in England, viz., the new road from the Bank to Paddington. Hancock says: "I entered upon that road, and continued running daily, solely with a view to demonstrate the practicability of so doing in the teeth of high authority to the contrary."

We now take leave of Mr. Hancock, the most successful locomotionist of those times, who, during sixteen years' experience, built ten different carriages, each of which was creditably designed and made; and the later ones, as we have seen, were most successful. And the wonder is, how it happened that mere speculators, in several instances, who never made a steam carriage that would run the shortest distance without a breakdown, managed to float companies for the purpose of introducing their locomotives, which were not a success, while Hancock and Maceroni, the former a modest and retiring man, the latter rather boastful, both of whom built carriages far surpassing any of their contemporaries, were most unfortunate in their connection with the companies they were instrumental in forming for helping forward the steam locomotion movement.

Redmund.—Mr. D. Redmund, City Road, London, while employed as engineer to the London and Paddington Steam Carriage Company, acted very dishonourably in secretly taking Hancock's new carriage, the Enterprise, to pieces, so that he could take dimensions and copy the design of the parts, to be embodied in a carriage he was making. He had previously patented a steam boiler, consisting of a series of vertical parallel chambers, an imitation of Hancock's patent. The manner of driving, the position of the engine, and even the external appearance, resembled the Enterprise closely. The driving wheels were of ornamental design, the subject of a separate patent, the cast-iron spokes were of hollow section. They appeared to be the only part of the carriage not stolen from others, for Hebert says, "The steering arrangement was like Ackerman's patent of 1816." Before Redmund had finished his carriage, or had made any experiments, he boastfully advertised that he was willing to furnish locomotives to run on common roads at any required speed. When his steam carriage was announced as being ready for trial, the editor of the *Mechanics' Magazine*, said, "We shall soon be able to judge whether he was justified or not in his confidence displayed in the advertisement." Redmund intimated that the private trials of his carriage were satisfactory, but publicity is the only test in such matters. But nothing was heard of Redmund's performances in public with his steam carriage, which he had named the Alpha. It was suggested that it might prove the Omega of his efforts in the steam engine line, and such turned out to be the case. The Alpha was a complete failure, and Redmund's project met with the fate it deserved.

THE SHIPBUILDING INDUSTRY.

THE *Newcastle Daily Chronicle* says: The great activity in the shipbuilding industry just now is shown not only in the reports given almost daily of launches, but especially in the statement of the output of the Clyde for May. There were more vessels than in any similar month for six years, and that despite the strike which is affecting many of the yards on the great Scotch river. All through this year the Clyde has launched a vessel every other day, and though there has been a number of those ships for special services on rivers and allied waters, yet there has been a considerable number of very large vessels. Included in the tonnage put off the stocks last month there were steamers respectively of 5,500 tons, 5,200 tons, and 3,200 tons, as well as three sailing vessels of over 2,000 tons each, so that it is evident that a considerable portion of the tonnage is in the form of large vessels for the great passenger lines, and of vessels for special work. Still, they add to the tonnage afloat, and they will increase the competition on the waters. On the Clyde the rapidity of construction has received a partial check from the strike of the riveters in the great majority of the shipyards. There will also be at several of the shipbuilding yards of the kingdom in the course of a month or so a further and a more enduring check to the production of mercantile vessels by the use of building berths at many yards for Government vessels; and it is quite possible, also, that there may be fewer orders for merchant ships in the market. There is another favourable feature to be borne in mind before expressing much opinion on the tonnage building, and that is, that there is not the building abroad that there is sometimes when our yards are so busy. At one or two of the foreign shipbuilding yards there is activity, but many have not received much benefit from the revival in shipbuilding. But our own yards are very busy, as the figures for the Clyde show. It has alone added a thousand tons a day to the operative tonnage of the nation, and it is quite evident that, with like activity elsewhere, there would soon be an overplus of tonnage for the needs of the world. As it is, the tonnage put into the market will increase the competition amongst the passenger-carrying lines, and will tend to keep down the general rates of freights. The oversea trades of the world are growing; the loss of tonnage is large and continuous; and new trades open out for ships; but when all has been taken into account that can fairly be so taken, those who are interested in shipping will look with some anxiety at the constant additions made to the fleet, though there is the fact that the world is more and more dependent on our fleets for the doing of its work on the great waters. We have the building of the ships, and the profit thereon—where there is profit—and we cannot have a large profit on the services of the ships and a large employment for builders also.

THE INSTITUTION OF CIVIL ENGINEERS.

THE annual general meeting, to consider the report of the council and the annual statement of the accounts, and to elect the council and officers for the ensuing year, was held on Tuesday, the 28th May, Sir George B. Bruce, the president, being in the chair.

The report stated that the institution included within it civil engineers of every denomination; but at the same time the council made a rigid inquiry into the qualifications of all candidates seeking membership, while no person was admitted a student unless he could produce evidence of a competent knowledge of certain elementary subjects of general education.

Considerable attention had been devoted by the council to the composition of its own body, it having been thought that a more rapid change would be beneficial to the interests of the institution; but the council had been unable to take any decided steps in the matter. On the other hand, it was considered advisable that the presidentship should be held by the same person for two successive years, instead of one year, as had generally been the case recently.

The number of members of all classes on the roll of the institution on the 31st of March was 4,739, being an increase of 4 per cent in the twelve months. The numbers were thus distributed: Honorary members, 19; members, 1,657; associate members, 2,613; associates, 450. At the same date there were 989 students on the register.

There had been twenty-five ordinary meetings, but only fourteen papers had been read and discussed, for some of which the council had made the following awards: A Telford Medal and Telford Premium to Mr. G. Kapp; Watt Medals and Telford Premiums to Mr. W. H. Greenwood and Dr. C. E. Emery; a George Stephenson Medal and a Telford Premium to Mr. E. Worthington; and Telford Premiums to Messrs. J. A. F. Aspinall and J. O. Arnold; and for papers to be printed in the Proceedings without being discussed: A Watt Medal and a Telford Premium to Mr. R. Runeberg; and Telford Premiums to Messrs. B. Donkin, jun., Prof. V. A. D. Dery, R. H. Smith, L. F. Vernon-Harcourt, G. Lopes, and N. Kennedy.

Twelve supplemental meetings for students had been held, which had been well attended, and thirteen papers had been read and discussed. A Miller Scholarship had been assigned to Mr. E. C. de Segundo, and Miller Prizes to Messrs. H. B. Ransom, W. W. F. Pullen, J. D. Twinberrow, S. Joyce, R. J. Durley, J. King-Salter, C. H. Gale, and V. W. Delves-Broughton.

The late Mr. T. R. Crampton had bequeathed £500 in trust to the institution, the interest to be devoted annually to the purchase of a medal or books, to be called the "Crampton Prize," for the best paper on "The Construction, Ventilation, and Working of Tunnels of Considerable Length," or, failing such a paper, for a communication on any other subject that the council might select.

The gross receipts for the year had amounted to £21,763 18s. 4d., including income, £17,400 13s. 3d.; capital, £3,840 18s.; and trust funds, £522 7s. 1d. The total expenditure had been £18,226 6s. 4d., including income, £13,972 8s. 9d.; capital investment, £3,901 9s. 3d.; and trust funds, £352 8s. 4d. The difference between the receipts and payments was accounted for by the larger balance at the bankers at the close of the last financial year. The total investments amounted to £98,042 13s. 10d.

The promoters of the Westminster (Parliament Street, &c.) Improvement Act had not yet carried out the stipulations in the Act for the protection of the interests of the institution, and had asked for an extension of the period for doing so, which the council had granted.

At the instigation of the council, Her Majesty's Office of Works had undertaken to record the name of the engineer, Thomas Telford, first president of the institution, on the structure of the Menai Suspension Bridge.

In conclusion, the council referred to the exhibition which had been opened under the auspices of the French Government, and which could not fail to attract all who were interested in engineering progress. The projected visit to France of many American engineers, who have promised to accept on their way the hospitality of their professional brethren here, would add greatly to the interest of the season. The establishment, in connection with the exhibition, of a series of congresses on scientific subjects, was likely to be productive of much good, by developing new and valuable views on the subjects treated. Many of the leading members of the engineering profession had been invited to take part in these meetings, and the council was sure that the Institution of Civil Engineers would meet there with due recognition.

The ballot for council resulted in the election of Sir John Coode, K.C.M.G., as president; of Mr. G. Berkley, Mr. H. Hayter, Mr. A. Giles, M.P., and Sir Robert Rawlinson, K.C.B., as vice-presidents; and of Mr. W. Anderson, Mr. B. Baker, Mr. J. W. Barry, Mr. E. A. Cowper, Sir James N. Douglass, F.R.S., Sir Douglas Fox, Mr. J. C. Hawkshaw, M.A., Mr. C. Hawksley, Sir Bradford Leslie, K.C.I.E., Mr. G. F. Lyster, Mr. J. Mansergh, Mr. W. H. Preece, F.R.S., Sir E. J. Reed, K.C.B., F.R.S., M.P., Mr. W. Shelford, and Mr. F. W. Webb, as other members of the council.

The session was then adjourned until the second Tuesday in November, at 8 p.m.

INDICATED HORSE POWER DIAGRAM.

We present our readers on page 463 with a diagram for readily ascertaining the indicated horse power (I.H.P.) developed by tri-compound engines having a maximum piston speed of 500ft. per minute, with mean pressures reduced to the low-pressure (L.P.) cylinder of 35lb. per square inch, and diameter of L.P. cylinder ranging from 20in. to 60in.

Owing to our limited space, we have thought it advisable not to crowd too much into one diagram, as the result would lead to confusion; and therefore intend shortly to supplement this with a similar one for engines of larger powers.

Before proceeding to show the application of the diagram, perhaps it may be as well to explain to those of our readers who are not familiar with the term what is meant by the "mean pressure reduced to the L.P. cylinder," for which purpose we will consider an engine having cylinder ratios of L.P.÷H.P. = 7·4, and L.P. ÷ I.P. = 2·8, and assume the mean pressures obtained from the indicator cards to be H.P. = 74, I.P. = 28, and L.P. = 10lb. If the pressure of the H.P. be divided by its cylinder ratio, 74 ÷ 7·4 = 10lb., then this reduced pressure, acting on the L.P., would develop the same I.H.P. as the H.P. engine. Treating the I.P. card in the same manner, we also get 10lb., and the sum of the pressures so reduced, together with the pressure of the L.P. (30lb.), if acting on the L.P. piston, would give the same power as that developed in the three engines collectively.

In working out indicator cards, it is customary to reduce the mean pressure of each engine to the standard of the L.P.; and tabulating the total pressure so reduced, it is then an easy matter to determine the I.H.P. which may be expected from any other sized engine working under similar conditions.

Turning to the diagram, the diameters of the H.P. and I.P. cylinders have been inserted so that it may be complete; but as the ratios which these cylinders bear to the L.P. vary in different establishments, they will serve as a guide in deciding upon the actual diameters, and in order to facilitate the use of the diagram, we may state that the ratios employed in the present case are L.P. ÷ H.P. = 7·4, and L.P. ÷ I.P = 2·8, as we believe these ratios are now generally adopted for the mercantile marine, with boiler pressures of 160lb. per square inch.

Let us now take an example. Required the diameter of cylinders of a tri-compound engine, with a piston speed of 390ft. per minute, mean pressure reduced to L.P. of 31lb., developing 1,000 I.H.P. From 1,000 on the I.H.P. scale drop a vertical to cut the diagonal representing 390ft. per minute; transfer this point horizontally until it intersects the diagonal of 31lb., and this point dropped to the scale of diameters gives 59in. as the diameter of the L.P. cylinder, with say 21¾in. and 35¼in. for the H.P. and I.P. respectively.

If the size of L.P. cylinder is given, then by working in the inverse order the I.H.P. can be found.

In like manner the piston speed could be determined, from which the revolutions, or stroke, could then be fixed; also the mean pressure reduced to L.P., which would develop a specified I.H.P. under any given conditions.

If any quantity should not come within the range of the diagram, it is only necessary to take a suitable divisor, and multiplying the amount thus obtained by the divisor used for the final result.

In conclusion, we may say that although the diagram is constructed with special reference to tri-compound engines, it is also applicable to either ordinary compound or single cylinder engines, except the table of diameters, which would require modification to suit the altered conditions.

LAUNCHES AND TRIAL TRIPS.

H.M.S. Marathon, built by the Fairfield Co., of Glasgow, and engined by Hawthorn, Leslie, and Co., of Newcastle, was taken to sea at Portsmouth recently on her twelve hours' continuous open stokehold trial. The maximum power obtained during the twelve hours was 6,973 horses, the minimum 6,053, the average being 6,510, or more than 1,000 H.P. over the contract requirements. The mean revolutions were 134, speed 17·6 knots.

On May 27th, at the yard of Messrs. Robert Thompson and Sons, Southwick, Sunderland, a steel screw-steamer was launched, built to the order of Messrs. Culliford and Clark, of Sunderland and London. Her principal dimensions are: Length, 288ft.; breadth, 38ft. 10in.; depth to Lloyd's floors, 19ft. 6in. She has a clipper stem, and is built on the web-frame system, having a short poop, raised quarter-deck, long bridge to foremast, and topgallant forecastle. She is also fitted throughout with water ballast on cellular bottom principle. She is schooner-rigged, and has four large hatches; also steam winches and donkey boiler, direct steam windlass, and steam steering gear, together with the latest improvements. The captain and officers are berthed in the poop, and the engineers in bridge just aft of engine-room. The topgallant forecastle is fitted up for the accommodation of the crew and firemen. The engines are by Geo. Clark, of Southwick, having cylinders 21in., 35in., and 57½in. by 39in. stroke. The vessel was named the Southery.

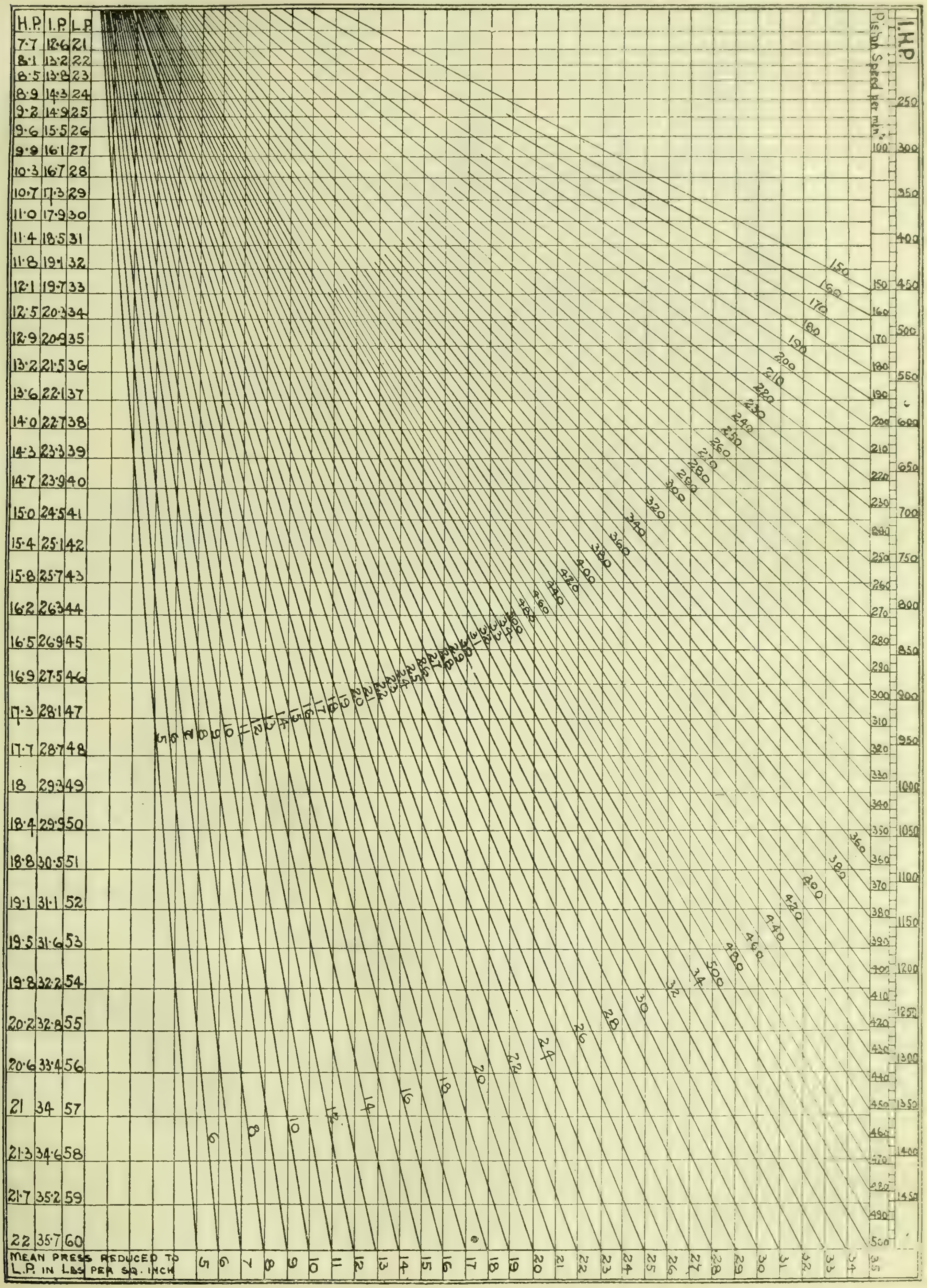
There was launched on Saturday, June 15th, from the shipbuilding yard of Palmer's Company at Jarrow, a steel screw-steamer of the following dimensions: Length between perpendiculars, 314ft.; breadth (moulded), 41ft.; depth (moulded), 24ft. The vessel will be rigged as a two-masted schooner, and is built to class 100 A1 at Lloyd's. She has a long raised quarter-deck. All the decks are of iron. The accommodation for captain and officers is provided in a sunk poop aft, the engineers' accommodation is at the aft end of the bridge, and the crew are berthed in the forecastle. Water ballast is fitted in a double cellular bottom, extending fore and aft; Clark-Chapman's direct steam capstan windlass is fitted forward, Harrison's steam-steering gear amidships, and Hastie's screw gear aft. The vessel will load about 4,300 tons dead weight on Lloyd's freeboard. She was named Wennington Hall by Mrs. Banks, of High Moor House, Wigton, Cumberland. The vessel was built to the order of Mr. C. G. Dunn, of the Globe Shipping Company, Liverpool, and is constructed as a general cargo trader.

On Saturday, June 15th, there was launched from the yard of Messrs. Wood, Skinner, and Co., Bill Quay, a steel screw-steamer, built to the order of Messrs. Fearnley and Eger, of Christiania. The principal dimensions are: Length, 281ft. 3in.; breadth, 37ft.; depth, moulded 20ft.; with a dead weight carrying capacity of 3,000 tons. She is constructed on the cellular bottom principle, and, as well as taking the highest class at Lloyd's, will also take the highest class in Norwegian Veritas, *A1, having been built under the special inspection of Mr. Lauritz M. Bodin, of London, principal surveyor to the Norwegian Veritas. The engines have been built to Lloyd's and Norwegian Veritas requirements by the North-Eastern Marine Engineering Company, Limited, Wallsend. They are on the triple-expansion system, having cylinders 21in., 35in., and 58in., by 39in. stroke, and are capable of indicating 1,000 horse power. The vessel was named the Skarpsno. She is specially adapted for the Black Sea, Baltic, and Indian trades, and is fitted with all modern appliances for efficient and economical working. This is the second vessel built for the same owners, and Messrs. Wood, Skinner, and Co. have another vessel to put down on the same berth.

A valuable addition was made to the fleet of steamers managed by Messrs. Stevens, Mawson, and Goss, of Newport, Mon., on Saturday, June 15th, when the Blyth Shipbuilding Company, Limited, launched from their works at Blyth a cargo steamer for the above-named firm. The principal dimensions of this vessel, which is built to Lloyd's highest class, are as follow: Length, 260ft.; breadth, 36ft. 6in.; and depth, 19ft. 4in. She has been built entirely of iron, and is on the cellular double bottom principle for water ballast, with well frames, &c., and her deck arrangements consist of a long raised quarter-deck and poop, and long bridge extending from the after end of the engine-room to the foreside of the foremast. The captain's and officers' accommodation is in a neat cabin aft below poop deck, while the engineers are provided with suitable accommodation at after end of bridge, the sailors' and firemen's berths being in the topgallant forecastle. The vessel has been built to comply with the Board of Trade requirements for carrying grain in bulk. There are four large cargo hatches for the rapid loading of cargo, with four powerful steam winches by Messrs. J. Smith and Son, of Newcastle-on-Tyne. Harfield's patent windlass is placed on the forecastle deck, and Messrs. Donkin and Nichol's steam and hand steering gear is fitted in a wheel-house on the bridge, and connected to the circular tiller aft. The engines are of the triple-expansion type, and will be supplied by Messrs. Black, Hawthorn, and Company, Gateshead, with cylinders 20in., 34in., and 54in., by 36in. stroke, and 160lb. pressure. The vessel was named the Crimea. The new graving dock, to be capable of docking vessels up to 350ft. in length, which Mr. Walter Scott, contractor, is constructing for the Blyth Shipbuilding Company, is making rapid progress.

INDICATED HORSE-POWER DIAGRAM.

(For description see page 462.)

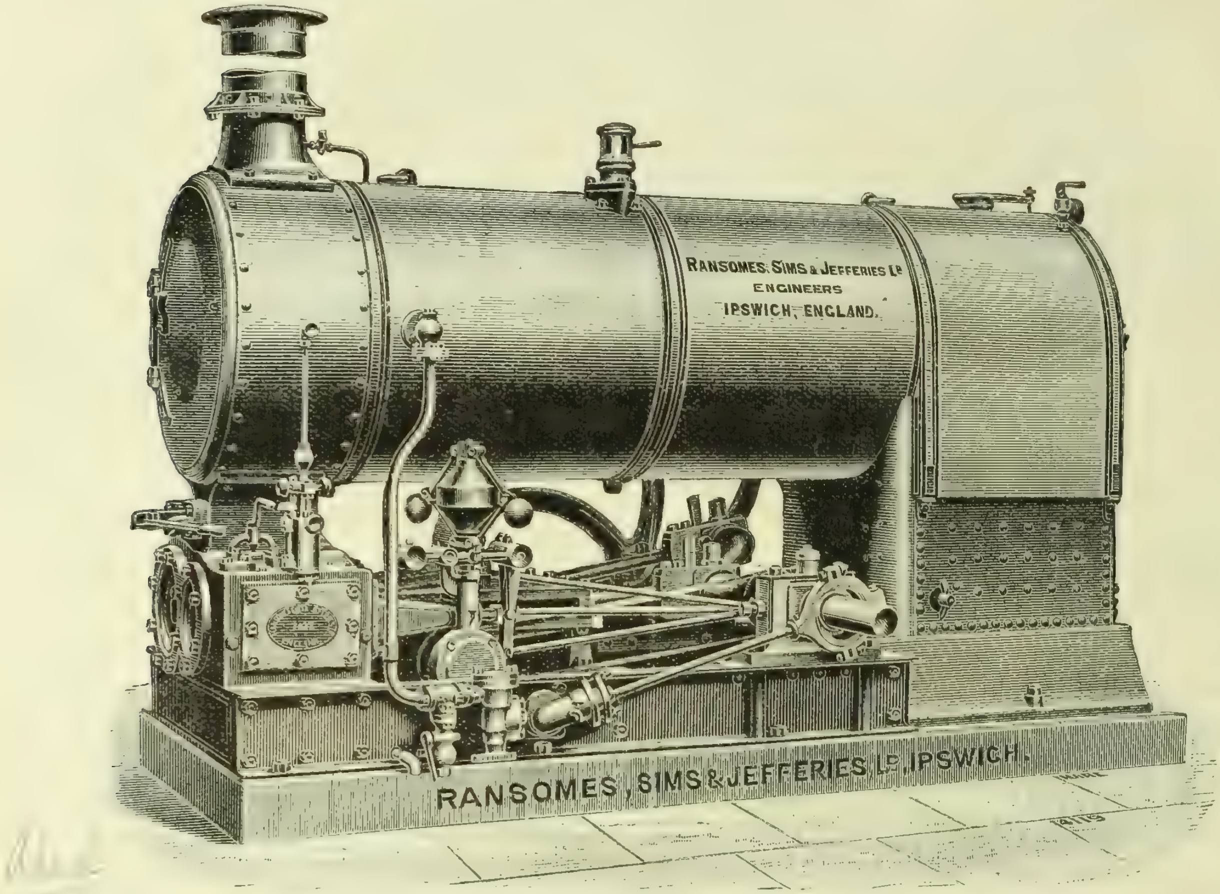


H.P.	I.P.	L.P.
7·7	12·6	21
8·1	13·2	22
8·5	13·8	23
8·9	14·3	24
9·2	14·9	25
9·6	15·5	26
9·9	16·1	27
10·3	16·7	28
10·7	17·3	29
11·0	17·9	30
11·4	18·5	31
11·8	19·1	32
12·1	19·7	33
12·5	20·3	34
12·9	20·9	35
13·2	21·5	36
13·6	22·1	37
14·0	22·7	38
14·3	23·3	39
14·7	23·9	40
15·0	24·5	41
15·4	25·1	42
15·8	25·7	43
16·2	26·3	44
16·5	26·9	45
16·9	27·5	46
17·3	28·1	47
17·7	28·7	48
18	29·3	49
18·4	29·9	50
18·8	30·5	51
19·1	31·1	52
19·5	31·6	53
19·8	32·2	54
20·2	32·8	55
20·6	33·4	56
21	34	57
21·3	34·6	58
21·7	35·2	59
22	35·7	60

MEAN PRESS REDUCED TO L.P. IN LBS PER SQ. INCH

THE R.A.S.E. WINDSOR SHOW.—SEMI-PORTABLE ENGINE,

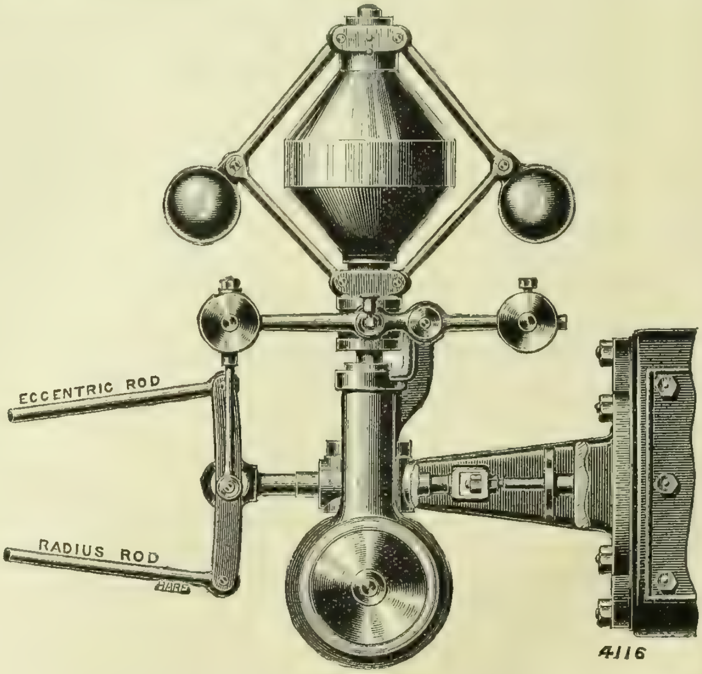
CONSTRUCTED BY MESSRS. RANSOMES, SIMS, AND JEFFERIES, LIMITED, ENGINEERS, IPSWICH.


RANSOMES, SIMS & JEFFERIES L^D
ENGINEERS
IPSWICH, ENGLAND.
RANSOMES, SIMS & JEFFERIES L^D IPSWICH.

Messrs. Ransomes, Sims, and Jefferies, of Orwell Works, Ipswich, had an excellent exhibit of their well-known engines and other manufactures at the Royal Agricultural Society's Show. We here illustrate a compound undertype engine and boiler of 10 H.P. nominal, which is of admirable design and workmanship. The stationary types of compound engine, with locomotive multitubular boilers, are often preferable to the semi-portable class, especially in the larger sizes, as the engines are self-contained, little foundation is required, and they are readily fixed and set to work.

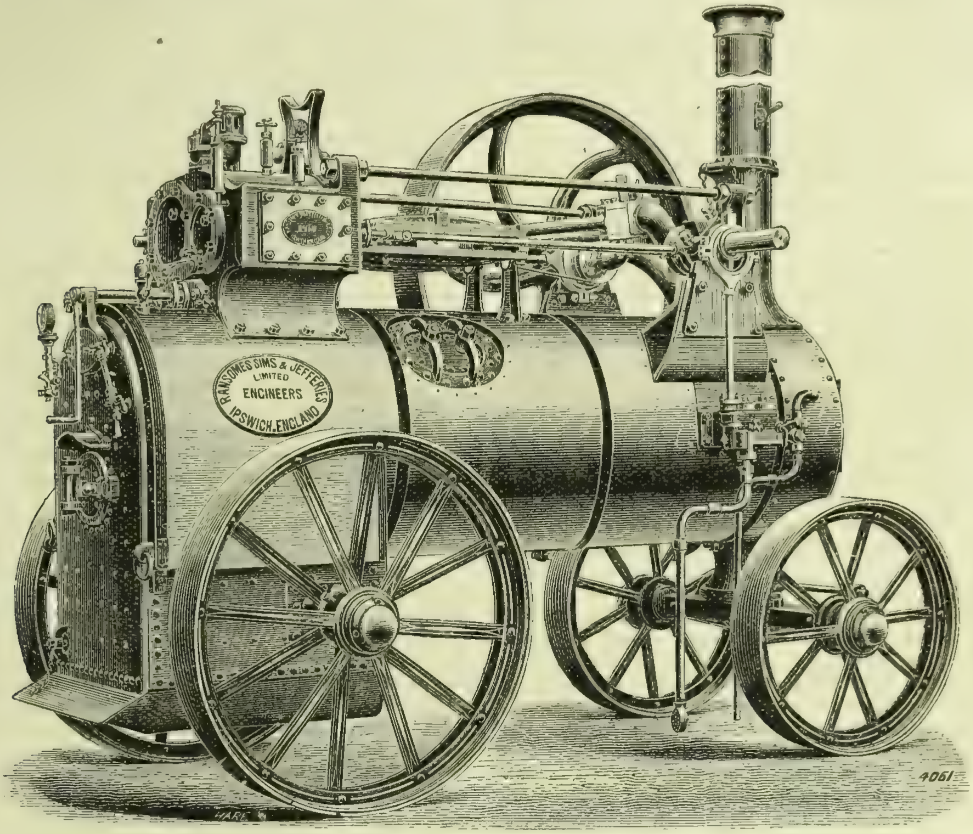
In this engine the cylinders are placed side by side, and are cast in one piece with the valve chests, which are arranged at the outsides, to allow of easy access for setting and examination. The cylinders, together with the working parts, are mounted on a strong wrought-iron girder frame. The boiler is placed over the engine, resting at the smoke-box end on the cylinder, and the frame is extended beyond the crank shaft to form an ashpit for the fire-box. As the boiler can be readily detached from the engine, and the girder frame taken to pieces, the weight of the packages required for transport can be considerably reduced, so that the engine is specially suitable for export. In many countries it is of the utmost importance to make the separate pieces as light as possible. For such countries wrought iron has the double advantage of lightness, and is not liable to break, even with rough handling, during transit. A sight-feed lubricator of improved design is fitted to the high-pressure cylinder, and the steam jacket is drained by an automatic steam trap. The boiler is of mild steel, while the fire-box is of Low Moor iron. 140lb. steam pressure is carried.

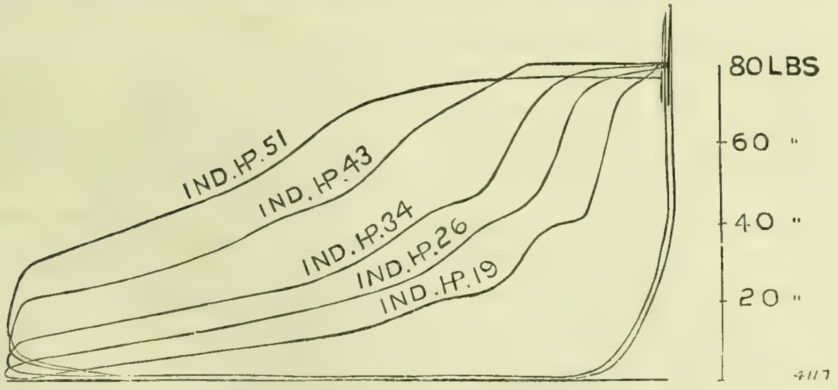
Messrs. Ransomes, Sims, and Jefferies' patent automatic governor expansion gear is used on this engine, and as it presents several interesting features, we here illustrate it. Many admirable automatic gears are now in use, but for engines and boilers under the care of comparatively unskilled attendants, as with agricultural work, it is necessary that the greatest possible simplicity should be attained. In this apparatus simplicity and efficiency have been skilfully combined. An independent gridiron expansion valve works upon the back of the main slide valve, and is operated through a knuckle joint by a link, one end of which is actuated by the cut-off eccentric, while the other end is held by a radius rod. The travel of the valve, and therefore the point at which it cuts off, are governed by the position of the link in rela-



tion to the knuckle joint, and this position is varied in accordance with the load on the engine by a powerful and sensitive governor of the Porter or loaded type, to which the link is connected.

By this method the cut-off can be varied between 0 and ·70 of the stroke, in proportion to the actual load for the time being on the engine, and the exact amount of steam necessary to do the work is admitted at full boiler pressure up to the point of cut-off, and the entire benefit of expanding is obtained. When an engine is required to work under varying loads a great saving is thus effected, and but few loads are absolutely constant. In addition to the advantage arising from the economy of fuel effected by the adoption of this gear, the speed of the engine is kept practically constant under the greatest difference of load. The extreme variation of speed does not exceed 2 per cent. On this page we give diagrams taken from a 10 H.P. nominal portable engine, fitted with this gear at varying loads, from which the engineer will readily judge the efficiency of the mechanism. The gridiron expansion valve acts admirably, as all the lines start from nearly the full boiler pressure.





On this page we illustrate above a compound portable engine of 16 H.P. nominal, also exhibited by this firm, which embodies their latest improvements. It is intended to work at 140lb. per square inch, and to develop three times its nominal power. It is also fitted with the automatic expansion gear, applied to the high-pressure cylinder only. The cylinders, which are cast in one piece, are bolted to the boiler; and the crank-shaft brackets, of wrought iron, are firmly riveted to the boiler and stayed to the cylinder by two strong wrought-iron tie rods, to take the strain of the engine. The crank-shaft bearings are of gun metal, and have large oil boxes. A continuously-acting feed pump is attached, having treble gun-metal valves, hollow brass plunger, wrought-iron pump rod, and wrought-iron suction and overflow pipes.

The engine can be fitted with Messrs. Ransomes, Sims, and Jefferies' straw-burning apparatus when required. Altogether, this exhibit is most complete, and fully worthy of the long experience and the attention which this well-known firm has devoted to this branch of engineering.

Messrs. Strawsons, Limited, exhibited the now well-known distributor known as the "Strawsoniser," and made many tests with it before the Prince of Wales and the Duke of Cambridge. This machine can distribute various substances by merely changing the nozzles, and it successfully distributed 1 cwt. of nitrate of soda on one acre, two bushels of barley on one acre, and six gallons of water on one acre. It is capable of treating six acres per hour in this way.

Messrs. Ladd and Co., of Queen Victoria Street, London, exhibited two of their baling trusses, one of which is heavy enough to form bales 15in. by 18in. by 36in., and weighing about 140lb. By this press it is stated that straw may be compressed to a density of 40lb. per cubic foot, with the machine turning out about 20 tons per day.

Messrs. J. and H. Gwynne, of Hammersmith, exhibited an 8 H.P. portable engine and boiler, in which the engine is vertical, with the crank overhead, and can be detached from the boiler if desired to work separately. The engine stands at the end of the horizontal boiler, close up, upon a kind of foot-plate, and the fire-door is in the side of the fire-box instead of at the end, as is usual.

Messrs. John Fowler and Co., Leeds, exhibited an interesting engine—Scott's patent—which we hope to illustrate and describe fully.

Messrs. Robey and Co., of Lincoln, had, as usual, a very complete and beautifully-finished exhibit of their well-known engines, and a new straw shaker.

THE CAPACITY OF AIR PUMPS.

(Continued from page 445.)

The absolute pressure in the condenser will then be 2in. vapour pressure + $(\frac{3}{4} + p)$ inches of air pressure, and the vacuum will be = height of barometer − $(2 + \frac{3}{4} + p)$.

The curve in fig. 9 shows the way in which the vacuum is related to the capacity of the pump, as calculated from the above formula. The barometric pressure is assumed in this case to be 29·5in., and the abscissæ represent pump capacity as a fraction of the cylinder pressure. Thus when the pump is ·04 or $\frac{1}{25}$th of the cylinder capacity, the vacuum is 24·15in., which increases to 26·52in. when the capacity of the pump becomes $\frac{1}{5}$th of that of the cylinder.

The capacity is supposed to be varied by keeping the diameter the same and varying the stroke, so that the depth of water over the valves is the same in all cases. If, however, the ratio of diameter to stroke be constant for the different sizes the larger-sized pumps would give slightly better vacua relatively to the smaller sizes.

There is, however, in addition to this a good reason for not reducing the diameter too much, for in such a pump as that shown in fig. 4 the area through the foot valves cannot be made more than a certain fraction of the bucket area, and this fraction decreases generally as the diameter decreases; but even assuming it constant for different diameters, it is evident that the pressure required to force the water through the valves will be greater for the smaller diameter than for the larger.

Suppose the air pump, considered above, were to run at 60 double strokes per minute, and that the effective area of the foot valves is $\frac{1}{4}$th of the bucket area, then the mean speed of the water would have to be $\frac{4{\cdot}72\text{in.} \times 4 \times 120}{60 \times 12} = 3{\cdot}15$ft. per second, and it would require a pressure of ·135in. of mercury to produce this velocity. If the velocity be doubled by reducing the area, the pressure would be ·54in. in addition to the pressure required to balance the water column and overcome friction.

The fluid friction will vary approximately as the square of the velocity, and ·8in. would probably not be too much difference of pressure to allow for forcing the water through the valves with a velocity of 6·3ft. per second, and ·2 with a velocity of 3·15ft. per second.

In the former case, if the difference in the level of the water in the condenser and in the air pump be equivalent to a pressure of ·75in., then the air pressure in the condenser must not be less than ·75 + ·8 = 1·55in., making, with the vapour pressure of 2in., a total absolute pressure of 3·55in. If the pressure in the condenser falls below this the pump will not take a full charge of water, and will draw no air, with the result that the air pressure will slowly increase until it is sufficient to force the water through the valves at a greater rate than that at which it accumulates in the condenser. The water level in the latter will thus gradually fall, and air will begin to pass into the pump as well as the water. As soon as the pump commences to draw air the air pressure in the condenser will begin to fall, and will keep on falling till the reduced air pressure is not sufficient to force the proper charge of water through the valves while the bucket makes its upstroke. The water and air will then accumulate in the condenser as before, and the cycle of changes will be repeated.

This explains the observed fact that in many condensers the vacuum slowly diminishes till a minimum value is reached, and then begins gradually to rise till a maximum value is attained, and then begins to fall again. The variation may amount to half an inch or more, or it may be less, but it has a regular and definite period when the engine is working regularly.

If the air pump is much too large for the work which it has to do, as is the case with pumps fitted to surface condensers, and having proportions suitable for working with jet condensation, it may happen that when the vacuum is at maximum value, as above described, the pumps will not take a charge of either water or air for several strokes.

This is easily explained when it is considered that the pressure required to raise the valves is greater than that required to keep them open when once off their seats.

Suppose the pressure in the condenser to be at its greatest, the valves open at each upstroke, and the pump draws water and air. The quantity of the former is insignificant, and as the pump is large a few strokes will probably reduce the pressure in the condenser to that just required to lift the valves. The next will be the last effective stroke, for the air in the condenser when the following stroke occurs will not have sufficient pressure to open the valves, and a few idle strokes may take place before sufficient air pressure has accumulated to open the valves again.

The maximum attainable vacuum would in this case not be increased by increasing the size of the pump, but would be limited by the pressure required to lift the valves. If this pressure be p, then the maximum vacuum would be height of barometer − vapour pressure − p.

Vertical Air Pump without Foot Valves.—In the preceding case the operations taking place above the bucket were not considered, as the vacuum depends only on the action below the bucket. It is true that if there were any leakage from the atmosphere into the space above the bucket the pump would require more power to drive it, but such leakage would not affect the vacuum so long as the bucket valves remain well covered with water.

The case is entirely different when the foot valve is omitted, since in such a pump the vacuum depends chiefly on the perfection of the vacuum in the space between the bucket and delivery valves. If every joint between this space and the atmosphere is well covered with water there will not be any air leakage, and the attainable vacuum can be found in much the same way as before.

Suppose the bucket fall up, as shown in fig. 5. If water is to pass the bucket valves, the level of the water inside the barrel will have to be considerably above the bottom of the barrel.

As air passes into the barrel during the latter part of the upstroke, the level of the water in the condenser will not be much above the bottom of the barrel. The difference of head A B represents the excess of the air pressure in the condenser over that in the barrel of the pump. Leaving inertia effects out of account for the moment, it is evident that as the bucket comes down the air below it will be compressed unless its pressure is sufficient to lift the bucket valves against the pressure of the water above them. By the time it has acquired this pressure the surface of the water inside the barrel will be lowered by an amount representing the increase of the air pressure, as indicated by the line at *c*. After this the level may tend to rise slightly, since the air pressure required to open the delivery valves is greater than that required to force the air through the water after the valves are open; but, on the other hand, it is not to be forgotten that as the air passes into the upper part of the pump the pressure in that part rises from that due to the vapour pressure to the sum of the air and vapour pressures. The relative effects due to each of these forces will depend on the size of the pump and other special conditions.

If the pump is to take a charge of water as well as air, the level of the water in the barrel must be more or less above the level of the top of the bucket when the latter is full down.

Just as the last portion of air is about to pass the valves and the water below touching them, the difference between the air pressure in the air pump and that in the condenser is represented by the difference in level of the water above the bucket and that in the condenser.

Now, if the water were not to yield to the pressure of the descending bucket on its upper surface (in other words, if it were to act as if there were a foot valve), this difference in level would be the sum of (1) height of water above bucket due to clearance; (2) height by which the water charge would raise the level; (3) height of top of bucket when full down above water in condenser. Comparing this with the difference in pressure which was found to exist in the case of a pump with a foot valve, viz., height of water above foot valve due to clearance + height due to entrance of water charge, we see that in the case of the pump without a foot valve the loss of pressure between the condenser and pump would be greater than the loss in the case of a pump with a foot valve by the height of the water above the bucket due to clearance between it and the delivery valve. (This is on the assumption that, for the pump without a foot valve, the difference in level between the water in the condenser and the top of the bucket when full down is the same as the height of the water above the foot valve due to clearance in the pump provided with a foot valve).

It would follow that the attainable vacuum would be less by this amount when a pump without a foot valve is used instead of an otherwise exactly similar pump with a foot valve.

The loss of pressure will be greater when allowance is made for the yielding of the water below the bucket.

The determination of the extra height of water in the barrel which would be necessary in order that a full water charge should pass the bucket valves is rather complicated, and could not be solved except in special cases. The following, however, is a convenient way of attacking such a problem.

Suppose the bucket valves to consist merely of a thin diaphragm, and let the downward velocity of the water below the bucket be u and that of the water above the bucket be U. When the two surfaces of water come in contact after impact, both the water above and that below will move downwards with a common velocity (less than U and greater than u), depending on the relative mass of water above and below the bucket. This velocity will be less as the mass below the bucket is increased, and would be practically constant were it not for the resistance in passing the valves and the decreasing difference in level of the water in the condenser and in the pump. The bucket is, however, moving downwards with a velocity which is greater at first but gradually diminishes as it approaches its lowest position, so that some time before it arrives at the bottom of its stroke it will be moving with the same velocity as the water, after which no water will pass up through the valves, and the latter will close.

The amount of water which passes the valve between the time of the impact and that at which the bucket has the same velocity as the water will represent the water charge per stroke.

It may be observed that in this case, as well as in that of the pump with foot valve, the water charge will be in excess of that due to accumulation of condensed steam and condensing water, since, while air only is passing up through the valves, some water will leak back.

Such a calculation, as indicated above, with its necessary corrections for friction, change of direction of flow, and effects due to the striking of the water by the ribs, boss, &c., of the bucket, would, of course, be out of the question for general practical purposes; but we may note that some results of the proceeding are: (1) The effective capacity of an air pump without foot valves is reduced by the volume of water which fills a length of the pump equal to the extra height at which the level of the water in the barrel must stand in order to provide for the yielding of this water under the impact of the bucket and the water above it; (2) this yielding may be reduced by increasing the mass of the water which is set in motion by the impact, and also by increasing the velocity of any portion of this water relatively to the velocity at the plane of impact, or, more concisely, by increasing Σmv where m is the mass of the portion which is moving with the velocity v.

CUMMINGS' PATENT SILENT BLOW-OFF, OR WATER CIRCULATOR.

We illustrate below a simple contrivance designed to silence the blow-off from steam boilers, or to heat water noiselessly by a steam jet. Fig. 1 is a section, and fig. 2 an exterior plan showing its application for heating water noiselessly. The inductive action of the steam jet produces a rapid but smooth movement of the water, so that it is quickly heated. It may be applied as feed heater, circulator, or silent blow-off; and we are informed that it is used successfully by the steamships City of Rome, City of Chester, City of Chicago, City of Richmond, and the Vancouver. It is made by Messrs. H. and C. Grayson, engineers, Regent Road, Liverpool.

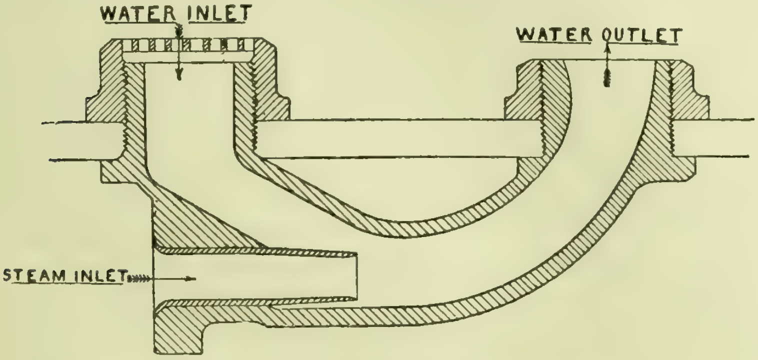


Fig. 1.

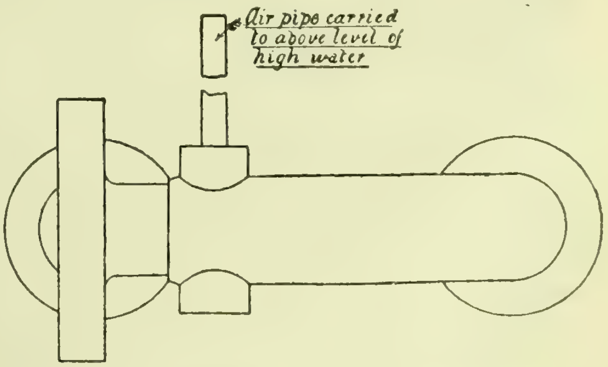
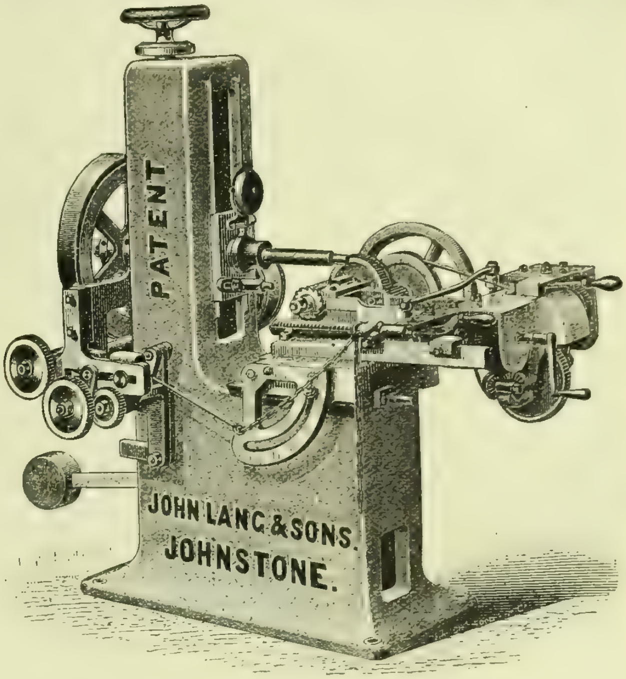


Fig. 2.

AUTOMATIC GEAR-CUTTING MACHINE.

Messrs. John Lang and Sons, engineers, of Johnstone, near Glasgow, now manufacture a new gear-cutting machine, which is universally applicable, and is entirely automatic in its action. We illustrate it here, and it will be observed that the design is exceedingly neat, strong, and compact, while ready access may be had to every part of the machine. The whole of the motions are entirely automatic, and after the blank wheel to be cut has been set in position, the machine adjusted and started, the gearing feeds the cutter through the wheel and withdraws it rapidly, moves the blank the correct distance for next tooth, cuts another tooth, and so continues till the wheel is completely cut, and then strikes a gong to notify the fact to the workman in charge. One attendant can thus keep a number of machines going, or do other work, so that the cost of cutting gears is reduced to a nominal sum. The machines have an adjustable rim support to take the strain off the cutter in large wheels, and a dial for setting the cutter to within one-thousandth part of an inch in depth, also a gauge to set the cutter exactly to the centre of the mandrel.



Graduated indexes are used for the different adjustments required when cutting bevel and worm wheels. Change gears are supplied to cut any number of teeth up to 100, and all, except prime numbers, to 200; and also a large range of higher numbers. The cuttings are carried off automatically, and the worm dividing wheel is made in sections, by an entirely new process, which ensures absolute correctness.

The machine is Eberhardt's patent, and is an exceedingly useful one where numbers of wheels require to be cut. Cut wheels should be far more used than they are at present, and the reduction in cost effected by this machine will no doubt extend their application.

DESCRIPTION OF THE LIFTS IN THE EIFFEL TOWER.*

The Eiffel Tower, though 984 feet high, would be of comparatively little interest if seen only at a distance. The details of this gigantic structure call for close examination; and from its successive platforms, as they rise one above another, a widening prospect is enjoyed, which at the summit extends to a distance of forty or fifty miles round.

In the erection of this work, the designer has also had in view the means of rendering it accessible to the greatest number. To climb 1,800 steps on foot to the summit was not to be thought of, though a staircase may suffice for mounting to the first platform, 187ft. above the ground. This platform can accordingly be reached without fatigue by two wide staircases, constructed in the east and west piers. Even the second platform may also be reached by small winding staircases, which occupy the four corners of the tower.

Independently of the staircases, however, the ascent is made by means of lifts, combined in the following manner: Two lifts on the Roux, Combaluzier, and Lepape system, with jointed rods, lift from the ground to the first platform, working alongside the staircases in the east and west piers. Two American lifts, on the Otis plan, work in the north and south piers, starting likewise from the ground, and rising to the second platform, at 377ft. height, with option of stopping at the first platform. Lastly, by a lift on the Edoux system, placed vertically in the centre of the tower, visitors are raised from the second platform to the third, at a height of 905ft. above the ground.

Each Roux lift is capable of raising 100 persons at a speed of 197 feet per minute, and will make 12 trips per hour; the two lifts together will thus raise 2,400 persons per hour to the first platform, where there are restaurants, cafés, and large covered galleries, whence to enjoy the surrounding views. The two Otis lifts will each hold 50 persons, and work at a speed of 394 feet per minute, and make eight trips an hour, thus conveying 800 persons per hour to the second platform. The Edoux lift will hold from 60 to 70 persons, and make twelve trips per hour, assuming a speed of 177 feet per minute; it will thus raise to third platform the 800 persons per hour brought up by the American lifts.

Roux, Combaluzier, and Lepape Lifts.

These lifts consist essentially of a double chain of jointed rods, provided with a roller at each joint, on which the chains run in guide trunks, fastened to the inclined girders that carry the cabin tracks. The rods are 1¾in. diameter and 3·28ft. long, and jointed together they form a complete circuit, each chain passing at top over a pulley 11½ft. diameter, placed above the first platform. On each side of the cabin is bolted a wrought-iron bar, which forms one link in the chain of jointed rods; and, in order to let this attachment pass, each of the two lower guide trunks has a longitudinal slot all along its inner side, facing the lift; the upper trunk, containing the return half of the chain, is entirely closed. At the bottom each chain of rods passes under a driving wheel, 12¾ft. diameter, with twelve arms. On the extremity of each arm is a hollow steel tooth, by which the eyes of the rods are caught successively, and thus the chain of rods is driven. The driving wheel of each circuit is driven from a hydraulic plunger, 41⅓in. diameter and 16½ft. stroke, which works horizontally in a hydraulic cylinder, 47in. diameter. A pair of 63in. pulleys, carried on the plunger head, engage a pair of triple-link pitch chains, one end of which is fixed to the cylinder bed-plate, whilst the other end winds round a double drum, 23½in. diameter, which is keyed on the shaft of the driving wheel. For each lift the mechanism is in duplicate; but the driving shafts are coupled together, and the motion is regulated by two water valves worked simultaneously, by which water is admitted from the reservoirs situated on the second platform, at a height of 377ft., for raising the lift; while in the descent the water is allowed to exhaust gradually from the cylinders. The water pressure accordingly acts in the ascent only; the descent is made by the weight of the cabin, which is more than sufficient for the purpose, and is partly counterbalanced by lead counterweights placed on some of the rods in the upper or closed guide trunks.

Balance.—The weight of the two-story cabin empty is about 14,080lb.; the counterweights weigh 6,600lb., leaving an unbalanced load of 7,480lb., of which the component parallel to the track inclined at 54° 35′ is 7,480 × sin 54° 35′ = 7,480 × 0·815 = 6,096lb. This load is sufficient to overcome frictional resistance, as well as to drive the plungers home to the end of the cylinders, and thus enables the cabin to descend empty.

In ascending with 100 persons, estimated at 15,400lb., the unbalanced weight of the cabin being 7,480lb., there is a total load of 22,880lb., representing on the incline a pull of 22,880 × 0·815 = 18,647lb. at the extremity of the arms of the driving wheels. On the plungers, according to the ratio of the tackle, and without allowing for friction, this pull becomes $18{,}647 \times \frac{12{\cdot}75 \times 12}{23{\cdot}5} \times 2 = 18{,}647 \times 13 = 242{,}411$lb. Assuming from 45 to 50ft. loss of head in the pipe from the reservoirs on the second platform to the cylinders, there will still remain a pressure of 142lb. per square inch on the plungers, or 2 × 1,342 square inches × 142 = 381,798lb. Of the difference, 381,798 − 242,411 = 139,387lb., about one half will be absorbed in overcoming the various frictional resistances of the lift.

Cabins.—The cabins consist of two separate rooms, one above the other, each 8¼ft. high and 10½ft. wide and 13¾ft. long. Each room rests on a wrought-iron floor frame. By means of slanting cheeks the travelling chains are fastened not only to the sides of the lower rooms, but also to each of the two floor frames.

The cabins are carried on four wheels, which run on the inclined tracks. The two rooms are fitted with sliding doors at the sides, which are opened and closed from the outside by the conductor of the lift, who stands on a platform projecting in front of the lower room; or an attendant stationed on the landings minds the doors of the upper rooms. Each room is fitted with a bench at the back, for the whole width, and several short seats; the total accommodation provided is for 100 persons, 30 sitting and 70 standing.

Water Distribution.—The water from the reservoirs on the second platform is brought to the foot of each pier through a wrought-iron pipe about 10in. diameter. The exhaust water which has passed through the cylinders is returned through another 10in. pipe to a tank which supplies the pumps placed in the south pier.

The distributors for the two cylinders are placed between the supply and exhaust pipes. Each distributor consists of a cast-iron box with three compartments, which are separated by two gun-metal valves partially balanced. The valve spindles are worked by two cams mounted opposite each other on the same shaft, so as to act on one valve or the other according as the shaft is turned one way or the other. The cam shaft is controlled by means of a double rope running along the route of the cabin, so that the conductor can work it at any height for regulating the speed. The cabins are stopped automatically on arriving at either end of the trip by means of tappets, which are struck by the heads of the plungers at the extremities of their stroke.

Safety.—Should the chain break at any part, the apparatus would simply stop. It could not fall, because the rods forming the chains are constantly abutting against one another; and as the chains are confined in the closed trunks, they cannot buckle under compression. Moreover, the mechanism is double, and each half is capable of sustaining the whole weight of the cabin, if not of raising it.

Otis Lifts.

The Otis lift resembles the Chrétien crane in its general arrangement, and is like a tackle acting inversely, the power being applied direct to the movable pulley block, while the free end of the rope is attached to the load. The power is derived from a hydraulic cylinder 38in. diameter and 36ft. long, having a piston with two rods, which are fastened to a truck carrying six grooved pulleys of 5ft. diameter. The cylinder is supported on two girders about 131ft. long, inclined at an angle of 61 deg. 20ft. The girders carry also the path on which the pulley truck runs; and at their upper ends are mounted six stationary pulleys, corresponding with the movable pulleys, the whole thus forming a gigantic 12-purchase tackle. The rope is quadrupled, being composed of four steel-wire ropes of 0·79in. diameter; the dead end is fastened to the top of the girder by means of a whipple-tree, so as to secure equal tension on each of the four component ropes. The free end of the rope rises above the second platform, being guided by flanged pulleys; the four ropes are then divided into two pairs, which pass down each side of the lift-track, and are attached to the trunk carrying the cabin. In order to diminish the stress on the piston, amounting theoretically to twelve times the load to be lifted, the dead weight is partly balanced by a counterweight, leaving only enough unbalanced for enabling the cabin to descend of itself when empty, and to take with it the pulley truck and the piston; the water pressure is admitted into the top only of the cylinder, which is thus single-acting. The counterweight consists of a long truck on wheels, loaded with pig iron; it travels on a track 148ft. long, laid on the principal beneath the lift-track, near the base of the tower, in a straight portion inclined at 54° 35′. It is connected to the cabin by two ropes of 0·9in. diameter, arranged as a six-purchase tackle, and passing over sheaves above the second platform, whence they descend at each side of the lift-track, parallel to the main ropes.

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* Paper read by Mr. A. Ansaloni, of Paris, before the Institution of Mechanical Engineers at the Paris meeting.

Balance.—The cabin and its truck, with safety appliances and other gear, make up a weight of 23,900lb., which when resolved parallel to the 54 deg. 35ft. inclination of the lift-track is reduced to 23,900 × 0·815 = 19,510lb. The counterweight of 55,000lb. becomes at the same inclination equivalent to 55,000 × 0·815 = 44,970lb., capable of balancing 14,660lb. on the cabin, after allowing for friction. There remains therefore an unbalanced weight of 19,510 − 14,660 = 4,850lb., to which must be added the resultant weight of fifty passengers, say 7,700lb. × 0·815 = 6,280lb.; and also the dead resistances, together with the increase of load due to the steeper inclination in the upper part of the track, say 4,740lb. The total resistance is accordingly 4,850 + 6,280 + 4,740 = 15,870lb.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

BALANCE OF LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—My attention having been called to the letters of your correspondents "Dreadnought" and W. H. Booth, perhaps you will spare me space for some explanation and extension of the criticised remarks.

It would have been but fair had "Dreadnought" stated that the words complained of were contained in an inquiry into the conditions that limit speed on railways, where any want of balance, which in the regular speeds on our roads would be scarcely felt, might at extreme speeds lead to derailment.

I must admit that in relation to the revolving weights I have laid myself open to criticism, through insufficient explanation, it being usual, when calculating the balance weights for locomotives, to divide the weight of the connecting rod, calling one part a reciprocating, and the other a revolving weight. This I did not make clear, it being, of course, possible to balance the crank axle and the crank boss, the only truly revolving weights in the wheel, as is proved by the formula $C = \frac{W \cdot v^2}{32 \cdot 2r}$, but in the case of what is usually approximately called the revolving part of the connecting rod this is not so.

With respect to the reciprocating weights, it is an enigma to me how Mr. Booth can "substantially endorse" "Dreadnought's" remarks, when he shows that "Dreadnought's" perfectly balanced locomotive would, at a certain speed, with a certain diameter of driving wheel and a usual load on that wheel, jump the rail.

Now, although "Dreadnought" may not accept anything I may say as authoritative—a position I do not in the least desire to assume—let us see the conditions Professor Osborne Reynolds, in his series of papers on "The Limits to Speed" (which I would recommend to his attention) lays down as necessary to a complete balance. (1) There must be no force to move the frame in any particular direction, or that there must be no tendency to move the centre of gravity of the frame. (2) That there must be no tendency to turn the frame around about its centre of gravity. The condition (1) may be simply expressed. The moving weights must be so arranged that, however the several weights may move, the centre of gravity of the whole system of moving pieces must not change its position during the motion. The condition (2) may also be simply expressed in the language of theoretical mechanics. It is that the moving weights must at no time have any aggregate moment of acceleration about any axis through the centre of gravity. To those not familiar with mathematical language, this second condition, as thus expressed, may not be very intelligible, but as the practical examples are for the most part very simple, it will be sufficient to explain the conditions as applied to one of these examples. For instance, in the case of crank axle in uniform rotation, the centre of gravity of the shaft itself, lying in the axis, will not move; but the centre of gravity of the crank revolving round the shaft will be subject to continual acceleration, directed from the axis. An equal weight, fixed at an equal distance from the axis, and on the opposite side to the crank, will suffice to satisfy the first condition, however far along the shaft it may be from the crank; but to satisfy the second condition, the centre of gravity of the counterweight and of the crank must be in a line perpendicular to the axis of the shaft; and since the connecting rod occupies the space opposite the crank, it is in general impossible to balance a crank with a single weight, two weights having to be used, placed so that the centre of gravity of the whole mass on one side of the crank axle shall be opposite the centre of gravity of the mass on the other.

Oscillating pieces, however, cannot be balanced in so simple a manner. They require a weight or weights, of which the centre of gravity is in the line of oscillation, and oscillating in exactly the reverse manner. Now, the manner of oscillation of, say a piston, depends not only on the motion of the crank, but also on the length of the connecting rod, the varying obliquity of which, when the connecting rod is short, will produce an important effect. The only way, therefore, in which a connecting rod and piston can be completely balanced is by oscillating weights connected with cranks on the crank axle by connecting rods of such length that their obliquity is always the same as that of the connecting rod, which is driven by the piston.

But for the effect of the obliquity of the connecting rod, the force arising from the acceleration of the piston in the direction of its motion will at all times be the same as the component in that direction of the centrifugal force of an equal weight revolving with the crank, and having its centre of gravity in the axis of the crank pin. The centrifugal force of the revolving weight, however, would not be confined to the direction of oscillation, so that if such a weight be used to balance the piston, it will introduce an equal force at right angles to the direction of oscillation. Thus, if weights be added to the driving wheels of a locomotive of such magnitude as to balance not only the weights of the cranks, but also weights equal to the connecting rods and pistons having their centre of gravity in the crank pins, the only horizontal forces will be those which arise from the effect of the obliquity of the connecting rods, while vertical forces will have been introduced nearly equal to what the horizontal forces arising from the pistons and connecting rods would have been.

Thus we see that it is possible to so arrange counterweights as to mitigate these forces in one direction, by introducing equal forces at right angles. The problem is as to how far it is desirable to do this. If the centrifugal force is sufficient, it will lift the axle box against the pressure of the spring, causing the wheel to leave the rail, on to which it will return with a blow; while short of this, a want of vertical balance will cause the wheel to run with a varying pressure on the rail, causing the wheel to wear out of round.

What is wanted to be known is the greatest proportion to the load on the driving wheel that the vertical component of the centrifugal force may be allowed to bear, and the counterweight may then be designed so as to produce this force when the engine is running at its normal speed.

Now, whatever proportion of the horizontal weights may be balanced, the counterweights may be so placed on the wheels as to entirely prevent the twitching or sinuous motion. The rule, therefore, so far as it is possible to state it, should be to use the largest counterweights which the load on the driving wheels will allow, and to distribute it so as to balance all tendency to turn the crank axle about a vertical axis.

"Dreadnought" is quite correct in stating that the rule propounded by him has been known for fifty years, but he will admit that some advance has been made in the knowledge of the locomotive during that period.

With regard to Mr. Booth's remark, that full balancing may be good for the engine but bad for the bridges, I fail to see how it is possible to disconnect the locomotive and the permanent way when arranging a correct balance.

My apology for quoting so freely from Professor O. Reynolds's paper must be that it presents such a complete view of the case, in such a precise and lucid manner, that it may be of benefit to your younger readers.—I am, &c., The Writer of the Paper.

THE STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

Sir,—Much very valuable information has been given in the recent correspondence on the above, but are experts more unanimous in their opinions than they were before, or have non-experts a clearer conception of the problem now than they had previous to the correspondence? I do not think so. Certainly many cases have been shown as proving conclusions arrived at, but are they all reliable? In my opinion the real working conditions have more to do with actual collapsing pressures than they are credited with, and a collapse by pressure of cold water may give as much as 75 per cent error compared with experience under unfavourable working conditions. We do not often gain much knowledge in perusing Board of Trade Reports, but Report No. 331 is worth reading, especially in this connection. There are two very strong features present in working conditions which are never (perhaps cannot be) taken into consideration, or allowed for by those who suggest the different formulæ, which are alteration of form due to buoyancy, and strains due to buoyancy and overheating. Now, in a tube 30ft. by 3ft. by ⅜in. we have about 2¼ tons, while the displacement is about 375 cubic feet, which would be equal to a distributed load of about 9,622lb. on the tube supported at both ends, which load might be sufficient to alter the form of the tube from circular to elliptical; and may it not in a measure account for many large unstrengthened flues collapsing at the bottom side, where the load of 9,622lb. would be most effective? The other feature is, in my opinion, more effective still. We all know how different metals lose their power of resistance when heated to an appreciable temperature, and the working temperature of plates in a boiler flue is at present an unknown quantity, and therefore its influence is unknown. Certainly we know of scores collapsing and bulging from grease, deposit, thickening, warping, &c., but we never know how *near* we have been until it actually happens, and then, of course, the collapse has been due to the presence of grease and so on, while the boiler flue may have been working for years with a supposed margin of safety of 4, while it has actually been almost at its collapsing limit all the time, but unsuspected until collapse actually occurs; and herein lies all the difference between theory and practice. Cross tubes have also been drawn into the correspondence, particularly by W. H. Booth, who in his letters condemns them wholesale, which condemnation is, in my opinion, quite unjustifiable. If his argument is sound in actual practice, how in the world can the Galloway boiler exist? He makes an attempt to compare them, to which I do not object; but if a few cross tubes are detrimental to economy in the working of a Lancashire boiler, how ever can a Galloway boiler, with about 38 tubes and 6 pockets, give satisfaction at all? Still they go on making and selling them, while the law of the survival of the fittest and W. H. Booth's argument should stamp them out at once. There are now three Galloway boilers at work, each 30ft. by 8ft., working at 90lb. pressure, turning 1,600 I.H.P. in a cotton mill, with about forty tons of coal per week less than when the work was done with seven Lancashire boilers; therefore cross tubes cannot be doing so badly here. W. H. Booth's argument may be sound when tubes are in or near the fire, but in Galloway and most Lancashire boilers the combustion is complete, or nearly so, before it comes in contact with the tubes or pockets. As circulators they are, in my opinion, very effective indeed, although it does happen that the last few tubes have a downward flow, to supply the upward flow at furnaces, front end of combustion chamber, and cone tubes. I have no doubt that "W. H. B.," along with many other of your experienced readers, will admit that grooving on end plates is far more severe in boilers without cross tubes than in those with them, while grooving is seldom seen in Galloway boilers; and this is due to a perfect circulation and a general equalising of the temperature within the boiler. As regards position, I believe the true position for cross tubes is vertical, not only on account of circulation, but also to support flue against the arching upward movement which is experienced in all boilers; and, in conclusion, may I not ask if inspectors are not occasionally unjustly prejudiced on account of the interference with easy accessibility.—Yours &c., CHALKLINE.

QUERIES AND REPLIES.

51. BORING OUT CRANK PIN HOLE.—What is the best method of boring out an old crank pin hole, to be most easily done?—CRANK PIN.

Answer.—"Crankpin" does not give any size or description of the crank he desires to rebore; it is therefore difficult to advise him as to the best method to adopt, this depending upon the nature of the work and the tools at his command. He will, however, find an illustration of a portable machine for turning crankpins in *Engineering* for 12th April, 1889, which can be easily modified to suit his purpose if he wishes to rebore in position. See also answers to question 43, page 333 of current volume of this journal.—ORION.

56. MOST ECONOMICAL STEAM BOILER.—I wish to put down a boiler to drive a 12 horse-power high-pressure engine using pressure at 100lb. per square inch. What is the most economical boiler to use? I would prefer one which requires no brickwork. What evaporation per pound of fuel can be obtained with the boiler recommended?—J. T. M.

Answer.—If this question be put to a number of patent boiler-makers, each would claim his own as the most economical. Therefore, "J. T. M." will have to use an amount of common sense in his selection. If his is an engine 12 H.P. indicated, then an ordinary well-proportioned vertical boiler, with a firegrate about 3ft. diameter, will do the work, consuming about 10lb. of coal per square foot of grate per hour, and evaporating about 6lb. of water per lb. of coal. If it is 12 H.P. nominal (which means anything between 12 and 120), then he had better have it indicated, and ascertain how much steam is required to do the work, and select a boiler afterwards. A good Cornish boiler will burn 16lb. of coal per foot of grate per hour, and evaporate about 8lb. of water per lb. of coal.—CHALKLINE.

57. PUMPS.—Will some reader oblige with a rule for the sizes of suction and delivery pipes. I have a double-acting plunger pump, 7⅜in. diameter, 31½in. stroke, 35 strokes per minute. Suction pipe 11¾in. diameter, and 820ft. long, 16ft. rise. This pump gives me trouble sometimes. Is the suction pipe too large? Delivery pipe 11¾in. diameter, 4,600ft. long, 360ft. lift?—W. H. H.

Answer.—Replying to "W. H. H.," in a suction pipe of 820ft. there are, necessarily, many joints, and it is very probable (as your correspondent "W. A." points out) that some of these may be "drawing air;" but with the other part of his answer I think many engineers will disagree. By having the suction pipe too large, eddies and local currents are set up along the sides of pipe, especially at joints and changes of direction. It also affords greater facility, in case of leakage at joints, for air to be drawn in, and, mixing with the column of water, prevents the plunger working so solidly as it should do. Nothing is to be gained by having the area of suction pipe larger than the plunger; and engineers, nowadays, make the suction pipe from one half to total area of plunger (or bucket), according to circumstances. An article on suction and delivery pipes of large pumps, dealing with the question of friction and some of their varied circumstances, would interest many of your numerous readers.—T. D.

59. POWER OF WINCH.—A wagon loaded, weighing one ton, is to be drawn up an incline 1 in 5 with a winch, by two men. If some reader of *The Practical Engineer* will give me a formula showing how to get the diameter of the gears, also the diameter of drum and radius of handles, and the power each man would have to exert on the same, he would greatly oblige.—CHATHAM.

Answer.—The resistances to be overcome are: (1) Raising the load up the incline; (2) the friction of the truck on its axles; and (3) the friction of the winch.

Let W = weight of loaded truck in pounds;
one in x = the rate of incline;
f = friction of truck in percentage of weight;
F = friction of winch in percentage of work done;
R = radius of handle in inches;
D = diameter of drum in inches;
d_1 = diameter of pinion on handle shaft in inches;
d_2 = diameter of wheel on drum shaft in inches;
M = mean pressure in pounds exerted by one man on handle;
N = number of men at winch.

The general formula for the ratio of gearing will be—

$$\frac{d_2}{d_1} = \frac{W.\,D}{2.\,N.\,M.\,R} \times \left\{\frac{f}{100} + \frac{1}{x}\right\} \times \left\{1 + \frac{F}{100}\right\}$$

The friction of the truck should not exceed 22lb. per ton, or say 1 per cent on a level; and that of the winch may be taken at 10 per cent. The average mean force exerted by a man at a winch is about 25lb. With these figures the general formula becomes—

$$\frac{d_2}{d_1} = \frac{W.\,D}{N.\,R.\,x}\left\{\frac{11.\,x + 1100}{50000}\right\}.$$

In your case we have $W = 1$ ton $= 2240$lb; $x = 5$; $N = 2$. Let $D = 12$in., and $R = 15$in., then—

$$\frac{d_2}{d_1} = \frac{2240 \times 12}{2 \times 15 \times 5}\left\{\frac{11 \times 5 + 1100}{50000}\right\} = 4{\cdot}139.$$

So, if there is a 6in. (d_1) pinion on the handle shaft, you will require on the drum shaft a wheel 24·8in.—say 25in.—(d_2) in diameter.—F. C.

41. HOT-WATER PIPES.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse?—WATER-HEATER.

50. SMALL AIR PUMP.—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—APPRENTICE.

52. DETAILS OF OLIVER.—Can any reader oblige me with details of an oliver, to work by foot, for making bolts from ⅜in. to 1in., with dimensions?—H. C., Egypt.

53. DASH POTS.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made, and what is the approximate cost?—CRANK PIN.

55. TESTING LUBRICATING OILS.—I wish to know the methods of chemically testing the purity of lubricating oils. Is there any simple mode easily applied by an engineer?—LUBRICATOR.

60. SET PINS.—Will you kindly permit me through the medium of your valuable paper to ask any of your correspondents if it is possible to get hexagonal-headed set pins $\frac{1}{16}$in. diameter, to buy, and where?—MODEL.

61. CENTRIFUGAL FORCE.—I have been attempting to analyse the formula $\frac{W\,v^2}{g\,r}$, and have met with a doubt, which a brother subscriber will perhaps be kind enough to clear up.

A body moves in a circular path in a horizontal plane, and with a given angular velocity, and is maintained in that path by a string, whose length is equal to the radius of the circle. Required, the tension in that string, expressed in pounds.

First, I learn that, taking a very small arc of the circular path, I may without sensible error consider the body to be moving along the chord of that arc, and in so doing being pulled centripetally along the smallest side of a right-angled triangle, whose hypotenuse is the chord aforesaid; whence I understand that the speed "set up," as it were, by the centripetal pull bears the same relation to the speed along the chord as the latter ("v") in turn bears to $2\,r$. Would it then be allowable to reason as follows: The force of gravity, acting for one second, produces in a unit mass a speed of 16·1ft. per second by exerting upon that unit a pull of one pound. Each unit mass in my circular-travelling body is travelling at $\frac{v}{2\,r}$ feet per second, a speed which is x times greater than 16·1ft. per second; hence the pull which produced that speed must be x times greater than one pound, and must equal y pounds for each unit of mass in the body. If my reasoning is thus far correct, I have eliminated $\frac{W\,v}{r\,\underbrace{2 \times 16{\cdot}1}_{\text{“}g\text{”}}}$, and I can easily see that the pull in my string in pounds, arrived at by those elements of the formula, will increase with the speed in the proportion $\frac{\text{new speed}^2}{\text{original speed}^2}$

I want to feel assured that to get the pull in my string in pounds for a body whose $W = 64$lb., for example, moving in a circle of 2ft. radius, at a velocity of 100ft. per second $= \frac{m\,v}{g\,r} = 3\frac{1}{8}$lb.; and under similar conditions, except that the velocity is 200ft. per second, the pull will be

$$3\tfrac{1}{8}\text{lb.} \times \frac{\text{new speed}^2}{\text{original speed}^2} = 12\tfrac{1}{2}\text{lb.};$$

whereas, if I use $\frac{W\,v^2}{g\,r}$ in both cases, I simply obtain comparative values, represented by 1 and 4 respectively, and these are no guide as to the actua pull in my string. The formula last quoted is used most recklessly at examinations, and the resulting values are pressed into service as pounds, tons, anythings, because one is not told that the results are merely numerical comparisons, and not actual values expressed in any one system of units. SHINY BOOTS.

62. BORING ROLL CYLINDER.—I should feel much obliged for assistance from you, or any of your numerous readers, with the following: I have a cylinder for a roll; its length is 8ft., inside diameter 25in., and its thickness in rough metal about ¾in. I wish it bored out at the ends about 5in. or 6in., so as I can fit in arms and shaft, and to run pretty fair for outside turning. Can it be done in the lathe with any arrangement, or how would you advise me for cheapest and best, as my appliances are very limited?—PRIMROSE.

TO CORRESPONDENTS.

E. A. G., Boston, U.S.A.—We shall insert a query. We have not been able to find the address of the inventor you name.

A NEW ALLOY.—MM. Schneider and Co., of France, manufacture steel containing a variable portion of copper, which is to be used in making artillery of large calibre, armour plates, rifle barrels, and projectiles. Ordinary copper is used for the purpose, care being taken to prevent it from oxidising before it is mixed with the steel in the crucible, and the composition containing 2 to 4 per cent of copper, the alloy being capable of far more resisting power, and more elastic and malleable than simple steel would be. This new material will also probably be valuable for making girders for building purposes and ship plates.

MISCELLANEA.

A new apparatus has lately been patented by Mr. Oswald Rose, of Bishopsgate Street, London, by which the vapour or gas produced from petroleum and water is burnt; the peculiarity is that the oil and water are vaporised separately before being mixed in the fixing chamber.

An Electric Tramway in Morecambe.—It is proposed to construct a tramway line from Scotforth, a suburb of Lancaster, through Lancaster to Morecambe, and to work the cars by electricity. The House of Commons has given its consent, but ordered that the speed of the cars should not exceed six miles on the level of the bridge, and four miles on the downward slope at each side.

Duration of a Lightning Flash.—M. E. L. Trouvelot now affirms before the Paris Academy of Sciences what nearly all mankind, including Wheatstone, have been accustomed to deny. M. Trouvelot concludes from his observations by photography that the lightning flash is not instantaneous. He contends for it having a perceptible duration beyond the thousandth part of a second. From Wheatstone's rotating mirror experiment, it was concluded that electricity would take a second to flow through a copper wire 462,133 kilometres long—that is, 289,456 miles.

The Largest Roof in the World.—A Paris correspondent says that the machinery hall, which occupies nearly the whole width of the Champ de Mars, is the largest building covered with one roof in the world. Its central nave measures 375ft. in width and 1,380ft. in length, and is roofed in by one span. On either side are galleries 57ft. 6in. wide, and these have a ground and first floor. The cost was, in round numbers, £300,000. Three-quarters of the space of the machinery hall is occupied by France, and the remaining quarter is divided between Great Britain, the United States, Belgium, and Switzerland.

Locomotive Coal.—A correspondent writes to the *Times*: Contracts for the supply of locomotive coal have just been entered into with several railway companies connected with the West Riding field, the price being 8s. 6d. per ton, or an increase in the rate equal to fully 40 per cent on the prices at which the tenders were delivered last year. In addition to this, it appears an advance has taken place in the price of all other locomotive requirements. It is estimated that in fuel alone the increase in the price will, for the London and North Western, be equal to more than £100,000 for the year, the cost reaching of late £260,000 per annum at the least, while the additional cost to the Midland will be equal to £90,000 for the year, and to the Great Western £80,000.

Pressure in Drilling Cast Iron.—Mr. L. B. Breckenridge, the instructor in mechanical engineering in the Lehigh University, has lately been making some experiments for the determination of the pressure exerted in drilling cast iron. He made a cylinder in which was a plunger having an area of 10 square inches. Three small grooves were turned in the plunger near its lower end, so as to prevent any leakage of the oil with which the cylinder was partly filled. Two holes were drilled in the cylinder near the bottom, and a steam gauge and an indicator were attached. The indicator cord was attached to the hub on the shaft of the quick return motion lever in order to obtain diagrams of considerable length. When the piece to be drilled was resting on the plunger, a diagram could be taken which would show the pressure exerted in forcing the drill through the work. With ¼in. twist drills the greatest downward pressure was 400lb.; with ½in., 900lb.; with ¾in., 1,100lb.; with 1in., 1,450lb.; and with 1¼in., 1,800lb.

Trials of H.M.S. Melpomene.—This vessel—one of the M. class of cruisers for the British navy—which has been built at Portsmouth Dockyard, and engined by Palmer's Steel and Iron Co., Limited, Jarrow, was taken out of Portsmouth Harbour on Tuesday, the 18th June, at 3 p.m., for her official trial of twelve hours' duration under natural draught. The trial was commenced at 5-30 a.m., and finished most successfully at 5-30 p.m., the result being as follows: Steam, 141·16lb.; vacuum, 24in.; revolutions, 128; mean I.H.P. for the 12 hours, starboard engine, 3,145; port engine, 3,071; total, 6,216; minimum I.H.P., 5,891; maximum I.H.P., 6,815; speed of vessel on the mile, 17·385 knots; log showed for the twelve hours 212 knots. Last Saturday the vessel was again taken to sea for the purpose of undergoing her full power trial of four hours' duration under forced draught. She left the dockyard at 6 a.m., and commenced her trial at 7-50 a.m., compleating it at 11-50. with the result that the I.H.P. attained was 9,641 or 641 above the guarantee of 9,000 with an air pressure of 1·7in. of water, and a speed of vessel of 19·7 knots. The following are details: Steam, 152·05lb.; vacuum, 23½in.; revolutions, 143·6; mean I.H.P., starboard engine, 4,838; mean I.H.P. port engine, 4,803; total mean I.H.P. for the four hours, 9,641; minimum I.H.P., 9,476; maximum I.H.P., 9,976. Both the trials were accomplished in a highly satisfactory manner, the engines working without a hitch. The dimensions are: Twin screw horizontal engines with cylinders, 54½in. by 51in. by 76½in. by 36in. stroke; four D.E. boilers 12ft. 3in. diameter by 18ft. 4in. long, having a working pressure of 155lb.

Cheap Production of Aluminium.—Most people are aware of the fact that the metal aluminium is to be manufactured from clay, and, so long ago as 1807, Davy tried to reduce alumina by means of the electric current. This silver-white metal is light and tough, and rustless, so that if it could be produced cheaply it would revolutionize the iron trade and give us a new metal for shipbuilding and for countless other industries. In the Paris Exhibition of 1855 a bar of this new metal was exhibited as one of the chemical wonders of the day. The price at that time was about three pounds per ounce, but we are now making it by the ton and selling it at about 20s. per lb.; but it is still a considerable way from being as cheap as iron. Fresh advances are being made in its production every day, and chemists are busy trying to win the secret of its cheap production, so that we may be on the eve of a revolution in our most important industries.

A few days ago a steel twin screw torpedo gunboat, or torpedo boat destroyer, named the Planet, built by Palmers' Shipbuilding and Iron Co,, Limited, of Jarrow, for the Austro-Hungarian Government, was launched. The vessel is 220ft. over all, 210ft. between perpendiculars; her moulded breadth is 23ft., and her depth 13ft. She draws 8ft. 4in. in sea-going trim, at which draught her displacement is 480tons. She has two sets of vertical triple-expansion engines, having cylinders of 18½in., 27in., and 43in. diameter respectively, with a stroke of 20in., capable of developing an indicated horse power of 3,500, which is expected to propel the vessel at a mean speed of 20½ knots per hour. The boilers, four in number, are fitted in two separate compartments, and are of the locomotive type, with a working pressure of 175lb. per square inch; the forced draught is on the closed ash-pit system, air being supplied to the furnaces by means of two large fans, one placed in each stokehole. Two feed-heaters and one feed make-up apparatus are to be supplied by John Kirkaldy, Limited.

A New Method of Rolling Metal.—Amongst other recent interesting inventions is a rolling mill for producing sheet metal direct from the molten state, instead of rolling it from a billet or bar. A machine of this character has been at work for several months at the can factory in Maywood, near Chicago. It is used for making sheet solder, six or eight inches wide, and 15-1,000 of an inch thick, which it produces at the rate of 400ft. a minute. The apparatus consists of hollow rolls with cold water running through them. The water is introduced through the axles, and the rolls are of sufficient size to at once change the jet of melted metal into solid form as fast as it is fed. The powerful compression exerted by rolls upon the molten metal in forcing it between the two surfaces, and at the same time changing it to a solid body, tends to give to the sheet an even and highly finished surface. The inventors of the machine believe that the principle could be successfully applied to the rolling of Bessemer steel, as well as to softer metals. Mr. O. W. Potter and other officers of the North Chicago Rolling Mill Company, recently examined the machine, and expressed themselves as being favourably impressed with its work.

Regulating Electric Light Like Gas.—An instrument for regulating electric lights, so that they can be turned up or down, as with gas or lamps, and whereby the dynamo will thus be relieved by the short circuiting of the current, has been patented by Mr. Frank J. Crouch, of Eugene City, Oregon. A vessel is employed containing a saline or other chemical solution, such vessel being of any desired shape or size, and in connection therewith are diverging conducting arms connected in circuit with the main line and insulated, a central arm being adapted to be lowered into the solution to any desired depth, the brilliancy of the lighting being decreased as the central rod is raised or lowered. Binding posts are secured to the cover of the vessel and insulated therefrom, and a transverse shaft, with a central pinion and a thumbscrew at one end, is journaled to extend across the top of the cover, the pinion operating a rack bar on the vertically moving central rod. On the opposite sides of this rod are secured the upper ends of a pair of downwardly diverging spring conducting rods, preferably made of copper, whose lower ends bear against the sides of the vessel. Coiled conducting wire connects the binding posts to the conducting arms, and enable the plunger rod to be removed up or down. The conducting wire of the electric light system is connected to the binding post, completing the circuit through the spring conducting arms and the solution in which they are immersed. A shunt circuit connects the wires of the system, this circuit having a resistance coil made to balance, the lamps used on the circuit having a switch to cut off communication between the coil and the shunt circuit. It is said that an instrument containing only three gallons of the liquid will regulate eighty lamps of thirty candle power each, and it is stated that such instruments have been used for more than a year past, with great satisfaction, in theatres and elsewhere.

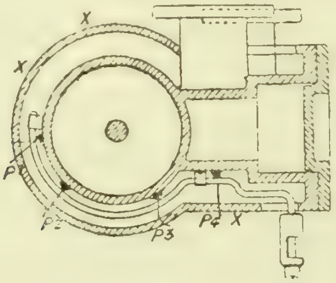
Increase of Electric Railways in America.—We learn from a New York correspondent that electric railways are increasing very rapidly in the United States. One firm, namely, the Thomson-Houston Company, has lately closed the following contracts: Lynn and Boston Railway Company, Nahant Line. This line has 4,305ft. of track, two turnouts, maximum gradient of 4 per cent. It will extend from Central Square, Lynn, to Nahant House, Nahant, Mass. One car will be put in operation at first, the power for which will be obtained from the station of the Lynn Electric Light Company. Newburyport and

Amesbury Horse Railway Company, Newburyport, Mass.—This line is about six miles in length, and will operate two cars. It is made up almost entirely of curves and grades, the maximum of which is 10 per cent. The cars will be operated by a current from the Newburyport Electric Light Company, Amesbury, Mass. The Newton Circuit Line, Newton, Mass.—This line will operate 10 cars, and is three miles in length, the maximum gradient being 5 per cent. It will run from Newton to Watertown, on the West End track, and on new track from Watertown to West Newton and Newtonville. The Plymouth and Kingstown Railway Company, Plymouth, Mass.—This line is four miles in length, and will operate three cars. The maximum gradient is 6 per cent. It will run from Chiltonville, through Plymouth to Kingston. On nearly all the line the bracket method will be used. The track is about laid. The Quincy Street Railway, Quincy, Mass.—This line will operate four cars, and is five miles in length. It extends from Quincy, through Wollaston Heights and Atlantic, to the Neponset River. The bracket method of overhead construction will be used. The company has also received orders for new cars from the Wheeling Railway Company, Wheeling, W. Va.; West End Street Railway Company, Boston, Mass.; Topeka Rapid Transit Company, Topeka, Kan.; Omaha and Council Bluffs Railway and Bridge Company, Omaha, Neb.; Lynn and Boston Street Railway Company, Lynn, Mass. The company has also constructed a track of about one mile for the Hillside Coal Company, at Scranton, Pa., on which a 40-horse power locomotive is used. This is used for carrying coal, and is capable of hauling about 20 cars loaded with one ton each.

ILLUSTRATED PATENTS.

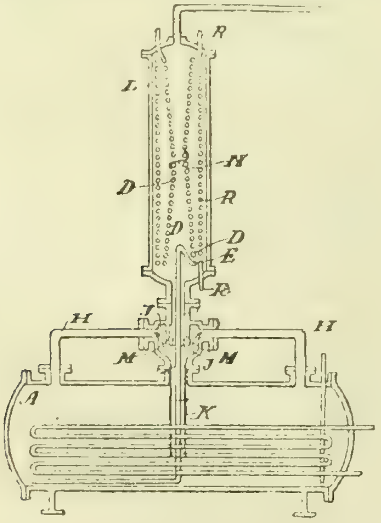
1324 Diminishing Condensation in Steam-engines, B. Donkin, London.

Consists in heating the cylinders, etc. by "Bunsen" gas flames, such as P^1, P^2, P^3, impinging directly on their interior. A sheathing lined with asbestos may be added to ward off draughts and prevent radiation.—January 28th, 1888. [8½d.]



1419 Absorption Refrigerating Apparatus, W. P. Thompson, Liverpool: (*J. B. Craft, New York, U.S.A.*)

The gas from the boiler or distilling vessel A passes through pipes H to a gas receiver J, in which are depending diaphragms M to separate the water and return it to the boiler by the pipe K. The gas passes on to the rectifier L, where it exchanges heat with the strong liquor descending in the coil D. The coil D has a trap E at the bottom, and is provided with a diaphragm or plate N at the middle. Cold water may be passed through the coil R.—January 31st, 1888. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

June 13th.

9724 Files and Handles, C. Bordes, London.
9730 Steering Gear, W. P. Thompson, Liverpool. (P. Caillard and V. Caillard, France.)
9740 Cutting Screw Threads, G. Warsop and W. Horsfield, Nottingham.
9750 Sawing Machinery, F. R. Lane, London.
9758 Consuming Smoke, E. Prime and W. Lee, London.
9764 Hammers, T. Evans, London.
9769 Regulators, H. H. Lake, London. (P. Noyes, United States)*
9771 Steam Engines, W. R. Renshaw, London.
9773 Fire-arms, F. Mannlicher, London.*
9775 Grain-crushing Mill, J. Curtis, London.

June 14th.

9789 Brake Gear, W. Hawkins, Bristol.
9790 Brakes, L. C. Niebour, London.
9794 Haulage Clips, W. Johnson, Derbyshire.
9812 Belts, A. Nicol, London.
9816 Furnace Fire-grates, L. Hopcraft, London.
9822 Valves, J. Giles, London.

June 15th.

9833 Gas Engines, J. Roots, London.
9834 Hydrocarbon Engines, J. Roots, London.
9842 Adjustable Wrench, E. Reilly, London.
9844 Sand-distributors, G. L. Till, Birmingham.
9847 Valves, T. Williamson, Newcastle-on-Tyne.
9850 Vacuum Drying Apparatus, J. Brown and G. Johnstone, Glasgow.
9851 Sawing Machinery, S. Bastow, London.
9853 Connecting Tubes, J. McDougall, Birmingham.
9877 Slip-couplings, J. J. Hall, London.
9880 Feed-water Heaters, A. C. Moffatt, London.

June 17th.

9887 Projectiles, T. R. Bayliss, Middlesex.
9898 Hot-water Boilers, J. Keish, Glasgow.*
9899 Heating Apparatus, W. J. Payne and A. J. W. Johnson, London.
9901 Securing Rails, W. C. Morison, Felixstone, Suffolk.
9911 Keying Railway Rails to Chairs, D. St. Lawrence S. Kelly, Lifton Devonshire.
9917 Electrical Switches, F. B. Nicholson, London.
9918 Washing Machines, R. Hoese, London.
9920 Stop Valves, J. W. Herquet, London.
9934 Furnace Doors, J. G. Willett, London.*
9936 Wheels, J. Cleminson, London.
9937 Sleepers, J. Cleminson, London.
9938 Steam Boilers, J. Mills, Manchester.
9939 Nut-making Machines, J. Brettell, Birmingham.
9941 Piston Packing, J. Graham, Morley.
9945 Arc Lamps, L. Hanson, Halifax.
9954 Locomotives, J. Lewis, Manchester.
9961 Steam Boilers, C. F. Dixon and W. N. Dock, Manchester.
9964 Water Pipes, C. Rignault, London.
9965 Combination Tool, A. H. Moss, London.
9980 Furnaces, S. Walker, Middlesex.

June 18th.

9986 Petroleum Tanks, J. Stewart, T. Charlton, and J. Casey, London.
9988 Electricity Meters, J. S. Raworth, London.
9989 Railway Switches, W. J. Kelly, London.*
9993 Indicators, A. R. Sherman, London.
10001 Balanced Pistons, W. J. Thomas, London.*
10007 Gas Engines, G. Daimler, London.
10016 Weighing Machines, N. Browne, London.
10017 Coupling, R. Aubrey, London.
10026 Braking Mechanism, W. J. Basher, Glasgow.
10027 Steam-escape Valve, T. C. Olney, Manchester.
10033 Triple-expansion Gear, J. Cochrane and W. Cameron, Birkenhead.*
10036 Metal-working Machinery, T. Mudd and J. Bowers, Liverpool.
10050 Gas Furnaces, R. S. Casson, London.
10055 Water-heating Apparatus, N. Wilson, Glasgow.
10058 Corrugated Boiler Flues, D. Dixon, London.
10059 Low-water Indicator, S. Mace, London.

June 20th.

10068 Coupling, J. Brandner, London.
10075 Governors, R. Robinson, Manchester.
10079 Portable Forge, W. Johnson, London.
10094 Feed-water Heaters, J. Y. Johnson, London.*
10100 Reversing Mechanism, F. Dangy, London.
10105 Steam Generators, W. Chambers, London.

June 21st.

10118 Wheels and Axles, T. Rowbotham, Stockport.*
10123 Propellers, W. Hutchinson, Salford.*
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10135 Air Brakes, F. A. Holleman, London.*
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10151 Wire-winding Machinery, F. M. Hale, London.
10155 Electric Tramcars, &c., J. S. Raworth, London.
10159 Furnaces, A. Piat, London.
10164 Water Gas, W. Crookes and F. I. Ricardo-Seaner, London.

June 22nd.

10168 Steam Pumps, S. Northrop, Birmingham. (J. D. Cooper, United States.)
10169 Fire Extinguisher, P. Schwartz, London.*
10176 Safety Lamps, J. R. Kempe, London.
10179 Steam Trap, G. Coggan, Gainsborough.
10180 Valves, D. Carmichael and A. Mackie, Glasgow.
10187 Fuel Economisers, G. G. Rhodes and J. S. Critchley, Bradford.
10204 Valves, G. Jacoby, London.
10219 Printing Machinery, W. B. Silverlock, London.
10220 Water Gauges, T. C. E. Rose and C. H. Stainer, London.*
10224 Ingot Moulds, J. Powell, London.
10232 Engine Packings, J. Elliott and A. Creed, London.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE
PRACTICAL ENGINEER,
JULY 12TH, 1889.

THE EIFFEL TOWER LIFTS.

THE Institution of Mechanical Engineers held their summer meeting in Paris last week, and several very interesting papers were read. The first one, "The Lifts in the Eiffel Tower," was exceedingly interesting to engineers as a description of various methods of applying passenger hoists under very exceptional circumstances. In ordinary mining work, depths of 1,000ft. present no special difficulty in winding, but miners are accustomed to very rapid descents and ascents, and, moreover, they are content to depend frankly and fully for their safety upon the trustworthy condition of the wire rope supporting the cage and upon the care of the engineer in charge to prevent overwinding and overrunning in either direction. Safety appliances, it is true, are generally applied to make connection between the cages and the ropes, intended to prevent accidents from breakage of the rope or from overwinding, but such contrivances, unhappily, often fail just when wanted. Accordingly, we are sometimes distressed by terrible pit accidents, due to defective winding mechanism. On the whole, however, considering the number of men who are daily taken to and from their work in this way, the percentage of accidents is exceedingly low. The dangers of the descent and ascent of the shaft form one of the smallest of those to which our miners are almost unavoidably exposed. With the general public the case is very different, and where ascents are only to be made for the pleasure of the thing, assurances must be given of the most absolute safety. This fact has been fully borne in mind by M. Eiffel, and in his wish to give a feeling of absolute security he has selected methods of work and firms whose experience in such work guarantees the most perfect confidence. Without absolute confidence on the part of the public the Eiffel Tower would have been financially a failure. We have accordingly read M. Ansoloni's paper, and considered the discussion which followed it, with great interest. The first platform, 187ft. above the ground, is reached by four lifts, two on the Otis system and two on the Roux, Combaluzier, and Lepape systems. The Otis lifts work in the north and south piers, and the Roux lifts in the east and west piers. The two latter ascend to the first platform only, and the two former to the second stage. The Otis lifts, in all essential details, are identical with the usual practice of the American Elevator Co., the details of the cabin or cage only being modified to allow it to run in an inclined position; but the safety rope balance and wedge-gripping devices are identical with those described by us in a recent issue. The Roux lifts also seem exceedingly safe, but are of somewhat peculiar and, in our opinion, very cumbrous design. They consist of a chain or chains formed of very long links, each link about 3ft. 3in. long and 1¾in. diameter, jointed by pins, upon which are rollers carrying the chains upon rails or guides. The cabin is attached to one link of each of two chains, one on each side, and the guide is formed by continuous tubes with slots opposing each other, in which work the points of attachment to the cabins. The chains are continuous, and pass over pulleys, one at the top 11ft. 6in. in diameter, and one at the bottom 12ft. 9in. in diameter; closed tubes above the cages form guides for the return portions of the chains. The guides or tubes are but little larger than the links with their rollers, so that if one portion were put in compression instead of in tension, then the chains could not double up, but would act practically as solid rods. Each bottom wheel has twelve projections or teeth, which engage the eyes in the jointed rods, and so drive the circuit, and the wheel is driven from a hydraulic plunger about 41in. diameter, of 16ft. 6in. stroke, by pulleys and triple-link pitch chains; the driving gear is duplicate, but the driving shafts are coupled together.

The rams are supplied from reservoirs placed upon the second platform, and after allowing for loss of head from friction, the available pressure is 142lb. per square inch. M. Ansaloni estimates that in this lift one half of the total energy is absorbed in friction, due to the resistance of the lift itself and of the chains. The water pressure is used only for the ascent, and the unbalanced weight of the lift serves to give the necessary movement for descent. Should the chains break, it is stated that the cabin could not possibly fall, as the close confinement of the long links within the guide tubes would prevent buckling, and the chains would act as solid rods to sustain the cabin. We do not think this a very desirable contrivance, considered from a mechanical point of view, as will be evident from a little consideration. If the cabin be ascending, for instance, and the chains on both sides be supposed to break above the cabin, then the ram will still continue to act, and the chain-wheels will push from below, and the chain will be forced up underneath instead of pulled from above, so that they would either lock by some buckling or continue to ascend. When descending, on the other hand, if this happened, the descent would either continue at the same rate, or else the links would lock. So far the safety of the passengers is assured. But what would happen if the chains coupling the rams to the driving drums should break? Then it does not seem to us there is any safety from the system of rigid chains, as the cabin would be free to fall very rapidly, driving the wheel, no longer subject to the retarding action of the water in the hydraulic rams. Of course this is a very improbable contingency, as the driving gear is in duplicate; yet it is an accident not provided for by the system of rigid links, and unless the connections between the rams and the driving wheels are very carefully made, the continuous chain will not compensate for neglect. The noise made by the numerous pulleys of this lift at work is very considerable, and is transmitted through the whole metal work of the tower, and we should think that, unless great care is taken in supplying oil plentifully, considerable wear will be caused.

The Edoux lift is alone used to raise passengers from the second platform to the summit, a distance of 525ft. It consists of two cabins balancing against each other, and connected by four steel-wire ropes passing over pulleys above the summit. One cabin travels from the second stage to an intermediate position between it and the third, while the other travels down to meet it at the same point. The passengers ascending pass into the upper one, and those descending from the upper to the lower. The 525ft. is thus accomplished in two stages. The upper cabin is supported upon two hydraulic rams, each 12·6in. in diameter, and travelling the full lift (262·5ft), and the rams are protected by guides. The lower cabin is suspended from the upper over the pulleys, and sufficient excess of weight is allowed on the upper cabin and ram to raise the lower cabin with its load. To prevent danger in the event of the ropes breaking a brake known as the Backman is applied to each side of the suspended cabin, and it consists of a cylindrical weight passing up and down within each column, the interior of which is threaded like a long pitch nut, and projections from the weight engage so that as the weight ascends and descends it revolves. If the ropes should break, it is supposed that the cabin would fall faster vertically than the weights in the spirals, the cabin would overtake the weights, and by locking against them prevent revolution, and so stop.

The plan does not seem a very feasible one, and we observe M. Eiffel stated in the discussion which followed the paper that it has been abandoned, and the suspended lift now depends for its safety upon the large margin of strength allowed in the ropes. The total load upon them, it is stated, does not exceed 3,030lb. per square inch, while the steel wire used has a breaking strain of 140,000lb. per square inch. This leaves a calculated factor of safety of over 40. We fear, however, that M. Ansaloni puts the tensile strength much too high, as it has been found by prolonged experience that steel wire of maximum tensile strength is not by any means the best adapted for hoisting or winding purposes. Wire of such tenacity is too hard, and suffers rapid deterioration when continually caused to pass and repass a pulley. For such work a wire rope of greater ductility and less tensile strength is infinitely preferable, and in our own experience we have found frequent examples of this fact. We have known hard steel wire ropes of great tensile strength rapidly deteriorate where softer and more ductile metal has proved capable of performing the work for long periods without deterioration. In the case of the Birmingham cable tramway, for instance, the first steel ropes used were destroyed in a very short time, and it was found that steel of much less tensile strength, but of greater ductility, was far more suitable, and performed the severe work of such lines with ease for long periods without the necessity of renewal. The highest tensile strength means hardness in steel, and renders it quite useless for any work where the fibres are constantly subjected to distress.

We regret that M. Eiffel should permit the suspended cage of the Edoux lift to depend wholly upon the wire ropes for the safety of its passengers, especially with steel of such tensile strength, and therefore hardness; the factor of safety is not in the least degree greater than that allowed in the Otis lifts, and yet they are supplied with most effective safety brakes. Mr. Hill stated, for the American Elevator Company, that on the first trial of the safety wedges by cutting away the supporting ropes, referred to by us some weeks ago, the cage fell 12ft., and was brought to a standstill without shock by the safety appliances, while at the second time it only fell 8in. In the second case the fall was arrested in a fraction of a second, and in the first case in not more than one second. If results so reassuring can be attained by the American Company, surely it is possible for the Edoux lift to be fitted with similarly good friction wedges. We think it due to the public that the best known appliances should be used in the daily carrying of so many passengers as are conveyed by the upper lift every week. Not less than 20,000 persons per week trust themselves to that lift, and it is certainly M. Eiffel's duty to see that no known precaution is omitted. His admission in discussion on Tuesday, last week, seems to us a somewhat serious one, especially in view of the assumed safety of steel rope having so high a tensile strength as 140,000lb. per square inch.

THE WORLD IN MINIATURE.

We inspected an extremely interesting and instructive exhibit in a recent visit to the Paris Exhibition. It is a magnificent model globe, 42ft. in diameter, which is installed in a special circular building close to the Grand Theatre, near the south pier of the Eiffel Tower. We enter a hydraulic lift and speedily ascend to the top of the building, where we find ourselves upon the upper portion of a special platform, and separated by a hand rail from a huge globe slowly revolving before us. Three gangways pass over the top of the globe, and enable us to inspect the geography of the north polar regions, and as we walk down the incline every portion of the surface can be inspected with ease. Our first impression is one of surprise at the very small proportion of land to water. We are all familiar with the statement that the area of the earth's surface under water greatly exceeds that above, but our maps do not enable us to realise this, and the drawings of the two hemispheres are necessarily distorted as seen upon a flat surface. We realise the relative magnitude of the Atlantic and Pacific in a way which no small globe can enable us to do. The whole surface is carefully drawn to scale, and even the outlines of the great cities of the world are shown. The lineal scale is one-millionth—that is, the diameter is one-millionth of the earth's diameter; the bulk is therefore one million million-millionth of that of the earth. It is impossible to realise from these figures the absolute magnitude of the earth, but many interesting facts are easily reduced to something like scale in one's mind by its aid. The flattening of the earth at the poles has not been shown on this globe, for instance, as even on this huge scale, it would only amount to about $\frac{7}{8}$ths of an inch, which could not possibly be observed on a 42ft. globe. The highest mountain on the earth would only be $\frac{5}{16}$ths of an inch high on this scale, so that one can realise how little they disturb the general spherical outline to the vision of an inhabitant of some other world. The principal railways, roads, rivers, and mountains, are all faithfully shown, while some of the leading ocean routes are indicated. Looking at Great Britain and New York, we realise at a glance how there is little to choose between the passage by way of the North or the South of Ireland in distance, and the relative positions and areas of the New World and the Old are brought into prominence in a manner impossible on a smaller scale. The globe is most beautifully finished, and, although so large, is so nicely pivoted that it is easily revolved by one man. The building is admirably adapted for viewing it from every point, as the spiral platform allows a thorough inspection of the sides of the sphere, while the gangways above and the pit below permit of a ready inspection of the north and south polar regions. Our friends visiting Paris should not fail to see this among the other attractions of the Exhibition.

THE COMPOUND WINDING OF DYNAMOS.

A most important judgment has been delivered by Lord Trayner, in the case of King, Brown and Co., against the Anglo-American Brush Electric Light Corporation Limited, which, if sustained by the Court of Appeal, will have a considerable effect upon engineers engaged in the construction of dynamos. In dynamos intended to supply electricity for incandescent lamps, it is most desirable that the machines should have the capacity of self regulation, so that with varying numbers of lamps in action the potential or pressure of the current should remain approximately constant. This property can only be conferred upon a dynamo by compound winding in a certain way, and it has been supposed till now that Mr. Brush's patent of 1878 covered the essential points of the construction. At the time of obtaining his patent, Mr. Brush does not appear to have understood that the system of winding then described would allow of dynamos being constructed which would so work; but after some years he discovered that it was capable of being adapted to incandescent electric lighting, and could be made to give constant potential.

The Brush Company, in 1885, attempted to levy royalties on all compound dynamos, and many firms preferred paying for licences to the uncertain chances in the law courts. Messrs. Crompton and Co., Gooldan and Co., the Gulcher and Co., and Messrs. Allen and Co., it is true, contested the patent, but after proceeding a certain length in their defence they all compromised the matter. The Brush Company have accordingly commanded the market till now. Messrs. King, Brown, and Co. have been for some time past threatened by them, but no proceedings were taken, so they very boldly assumed the offensive and brought an action under the new patent law for the reduction of the Brush patent of 1878, on the ground that it was invalid, because (1) Series-shunt winding had already been published in Varley's specification; (2) Series-shunt winding had been used in public by Varley in his machine; (3) That detachable wearing commutator segments were old, and had been used by Wilde and Varley; (4) That a number of commutator claims went beyond the provisional specification.

From the evidence, which included that of Sir William Thomson, Professor S. P. Thompson, Professor Perry, Mr. Imray, Mr. Varley, and other electricians, it appeared that the earlier dynamos were series wound; that is, the circuit exciting the electro-magnets was the same as that used for producing light. In the shunt-wound type of dynamo the main circuit and the electrio-magnet circuit were separated, but in the compound or series-shunt system the electro-magnets were surrounded by two insulated wires of different dimensions—one the main circuit, and the other a shunt circuit of greater resistance. This arrangement insured the continued excitement of the magnets when the main circuit was open and no light was used; so that whenever light was required the dynamo was ready to produce the required current. When the current was flowing in the main circuit it increased the excitation of the electro-magnet in proportion to its amount, so that by proper arrangement a constant potential or pressure could be maintained for all demands. This method of winding the electro-magnets with two wires of different resistance, is known as the compound or shunt-series system, and it is now very widely used. It was proved that Varley's specification of 1876 clearly described compound winding, both by description and drawing, but it was contended with success that Varley did not appreciate the full importance of his invention, and had no idea of the important property of maintaining constant potential which was its legitimate outcome. Mr. Brush's patent of 1878 also described the system, and he also failed to foresee its important and wide-reaching consequences.

Notwithstanding this, his patent would have commanded the whole industry but for the existence of Varley's description of a matter which he thought so little novel that he did not even include it in his claims. Lord Trayner found that Varley clearly described compound winding in such a way as to amount to full publication in the eye of the law, and that Varley publicly used a machine constructed according to his specification to an extent sufficient to constitute prior user; that as a mechanical arrangement the Brush commutator was new and useful, but that, notwithstanding this, the fact that it was not described in the provisional specification renders the patent invalid. Practically he decided against the Brush Company on all essentials.

This decision leaves the compound wound dynamo free to the whole world, and cannot fail to accelerate the progress of electric lighting, which has been too much hampered by vexatious patents. The decision also emphasises several points in connection with the preparation of patent specifications, which are of the utmost importance to inventors, and are, we fear, too often neglected. We shall discuss these points fully in a subsequent issue.

THE PARIS EXHIBITION.

From Our Own Correspondent.

One of the most popular entrances to the Exhibition is that nearest the Chamber of Deputies at the extreme end of the Great Agricultural Hall, which runs parallel to the Seine in a long strip connecting that portion of the Exhibition with the main buildings. In front of this hall lies the Seine, with many separated buildings lining the quays, and behind it is the little but extremely convenient Decauville railway. The railway runs to the Eiffel Tower Station and then round the Liberal Arts Palaces to one end of the Great Machinery Hall, and it is the most rapid and convenient method of transport from one extreme of the Exhibition to the other. Each train is made up of five open cars, and is drawn by a small but powerful locomotive with four cylinders, and about 250 passengers are carried per train. The fare for the whole or any part of the journey is twenty-five centimes, and during the whole of our visit every train was fully loaded; a double line has been laid down, and the space is extremely limited, so little are the trees clear of the carriages, that notices, in many languages, warn the travellers to keep in heads, arms, and legs.

We saw it stated the other day that the French have shown their hatred to the Germans by omitting this warning in German, but this is not so. The Germans have the benefit of the warning quite as frequently as other nations, the whole of the walls and fences along the line are continuously covered with these notices. The greater number of passengers terminate their journey towards the Exhibition at the Eiffel Tower, but many besides ourselves find it very convenient to continue upon the cars until the terminus is reached, and we are landed at that end of the great machinery hall.

Just outside the great hall we find one of Messrs. Stothert and Pitt's 5-ton portable steam cranes, with a Wild's patent single chain grab or excavator in action, lifting gravel and sand from a large receptacle and letting it fall again in a rattling shower to the great delight of a crowd of good humoured French peasantry, who never seem to tire of watching its well-regulated motions as the great fingers of the grab close upon a huge handful of gravel, lift it up, and let it go again. This crane works with admirable smoothness, and is well within the control of one attendant. On entering the central doors of the hall we immediately come upon a most remarkable looking engine at work, driving a dynamo. It is the hot air engine of Messrs. Benier Freres, and this example we are told is of fifteen horse power. Like all hot air engines it looks exceedingly large for its power, and its size is somewhat emphasised by its peculiar design. In a vertical cylinder at one end of the engine there works a trunk piston driving a beam by a connecting rod; the crank shaft is driven from the other extreme of the beam, and a horizontal piston is also driven from the crank by a rod, so that the main crank pin carries the ends of the two rods. The vertical cylinder is placed above an enclosed fire, and the fuel (coke), is fed to it by means of a very thick slide valve.

The coke is broken small to begin with, and then placed on a hopper, from which it passes by an ingenious plunger arrangement driven from a pitch chain, by which are selected only pieces of the requisite size. These pieces fall down an incline, one at a time, and then pass into a port in the thick slide valve, which then moves, and first closing to the outer atmosphere, it opens to the air furnace under pressure and passes in the piece of fuel. The horizontal cylinder is an air pump which feeds the furnace at every stroke with compressed air, and as it is at right angles to the motor cylinder, and in advance, the pressure is raised at every stroke to the maximum to be reduced by expansion. In this engine the furnace is immediately under the motor piston, and the gases do not pass through valves or ports and lose heat. The engine is very well made, and works more satisfactorily than any hot-air engine we have ever examined. We stood by it quite an hour to study its action, and hope to give particulars in an early issue.

As the British section is at the other end of the hall—by the way, quite a walk of over a quarter of a mile—we shall not, meantime, consider the locomotives to our left, or the gas engines of Mr. Otto on our right. The most prominent object, so far as size is concerned, is perhaps the large vertical blowing engine of the Sociéte John Cockerill, an admirable example of work; and close beside it are a pair of large horizontal engines and air compressors for the System Popp, used in the distribution of power by compressed air. Next in magnitude, perhaps, comes the electrical travelling crane, which makes periodical trips with passengers, high above the machinery, from end to end of the hall. It is difficult to form a correct idea of the magnitude of the engines and some of the machines, because of the dwarfing effect of the magnificent roof above us. The roof is beautiful, but the effect is disappointing, and we could not but feel that the smaller machinery halls of either the Manchester or the Glasgow exhibitions did more justice to the engines, and allowed one to form better estimates of dimensions.

Perhaps the most striking engines in the hall, so far as beauty of finish and design can make them so, are those exhibited by Messrs. Sulzer, of Winterthur, of their well-known Corliss valve type. They act with great smoothness, and the automatic governing is exceedingly perfect; it is quite a pleasure to stand beside them and watch the action. The American Wheelock engines come next in beauty of get-up, although there is no new departure in either. Passing on towards the British section of the hall, we observe the Edison exhibit, which forms quite an imposing span, and is constantly filled with people eager to hear the phonograph at work. Several phonographs are kept constantly in action for the use of visitors. The incandescent lamp is here seen in all forms, and some of the combinations are most effective.

A large painting on one side shows a huge incandescent lamp mounted above Mr. Edison's workshop at Menlo Park, and separate rays from it illuminate Great Britain, France, Germany, Turkey, Persia, &c., each country being represented by an appropriate scene. Mr. Edison's portrait, too, is very prominent, and his youthful appearance is unexpected to most of those unaware of the rapidity of his rise to fame. The British section in the machinery hall is small, although good so far as it goes; the exhibits are very interesting, and present novelties in detail well worth careful study.

THE LUCIGEN LIGHT AT THE PARIS EXHIBITION.

The Lucigen Light Company Limited, of Westminster, at Stand No. 243 in the British Section, Palais des Machines, show a variety of their now well-known apparatus as used for illuminating large open spaces, such as sites for building operations, shipyards, ironworks, &c. There is a triplex Lucigen of 9,000 candle power, two of which have been recently erected on the Thames at Greenwich, a "Railway Lucigen" that can be mounted on a post at any required height, and operated entirely from the ground, also examples of various styles and sizes of the same description of lights, all of which are actuated by compressed air, requiring an air compressor and steam power, burn heavy tar oil or creosote, and are included in the category of spray lamps. The chief feature of interest in the exhibit, however, is a new, self-contained, portable Lucigen of 2,000 candle power. It is worked by means of a steam jet generated by the heat of the flame itself, which also converts the oil into a gas and produces a brilliant flame without any waste of oil, and

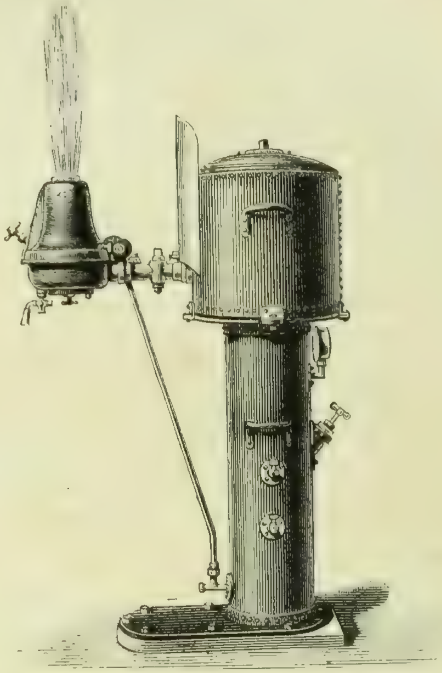


Fig. 1.

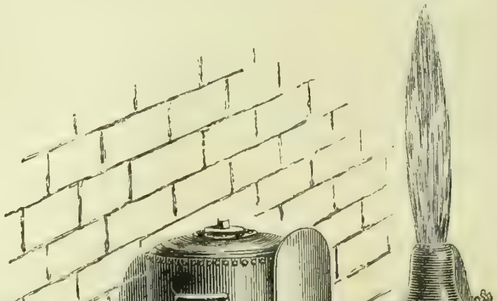


Fig. 2.

without the production of any spray whatever. The lamp is free from all tubes that can choke up with the products of distillation, and having no small orifices for the oil to flow through, specially prepared oil is unnecessary, the heavy tar oil of commerce being all that is required. The Portable Lucigen as illustrated here (fig. 1), is readily movable, quite safe, will give a powerful, continual and cheap light, unaffected by wind or weather, and is independent of outside machinery or motive power; its first cost is small and the expense of maintenance nominal.

The improved steam Lucigen shown, of which we also give an illustration (fig. 2), is identical with the Portable, except that steam is conveyed to the lamp in any convenient manner, the heat of the flame ensuring its perfect dryness, and thus overcoming what has hitherto been the greatest drawback to the efficiency of steam lamps.

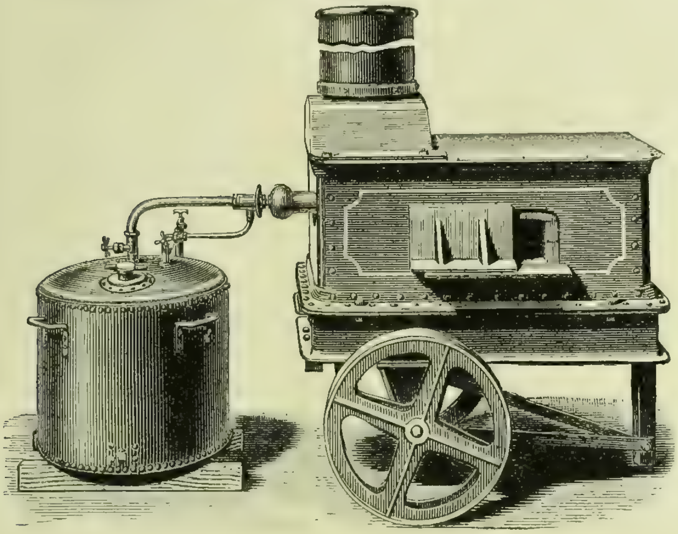


Fig. 3.

On the stand there are two air compressors mounted on receivers, complete with all necessary fittings and connections, one for steam power and the other to be driven by a belt; also an oil furnace called the "Pyrigen" (fig. 3). It is a compressed air Lucigen, made to do heating work instead of lighting. A full heat for rivets can be got up in about fifteen minutes, and the cost of working is stated to show a saving of three-fifths as compared with breeze furnaces. This stand is in the great gallery above the British section, in common with many other interesting exhibits. The light is not shown in action here, but we notice one of the new type Lucigens at work on the Quai d' Orsay, close to the bridge joining the main portion of the Exhibition with the Trocadero on the north side of the Seine. The light burned well and brilliantly on the evening of our visit to that portion of the Exhibition.

DESCRIPTION OF THE LIFTS IN THE EIFFEL TOWER.

(Concluded from page 469.)

The stress on the piston rods will theoretically be twelve times this amount, or 15,870 × 12 = 190,440lb. But the weight of the pulley truck and also that of the piston have to be deducted, representing together about 33,060lb. in favour of the power. The height of fall from the level of the reservoirs at the second platform down to the discharge of the water from the cylinder is 393½ft.; allowing for loss of head, a pressure of 156lb. per square inch may be taken in the cylinder of 1,134 square inches area; and 1,134 × 156 = 177,340lb. The total power is therefore 33,060 + 177,340 = 210,400lb., which is considerably greater than the power required to balance the total resistance of 190,440lb. on the piston.

Cabins.—The cabins are nearly identical in dimensions with those of the Roux lifts; and that the two rooms accommodate only 50 persons instead of 100 is in consequence of seats being provided for all the passengers, as a precaution against the tilting movement of the cabin during the journey, owing to the change of inclination of the track, which is about 20 degrees steeper between the first and second platforms. The consequence is that, if the floor of the cabin were horizontal during the lower part of the trip, it would assume a slope of 40 in 100 during the upper part. To obviate this inconvenience, the floor of the gangway from front to back of each room is formed of steps pivoted on beams, which are adjusted by the conductor to the required inclination by means of a lever. The cabins are so arranged that in their position of mean inclination—namely, at the first platform—the fixed floor is practically horizontal, so that the total change of inclination is divided equally and in opposite directions between the lower and the upper portion of the journey. The movable steps, being adjusted by the lever to the horizontal position, form an actual stairway, downwards or upwards according to the direction of inclination of the cabin. The seats and their backs are rounded, so as to afford suitable support to the body in all positions of the cabin on the inclined track. The conductor's place is under cover, in front of the lower room of the cabin, whence he can regulate the motion of the lift by means of two ropes working over pulleys, and controlling the lever of the water distributor.

Water Distribution.—The two ends of the hydraulic cylinder are connected by a circulating pipe of 9in. bore, on which the distributor is placed. For lifting, the water pressure is admitted into the top end of the cylinder, while at the same time the discharge from the bottom is opened. For lowering, communication is opened between the top and bottom of the cylinder, so that the water simply passes from the upper to the under side of the piston through the circulating pipe. When the lift is at rest, no water is either admitted or allowed to circulate.

The working is effected by means of a three-ported cylinder 9in. diameter, in which works a double piston valve packed with cupped leathers. Two ports on one side of the distributing cylinder communicate respectively through the circulating pipe with the top and the bottom of the main cylinder. The third port, which is on the opposite side of the distributing cylinder, admits the water supply into the top of the distributing cylinder, which is always under pressure. When the double piston valve entirely covers the lower port, the water cannot circulate, and motion is arrested. When the piston valve is raised, the discharge takes place from the bottom of the hydraulic cylinder, and the cabin rises; when the piston valve is lowered, the discharge is stopped, but the water can circulate more or less freely from the top to the bottom of the main cylinder, and the descent is effected by the weight of the cabin, which raises the movable-pulley truck as well as the large piston.

The power required to work the piston valve of the distributor under pressure is about 8,800lb.; and to save having to do this by hand, an auxiliary motor is attached to the distributor, consisting of a piston valve 1¾in. diameter, which controls the distributor just as the distributor controls the main hydraulic cylinder, by applying the water pressure to an 11in. piston fixed on the same spindle as the double piston valve of the distributor.

At each end of its journey the cabin is stopped automatically by means of an ear or lip cast on the piston of the main hydraulic cylinder, whereby the aperture of the circulating tube in either end of the cylinder is closed just as the piston is reaching the end of its stroke.

Safety.—It was indispensable with this kind of lift to provide specially against possible breakage of the ropes. A safety brake with automatic clutches has accordingly been applied to the counterpoise truck, as well as to that carrying the cabin. On each side of the cabin truck, and level with the head of the rail, are a set of jaws running on a special lorry. The levers working the jaws carry two steel plates, between which are inserted gun-metal wedges facing each other. When the lower wedge is pressed inwards, the corresponding jaw clutches the two faces of the rail; and the motion being retarded by the friction, the facing wedge above forces its way inwards between the two plates, and thereby increases the friction. The next wedge, meeting with a greater resistance, goes still further home. The result is that the cabin is stopped in a few seconds. Not only breakage of a rope, but even its mere stretching to any unusual extent, is enough to bring the brakes into action. The ropes are attached in pairs, not direct to the cabin truck itself, but to a bracket mounted upon two axes which are fixed on the truck; two grooves in the bracket, forming arcs of circles, allow of its swinging upon either one of the two axes, and in so doing it liberates by means of a tappet a spring, which acts through a lever upon the lower wedge of the safety clutch, thus causing the clutch to grip the rail and stop the descent of the cabin. Should all the ropes happen to break simultaneously, a centrifugal governor inside the lorry that carries the clutch liberates the spring as soon as ever the speed of descent exceeds 10ft. per second.

Edoux Lift.

The Edoux lift is widely employed in Paris, the most important example hitherto constructed having been erected in 1878 in one of the towers of the Trocadero. The cylinder is vertical and about 230ft. long, necessitating the excavation of a deep pit to receive it. For balancing the lift very large ropes are required, inasmuch as they have to be equal in weight to half the volume of water displaced by the piston.

In the erection of the lift in the Eiffel Tower between the second and third platforms, both the above inconveniences have been obviated by an ingenious arrangement. Instead of effecting the ascent of 525ft. in a single flight, which would have been difficult to manage and sadly inefficient, the trip has been divided into two equal flights by a midway platform; and there is one cabin for each flight. The two cabins counterbalance each other, being connected by means of four steel-wire ropes, which pass over pulleys above the third main platform. One cabin travels up and down the lower half of the trip, a height of 262½ft., whilst the other travels through the same distance in the upper half. Travelling in opposite directions, the two cabins thus meet and part at the midway platform, where the passengers brought up by the lower cabin change into the upper cabin, in which they complete their upward trip to the third main platform.

The two cabins are both guided by one central vertical column extending through the whole 525ft. height of the lift; and also by two smaller columns, each of which is half this height, the one on the left rising from the second main platform to the midway platform, and the one on the right from the midway platform to the third main platform. The upper cabin is carried on two hydraulic rams of 12·6in. diameter, working in cylinders of 14·96 in. diameter. To shelter them from the action of the wind the rams are arranged to work with the upper guiding columns, within which also work the ropes that carry the lower cabin. The cylinders and rams are of steel plate riveted, except a portion of the rams, which is made of cast iron, in order to obtain the extra weight necessary for lifting the suspended cabin with its passengers. The bottoms of the hydraulic cylinders hardly protrude below the floor of the second main platform.

Balance.—The sectional area of each ram is 124 square inches, or 248 square inches for the two; and their weight is 42,330lb. Supposing the lower or suspended cabin to be empty and to balance only the dead weight of the upper cabin, and that the latter be loaded with 8,800lb. weight of passengers, then in starting from the midway platform the pressure required under the rams to correspond with the unbalanced load should be equal to 42,330 + 8,800 = 51,130lb. The water, being supplied by a reservoir 525ft. above the bottom of the cylinders, gives a pressure of 227½lb. per square inch at starting. On the combined area of the two rams the total pressure accordingly amounts at starting to 227½ × 248 = 56,420lb.; and the difference, or 56,420 – 51,130 = 5,290lb., represents friction and loss of head. As the rams rise out of the cylinders, their weight increases while the head diminishes; but the balance is maintained by the increasing length of the ropes on the other side.

Safety.—The four ropes weigh together 53¾lb. per foot, or 53¾ × 525 = 28,220lb. for the total height. Their net sectional area is about 15½ square inches. Taking the weight of the lower cabin full of passengers at 18,740lb., the maximum load to be supported by ropes is 28,220 + 18,740 = 46,960lb., or 3,030lb. per square inch of section of steel wire, which has a breaking strength of upwards of 140,000lb. per square inch. Hence the apparatus is perfectly safe.

Backman Brake.—In order to dispel all misgivings, the Backman brake will be applied on each side of the suspended cabin. In this plan a drum turning on a vertical spindle works up and down within each guiding column of the lower cabin, like a long-pitch screw in its nut, being threaded helically so as to gear with a corresponding helical rib fixed on the inside of the column. Round the drum thread are spaced a series of rollers running on the rib, which enable the drum to accompany the cabin up and down with scarcely any resistance. The top of the drum is turned conical, to fit into a corresponding hollow cone turned in a bracket attached to the cabin. Should the cabin fall, it would quickly overtake the drum, because the latter has to run down its helical path, while the cabin is falling vertically; the cones then coming into contact would cause friction enough to stop the drum from rotating, and the drum, being thus locked in the column, would support the cabin and prevent its falling further.

PUMPS.

Water under pressure is the only motive power combining the precision and the ease of management required for lifts; and accordingly all the tower lifts are worked by water, which is supplied by pumps placed in the bottom of the south pier. Those by which the four ground lifts are fed pump the water through a pipe of 9·48in. diameter into two cylindrical tanks, each 9ft. 10in. diameter and 23ft. long, placed on the second platform. The two tanks are connected together by a pipe 19·69in. diameter, from which four branches are led down to supply the cylinders at the foot of each pier. On leaving the cylinders, the water returns through underground pipes into the feed tank at the south pier, whence it is pumped anew into the upper tanks.

The Edoux lift is supplied by two Worthington pumps, which deliver the water into a tank 9·84ft. diameter and 13ft deep. placed on the third platform. A similar tank on the intermediate platform receives the discharge water, so that the pumps take their water from a height of 656ft. and deliver it to a height of 918ft. The cast-iron pipes are made extra strong to resist so great a pressure.

WORK DONE AND CONSUMPTION OF WATER.

Each of the Roux lifts consumes 1,925 gallons of water per trip, or the two together 3,850 gallons. Each Otis lift consumes 1,728 gallons per trip, or the two together 3,456 gallons. The four lifts consume together therefore 7,306 gallons in one minute, since each of them takes one minute for the ascent. This is equal to 121·8 gallons per second.

The difference of level between the pumping tank at the south pier and the supply tanks on the second platform is about 443ft., after adding the loss of head. The power absorbed during the ascent of the four lifts from the ground level is thus equivalent to

$$\frac{7306 \times 10 \times 443}{33{,}0000} = 980{\cdot}7 \text{ horse power, or say 1,000 horse power.}$$

The Edoux lift consumes 31·69 gallons per second. The difference of level between the two tanks, adding the loss of head, may be estimated at 393·7ft., which will give for the power exerted in the ascent $\frac{31{\cdot}69 \times 60 \times 10 \times 393{\cdot}7}{33{,}000} = 227$ horse power.

The combined power thus amounts to over 1,200 horse power, which, however, is in reality exerted only at intervals, namely, at the times of the ascents—that is to say, for about one-fifth of the time occupied in making the complete trip up and down. The power is accumulating in the tanks during the stoppages and descents, and consequently less than 300 horse power is required to be developed continuously by the pumps.

The Roux lifts, consuming 3,850 gallons of water per trip, take for their twelve trips per hour 3,850 × 12 = 46,200 gallons per hour. The Otis lifts consume 3,456 gallons per trip, or for their eight trips per hour 3,456 × 8 = 27,648 gallons per hour. The total quantity of water required is, therefore, 73,848 gallons per hour, or 20·5 gallons per second, to feed the four lifts ascending from the ground.

The two pumps furnishing this supply each deliver 11 gallons per second at their ordinary speed, and at a higher speed are capable of supplying 18 gallons per second. The steam cylinder employed to work each pump has the Wheelock valve gear, and is 23·6in. diameter with a stroke of 3½ft.; it works direct a horizontal double-acting plunger on the Girard plan, 11·4in. diameter. These engines were constructed at the Quillacq works at Anzin.

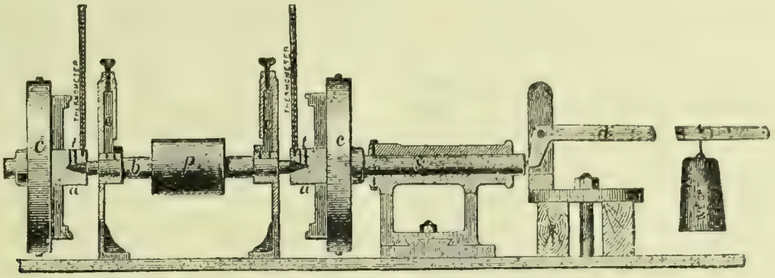
The two Worthington pumps for the Edoux lift are driven by two tandem compound cylinders. Together they supply 9·68 gallons per second at their ordinary speed, corresponding with a consumption of 34,862 gallons per hour. The volume of water required for each ascent is the product of the joint area of the two rams, or 248 square inches, or 1·72 square feet, multiplied by the height of the half-lift, or 262½ft.; it is therefore 452 cubic feet, or 2,818 gallons. The total volume consumed for the twelve ascents made in an hour is therefore only 2,818 × 12 – 33,810 gallons.

A range of four Collet safety boilers is placed underground at the south pier, near the steam pumps. Each boiler is capable of generating 3,300lb. of steam per hour at a pressure of 140lb per square inch. Three boilers are sufficient for driving the pumps in full work; the fourth is kept in reserve.

THE MAGNOLIA ANTI-FRICTION METAL.

IN consequence of the high speeds and pressures now so common both in steam engines and other machines, the use of white metal bearings, having a lower co-efficient of friction than ordinary brass or gunmetal, is extending very much, and many attempts are being made to produce alloys which combine the requisite qualities in the highest degree. Babbit's metal and Parson's white brass are well known in this country, and have been extensively used. Although good, however, they still leave much to be desired in capacity to withstand high pressures and speeds without heating, and a perfect metal as a bearing lining would be a very great boon to all makers of engines or high speed machinery. We have now before us details of tests made in America by well-known engineers, acting for the United States Navy authorities, upon a metal which possesses qualities much superior to Parson's white brass. It is produced by the Magnolia Anti-Friction Metal Co., and is introduced to this country through the Company's offices at 75, Queen Victoria Street, London.

The tests were most carefully made, one set with the machine we illustrate at fig. 1, and another set with the machine shown at fig. 2.



MACHINE FOR TESTING METALS

Fig. 1.

Messrs. C. J. MacConnal, W. A. Windsor, and F. C. Bowers, engineers of the United States Navy, conducted the first set, made with a view of comparing the power of the metal to withstand pressure at high speeds as compared with Parson's white brass, and to measure their relative heating. The apparatus consisted of a steel spindle *b* (fig. 1), driven from a belt by a pulley *p*, and having conical ends fitting into two metal plugs *a a*, held and truly centered in chucks *c c*, carried at the ends of spindles *s s*, one of which only is shown. Brackets, *e e*, carrying bushes, take the strain of the driving belt, leaving the chucks *c c*, freedom to be pressed up by a lever *d*, and suitably weighted. The chucks *c c*, were firmly held to prevent rotation, and three holes were drilled in each end of the plugs, two inside, marked *t t*, and one carrying a thermometer. The holes *t t*, served for oiling, and the spindle cones were pressed into the plugs, which were accurately drilled to fit; any required pressure could be brought to bear by means of the weights upon the lever *d*. The experiments proved that, with equal loads, and the spindle running over 2,000 revolutions per minute, Parson's white brass plugs rapidly rose from 59 deg. Fah., the heat of the room, to 280 deg., while the Magnolia only rose to 103 deg. At high pressure the Parson's brass became completely abraded, while the Magnolia remained nicely polished and comparatively cool.

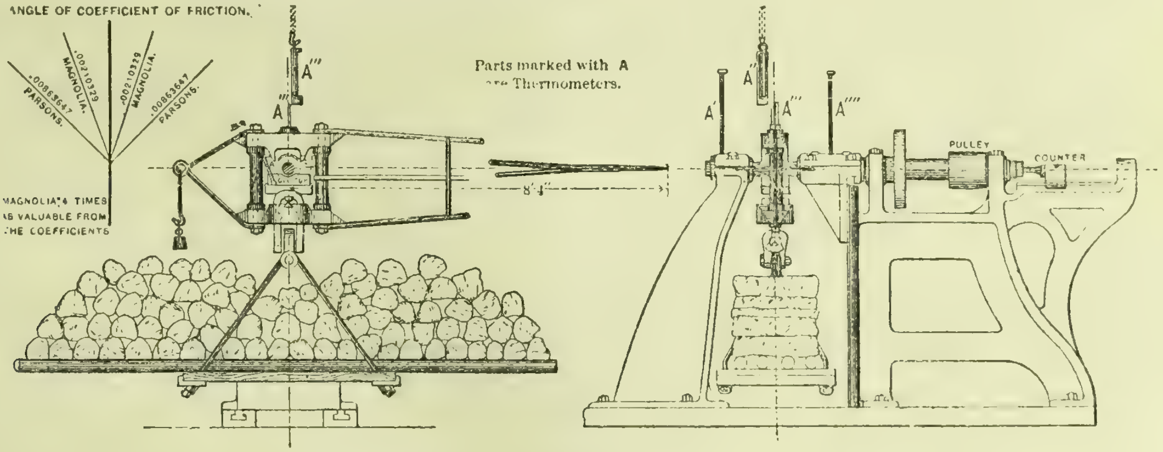

ANGLE OF COEFFICIENT OF FRICTION.
·00863647 PARSONS.
·00210329 MAGNOLIA.
·00210329 MAGNOLIA.
·00863647 PARSONS.
MAGNOLIA 4 TIMES AS VALUABLE FROM THE COEFFICIENTS
A'''
A'''
Parts marked with A are Thermometers.
8' 4"
A'
A''
A'''
A''''
PULLEY
COUNTER

Fig. 2

The other machine (fig. 2) is similar to that used in the well-known friction experiments for the Institution of Mechanical Engineers, by Mr. Beauchamp Tower. It consists of a shaft revolving in suitable bearings, between two of which is a steel journal (keyed on shaft), on which the test piece is placed, the top half only of the bearing being used for tests by this machine, and which for these particular tests was lined with soft metals to be tested. The brass sets in a yoke-frame, which incompasses the bearing, to the under side of which is suspended a platform on knife edge. On this platform the weights are placed for producing the pressure on the test bearing. There are two knife edges, one above the other, thus allowing perfect freedom of the yoke-frame, and the weighted platform independently of each other, and also avoiding bringing any influence of the weight on the journal other than that caused by direct downward pull. The knife edge on which the weight is suspended, when in its normal position is directly under and 5in. from the centre of the shaft.

A long arm, or pointer, of light weight, with a needle in the extreme end, is attached to one side of the yoke-frame, and is counter-balanced by a weight on the opposite side. In this particular test the length of the pointer from centre of shaft to needle end was 100in. A rectangular pan rested on the lower part of the yoke-frame beneath the test journal, in which, when the pan was raised in position, the journal revolved, carrying oil around with it, and thus the bearing was lubricated. This is considered the most perfect method of lucubration, as well as the most economical for this machine. The total weight of all parts suspended and resting on the steel journal was 320lb. The dimensions of the steel journal and bearing surface of metal of journal was: diameter of journal 4in., length 3½in.; wearing surface of metal 3½in. long; chord of arc of contact 3in., giving a circumference of journal of 1·0472ft., and projected area of wearing surface 10 square inches. The shaft was operated by a 4in. belt from countershaft, which again was driven by similar belts for ahead and reverse from the line shaft of machine shop (2nd floor).

A positive motion counter was operated from one end of this shaft, which indicated the revolutions to be about 484 as a minimum average, and about 500 as the maximum average, depending on the amount of work the machine shop engine had to do in driving the machinery of the machine shop. Thermometers were inserted in the oil bath and in a recess in top of metal. In this machine the co-efficient of friction is obtained by the angle or deviation of the knife edge from a vertical line passing through the centre of the journal in terms of the radius journal, and is independent of the weight entering directly into this calculation.

These tests were conducted by Messrs. Windsor and Bowers, and as a result it was found that the Magnolia metal under favourable conditions gave a co-efficient of friction of only 0·00118, while white brass at the same test gave 0·005312. This is an exceedingly good result, and at once proves the superiority of the new metal. Even with water instead of oil as a lubricant very little friction was experienced. This seems due to the fact that graphite is one of its constituents, and the metal is to a great extent self-lubricating.

Further information may be had from the offices of the company at 75, Queen Victoria Street, London. We shall be very pleased to hear from any of our readers the result of their practical experience with this metal.

THE CAPACITY OF AIR PUMPS.

(*Continued from page 467.*)

Thus a good construction would be to reduce the diameter of the chamber into which the lower end of the pump projects, so that the level of the water in that chamber would rise at a greater rate.

Other effects due to inertia and oscillation of the water cannot be considered here.

The speed of the pump is an important factor, and the period of free oscillation of the water would affect its working to some extent, but it is probable the vacuum, as calculated on the above principles, would not be very far wrong. In pumps working in connection with surface condensers the quantity of water to be removed at each stroke is insignificant, and if the bottom of the bucket valves strikes the water a few inches from its lowest position enough water will probably be passed.

The working of pumps of marine engines must be affected by the rolling and pitching of the vessels; drawing a large charge of water sometimes, and none at others.

The common horizontal double-acting pump, with the suction valves below, is said to be not very efficient, and this is probably the case. One of its disadvantages is that the height of the water over the foot valves is greater than for vertical pumps, and the loss of air pressure between the condenser and the pump will be greater in consequence. Suppose that at the end of the suction stroke the height of the water over the valves were 13·6in. in excess of that over the foot valve of the vertical pump (fig. 4), with the same discharging capacity, the vacuum maintained by the horizontal pump would be less than that given by the vertical one by 1in.

This would not probably represent the whole difference between results from the two types, for the horizontal pump is more liable to leakage as usually made, and the fall of the water on the foot valves, when the latter are about to open, is another defect.

As, however, it possesses this defect in a less marked degree than the pump shown in fig. 7, while the latter being altogether a unique example of bad design, forms a good illustration of what an air pump ought not to be like.

After saying this much, perhaps it is superfluous to add that the pump was not designed or built in this country, also that such a pump gave very poor results on the trial run.

When the plunger is drawn out the water above and around it falls on to the foot valves, which ought to be just opening at this time. It will require a greater difference of pressure to lift them against this impact, and, as in the ordinary horizontal pump, the static head will be large, too. The stuffing box affords a tolerably easy means of access for air, and any calculation would in all probability give results considerably wide of the mark on account of leakage from it.

Before leaving the subject of the capacity of air pumps working with jet condensation, it may be of interest to consider how a change in the working conditions affects the attainable vacuum.

If the temperature of the condenser be altered, as would be the case if the point of cut-off of the steam be changed without altering the quantity of injection water, the vacuum would be altered by an amount equivalent to the difference in the vapour tensions, due to the initial and changed temperatures. If the cut-off be earlier, the temperature will be lowered and the vacuum increased; and, if later, the temperature will be raised and the vacuum diminished. If the temperature of the injection be varied without altering its quantity, there will be a similar consequent variation in the temperature of the condenser. If the quantity only of the injection be increased, more water and air will have to be removed, and the vacuum would be lowered in consequence of the increased air pressure in the condenser, and it would be raised owing to the reduced temperature of the discharge; the change in the vacuum would thus be the difference in these effects.

Engines built for tropical countries may have to work with the injection water at 100 deg. Fah. or more. As such cases occur sometimes in practice, the following example is worked out for a single-acting vertical pump with foot valves:—

Suppose the temperature of injection water to be 100 deg. Fah., the temperature of discharge = 120 deg. Fah., the quantity of air dissolved being four per cent by volume at 100 deg. Fah., and the atmospheric pressure 30 inches. Let us assume, as before, that the volume of water resulting from the condensation of steam is ·000983 V per revolution, V being the volume swept by the low-pressure piston per stroke. The temperature of the condensing water rises by 20 deg., so that the water required is 52·5 times that of the condensed steam. The volume of water to be removed per stroke is 53·5 × ·000983 V = ·0526 V.

Now, this will fill the pump to a greater depth than in the former case, and the loss of air pressure between the condenser and the barrel of the pump will in consequence be greater. Suppose it is 1in. instead of ·75in.

If p be the air pressure in the barrel of the pump, then the latter should have a capacity above the water level of

$$\cdot 0526\mathrm{V} \times \frac{4}{100} \times \frac{461 + 120}{461 + 100} \times \frac{30}{p} = \cdot 0644\,\frac{\mathrm{V}}{p}.$$

Let k be the capacity of the pump expressed as a fraction of that of the cylinder. Then

$$k\mathrm{V} = \cdot 0526\mathrm{V} + \cdot 0644\,\frac{\mathrm{V}}{p};$$

whence

$$p = \frac{\cdot 0644}{k - \cdot 0526}.$$

The vapour pressure corresponding to 120 deg. is 3·42in., and the pressure in the condenser will be 3·42in. + 1in. + p inch and the vacuum, with the barometer at 30in., 30 − (3·42 + 1 + p). Putting k = ·08, ·12, ·16, ·2, ·24 in succession, we shall find the corresponding values of p to be 2·35 ·955, ·6, ·43, ·35, and the vacua 23·23, 24·62, 24·98, 25·15, 25·23. The result is shown graphically by the curve, fig. 10, Plate

To obtain the above results in practice the area through the valves would have to be made larger in proportion to the larger volume of water to be dealt with.

If the injection be clean spring water, the vacuum attainable ought to be greater than the above; but if, on the other hand, it be turbid river water, the vacuum would perhaps be less, since in the former case the dissolved gas would probably not amount to more than 3 per cent by volume, while in the latter it might reach 8 per cent.

It will thus be seen that, in addition to the numerous observations which are necessary to give complete information as to the working of any air pump, the percentage volume of dissolved gases would have to be known. It is, however, not a difficult matter to find this volume with an accuracy sufficient for all practical purposes.

It is more difficult to reconcile theory and practice when the surface condenser and the capacity of its attendant air pump are to be discussed than it is in the case of jet condensation.

The practice of most engineers seems to be to make the air pump large enough to act properly with jet condensation, but smaller than the usual size of pump fitted to jet condensers.

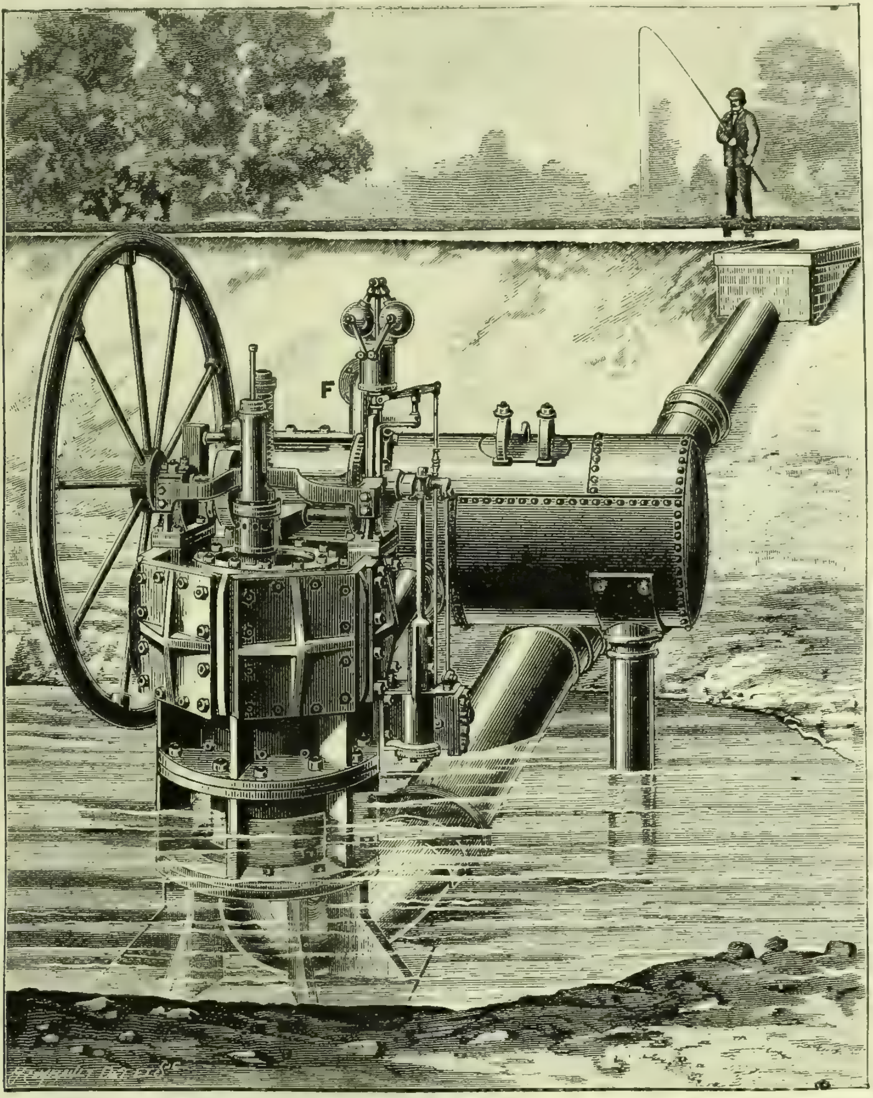
In such a case it may be interesting to note what vacuum should be obtained when working with jet condensation. Thus if the temperatures, &c., are the same as those used in the calculation of the curve in fig. 9, page 445, it will appear on reference to that curve that ·08, or $\frac{1}{12\cdot 5}$ (a common proportion) might be expected to give a vacuum of 26in., always supposing the valves were large enough in area for working with jet condensation. A much smaller pump would doubtless give as good results when working with surface condensation if an automatic arrangement be employed to prevent the feed pump drawing air, and if the joints and piston rod glands are tight. If, however, the feed pump worked by the engine draws direct from the hot well, or from the air separating vessel, it seems inevitable that some air must be drawn in. This air being agitated and thoroughly mixed with the water on its passage to and from the feed pump will be dissolved more or less. Some which does not dissolve will find its way into the air vessel, on the feed delivery, and some may pass along with the water without dissolving. Whether this last action takes place or not depends a good deal on the design of the feed discharge passages into and out of the air vessel, and of course also on the quantity of air; for if this is excessive, the water level in the air vessel will be kept near the top of the outlet pipe, and portions of air must pass out occasionally as the water oscillates about. It is possible, however, for some air to pass in bubbles along the pipe and be carried past the air vessels, for the following reasons: Air bubbles rise upwards through water, because their specific density is small. The velocity with which they rise depends on the difference between their density and that of the water.

(*To be continued.*)

NEW HYDRAULIC ENGINE.

Mr. H. D. Pearsall, A.M.I.C.E., of Orpington, Kent, has produced a new form of hydraulic engine, which we illustrate below, in which the principle of the hydraulic ram is utilised in such a manner that the machine performs its work entirely without shock. The machines are for the purpose of making use of water power wherever it is desired to use such power for pumping or forcing water, or for compressing air. By the agency of compressed air (or of water) they are also useful for obtaining motive power for any purpose at a distance from the fall of water whence the power is derived.

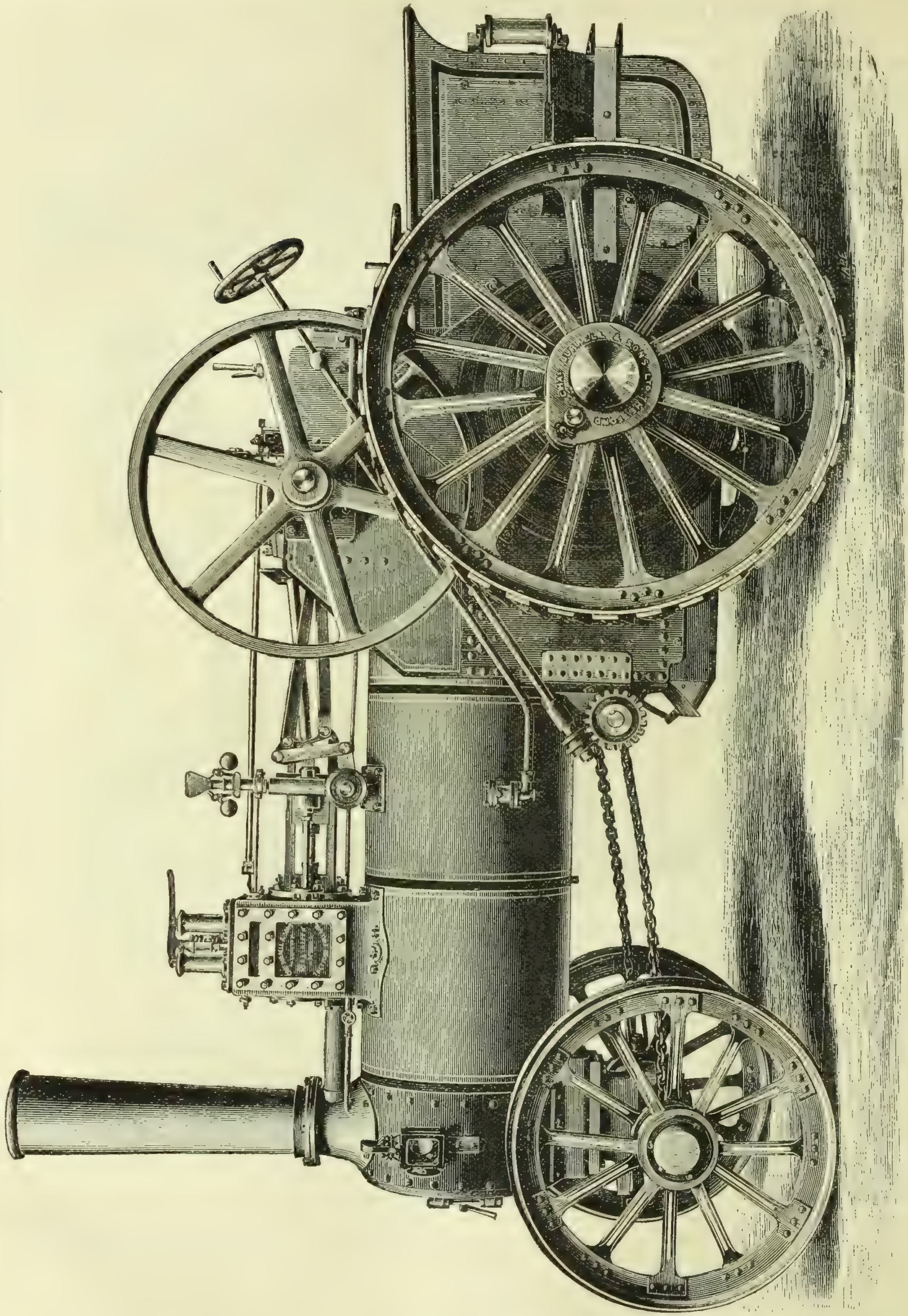
They embrace several new features which distinguish them from any machinery hitherto known, and it would, therefore, be misleading to call them by the name of known machines. To understand their action, however, it may be stated that they work on the principle of the hydraulic ram to this extent, that both the new machine and the hydraulic ram "obtain their pumping power by the arrest of a column of water which has been previously set in motion by gravity." They differ, however, so much in other respects from hydraulic rams, that the objections to which those machines are open are not applicable to the new engines.



The hydraulic ram cannot be made to deal with large quantities of water on account of the violence of its action, but these machines have no violence in action, and work with perfect smoothness.

They have, however, the advantage which the hydraulic ram possesses above other machines, of performing, in one machine and at one operation, the task of using the power of a fall of water to raise or force water or other fluids, or to compress air. They are at the same time stated to be simpler and cheaper in construction than ordinary reciprocating pumps, and more economical in their use of the water power. The same power, it is stated, will do 50 per cent more pumping when used in these machines than it will do when used by means of turbine and pumps, as the efficiency is higher. The novelty consists mainly in the valves and gear used to control the flow of water, and the arrest of the moving column is made reliable and periodic by a small engine driven from air compressed by the column, as seen in our illustration. By this arrangement, and by the use of an auxiliary air chamber, the main valve is made to close entirely without shock. In consequence of this large bodies of water can be dealt with, and the machine may be applied either to raising and forcing water, compressing or exhausting air for the transmission of power. The machine is very ingenious, and we may return to it again in a future issue, and give a section, with diagrams of its performances. Direct action is always an advantage wherever it can be simply obtained, and the system illustrated has now been at work for nearly two years.

Heavy Dispatch of Welded Steel Pipes.—An unusual scene was witnessed last week at the Hockley Station of the Great Western Railway, when a large quantity of light steel water pipes, made by Messrs. Piggott & Co. of Birmingham, were despatched to Glasgow for shipment to Mexico. Three special trains, each consisting of forty-two wagons, were sent away; and each pair of wagons carried 28 light steel spigot and socket water pipes, 12in. and 14in. diam., by 14ft. long by 13 G. thick, all coated with special composition to prevent oxidation when in work. The smaller pipes were stowed inside the larger ones to reduce freight, a saving being effected by this means, we are told, of about 50 per cent.



THE R.A.S.E. WINDSOR SHOW.—8-H.P. SPRING-TRACTION ENGINE.

CONSTRUCTED BY MESSRS. CHARLES BURRELL AND SONS, LIMITED, ENGINEERS, THETFORD.

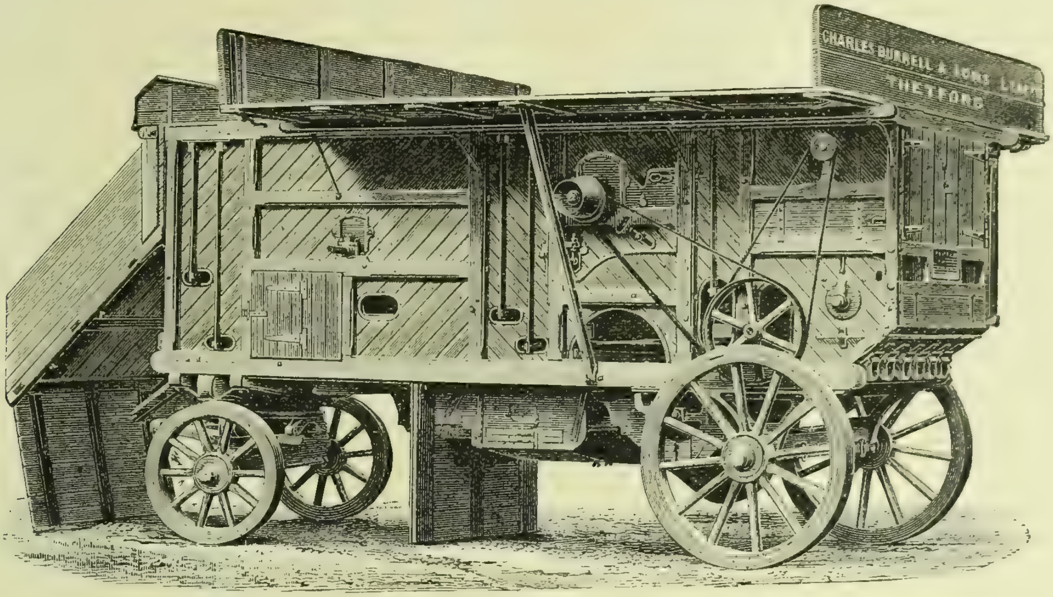
THE R.A.S.E. SHOW AT WINDSOR.

Messrs. Charles Burrell and Sons, Limited, of St. Nicholas' Works, Thetford, exhibited two traction engines, one of eight horse power and one of seven horse power. The eight horse power engine is specially intended for road work, and is mounted on springs (Burrell's patent). This spring arrangement is most perfect, being so simple and so thoroughly protected from dirt and dust that it is likely to last long and give entire satisfaction There are a great number of these engines at work, some having been in constant use for over two years without giving any trouble. The arrangement of springs is such as to admit of engines being driven at high speeds over ordinary macadamised roads, and for use in towns where the jar of engines would cause damage to property near which they have to travel, this invention is invaluable.

In general design this engine is similar to those hitherto made by Messrs. Burrell, which are now well-known. They also exhibit one of Proctor's patent agricultural diggers, 5 horse power, fitted with compounded cylinders, arranged in such a way as to require one crank, one link motion, and one connecting-rod only. The cylinders are arranged diagonally one over the other, and so constructed that they can be fitted to any existing traction engine without altering the distance of the centres of the crank shaft from the top of the boiler.

This invention is intended to provide a cheap form of compound engine, which can be handled in the same way as a single cylinder engine, and one which can be applied readily to existing engines by merely taking off the single high-pressure cylinders, and replacing them with Burrell's patent cylinders, utilising the same link motion.

Messrs. Burrell also exhibited a 20 horse power compound undertype engine, *i.e.*, with engine under boiler, suitable for driving electric light or other machinery. Also one 10 horse power horizontal engine of entirely new pattern. This is a very neat and substantial engine, with very large bearing surfaces, and automatic expansion gear, controlled by governors. They also exhibited 10 horse power portable engine and thrashing machine, which we illustrate, and Wood's patent corn grinding mills, of different sizes, which are now so well-known as to require no further description.



DESCRIPTION OF AN APPARATUS FOR DRYING IN VACUUM.*

Wet By-products.—The by-products, consisting of wet grains from breweries, distilleries, &c., and of root chips from sugar manufactories, form in many cases food-stuff of great value; but on account of the great quantity of water they contain they are subject to rapid destruction by decomposition, and their nutritious qualities especially suffer most. The same cause also prohibits their carriage over any great distance. In the case of wet beer grains for instance, carriage has to be paid for about 75 per cent of water. Hitherto, therefore, it has been necessary to utilise these by-products on the spot where they are produced, or at least in close proximity thereto, as well as with the least possible delay. The natural consequence is a low price for such products, of which, moreover, the supply is often greater than the demand, and thus prevents their realising anything like their market value, particularly during the hot summer months, when plenty of other food-stuff is to be had. The old plan of preserving such perishable substances in pits or silos is only a very rough and poor remedy, and does not answer its purpose at all completely; for, notwithstanding all precautions, decomposition sets in, and a loss of as much as 50 per cent in the nutritious qualities is generally sustained, while at the same time the moisture is by no means reduced, and consequently carriage still remains impracticable.

Importance of Drying.—It has long been endeavoured to overcome these disadvantages by removing the surplus moisture by drying the by-products, so as to allow of storing and transporting them, and at the same time of realising their full market value. The result of such endeavours has been the construction of different kinds of drying machines, which has certainly been a step in the right direction, inasmuch as drying is undoubtedly the surest and safest way of preserving this class of perishable substances. The removal of the water overcomes at once the two great obstacles previously encountered; the rapid decomposition ceases, and carriage to a distance becomes practicable, because the reduction in weight is very considerable. The consequence is that these by-products so dried fetch their full market value.

To solve this problem, however, has not been so easy a task, because, besides the necessity of keeping the expenses of drying as low as possible, a low temperature also has to be employed during the drying process wherever it is wished that the dried substance should retain its chemical composition unchanged, which in any article of food is a most important point for enabling a profitable result to be obtained. In general two drawbacks have rendered themselves conspicuous in connection with the drying machines hitherto in use: either, in order to shorten the drying process as much as possible, and to make it sufficiently economical, too great a heat has been employed, with the unavoidable result of seriously deteriorating the nutritious qualities of the material, or else, when a longer time and a lower temperature have been employed for drying, the capacity of the machines has been so small that the working expenses have rendered the process unsuccessful commercially. In both cases the advantages of drying are outweighed by the disadvantages incurred; and it is on this account that the drying of such perishable by-products has not become more general, as it ought to have done in consideration of its importance.

Requirements in Drying.—The following are considered by the author to be the three essential requirements for a successful and economical process of drying: firstly, cheap evaporation of the moisture; secondly, quick drying at a low temperature; thirdly, large capacity of the apparatus employed.

The removal of the moisture can be effected in either of two ways: either by slow evaporation, or by quick evaporation—that is, by boiling.

Slow Evaporation.—The principal idea carried into practice in machines acting by slow evaporation is to bring the wet substance repeatedly into contact with the inner surfaces of the apparatus, which are heated by steam, while at the same time a current of hot air is also passing through the substance for carrying off the moisture. This method requires much heat, because the hot-air current has to move at a considerable speed in order to shorten the drying process as much as possible; consequently a great quantity of heated air passes through and escapes unused. As a carrier of moisture hot air cannot in practice be charged beyond half its full saturation; and it is, in fact, considered a satisfactory result if even this proportion be attained. It is evident that a great amount of heat is here produced which is not used, and the expense of drying is accordingly high; whilst, with scarcely half the cost for fuel, a much quicker removal of the water is obtained by heating it to the boiling point.

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* By Mr. Emil Passburg, of Breslau. Communicated through Mr. Samuel Geoghegan, of Dublin. Inst. M.E., London Meeting.

Quick Evaporation by Boiling.—This, as is well known, does not take place until the water to be evaporated is brought up to the boiling point and kept there, namely, 212 deg. Fahr. or 100 deg. Cent. under atmospheric pressure. The vapour generated then escapes freely. Liquids are easily evaporated in this way, because by their motion consequent on boiling the heat is continuously conveyed from the heating surfaces right through the liquid. But it is different with solid substances, and many more difficulties have to be overcome, because convection of the heat ceases entirely in solids. The substance remains motionless, and consequently a much greater quantity of heat is required than with liquids for obtaining the same results. With less heat such results would only be possible if there were a great difference between the boiling point of the water contained in the substance to be dried and the temperature of the heating surfaces; but to carry this out in practice under atmospheric pressure would be impracticable, because steam of the required high temperature for the heating surfaces would be of too high a pressure. Another drawback is that the temperature of boiling water under atmospheric pressure is so high that in most cases the nutritious qualities of the material to be dried would be seriously impaired thereby, and the value of the whole material as food-stuff would thus be lessened.

Evaporation in Vacuum.—All the foregoing disadvantages are avoided if the boiling point of water is lowered—that is, if the evaporation is carried out under vacuum. This plan is widely known and used for liquids, but not so for solid substances. For the latter it has first been successfully applied in practice by the author's vacuum-drying apparatus, which is designed to evaporate large quantities of water contained in solid substances, in as short a time and at as low a temperature and expense as possible. Former plans for drying solid substances have not possessed the capacity of the author's apparatus: firstly, on account of their having been attempted on a much smaller scale, with much smaller heating surface; and secondly, on account of the water being evaporated by boiling under atmospheric pressure, whereas the evaporation cannot be done at less expense, in shorter time, and in smaller space, except when it is effected in a vacuum. Although it has often enough been tried to use a vacuum in practice for the drying of solid substances, as it has been so successfully employed for liquids, yet the attempt has always been given up again; and even for laboratory work the author is not aware of the plan having anywhere been applied.

Apparatus for Drying in Vacuum.—As shown in the accompanying diagram, figs. 1 and 2, drawn to scale, the drying apparatus consists of a top horizontal cylinder A surmounted by a charging vessel C at one end, and a bottom horizontal cylinder B with a discharging vessel D beneath it at the same end. Both cylinders are encased in steam-jackets, heated by exhaust steam. In the top cylinder works a revolving cast-iron screw S with hollow blades, which is also heated by exhaust steam. The bottom cylinder contains a revolving drum of tubes T, consisting of one large central tube surrounded by two dozen smaller ones, all fixed in tube plates at both ends; this drum is heated by live steam direct from the boiler. The substance to be dried is fed into the charging vessel C through two manholes, and is carried along the top cylinder A by the screw creeper to the other end, where it drops through the valve U into the bottom cylinder B, in which it is lifted and carried along in the reverse direction by blades attached to the drum T; from the other end of the bottom cylinder it falls into the discharging vessel D through another valve V, having by this time become dried. The vapour arising during the process is carried off by an air pump through a dome and air valve E on the top of the upper cylinder, and also through a throttle valve F on the top of the lower cylinder; both of these valves are supplied with strainers.

As soon as the discharging vessel D is filled with dried material, the valve V connecting it with the bottom cylinder is shut, and the dried charge taken out without impairing the vacuum in the apparatus. When the charging vessel C requires replenishing, the intermediate valve U between the two cylinders is shut, and the charging vessel filled with a fresh supply of wet material; the vacuum still remains unimpaired in the bottom cylinder, and has to be restored only in the top cylinder after the charging vessel has been closed again.

The practical success of this apparatus is owing to the employment of the vacuum and to the arrangement of the heating surfaces, as well as to the construction in general, whereby the charging of the wet substance and discharging of the dried are effected without destroying the vacuum in the bottom cylinder, which constitutes the main drying chamber of the apparatus. In this vacuum the boiling point of the water contained in the wet material is brought down as low as 110 deg. Fah. or 43 deg. Cent.; the difference between this temperature and that of the heating surfaces is amply sufficient for obtaining good results from the employment of exhaust steam for heating all the surfaces except the revolving drum of tubes. Under atmospheric pressure this difference of temperature would not exist; and to the same cause is also due the short time occupied in drying, notwithstanding the low temperature employed. The water contained in the solid substance to be dried evaporates as soon as the latter is heated to about 110 deg. Fah.; and as long as there is any moisture to be removed the solid substance is not heated above this temperature. The dried product therefore remains perfectly unaltered in every respect, and is not in the least impaired in its chemical composition and nutritious properties by the drying process. But it is not time only that is gained; there is also a great saving in the cost of drying, because all the heat expended is here usefully employed, and the vapour leaving the apparatus is fully charged with moisture, which is a result widely different from that obtained by slow evaporation under atmospheric pressure. For solid substances containing moisture, therefore, this vacuum-drying apparatus is considered to be the most economical.

If all the water were evaporated from the substances to be dried, the latter would, of course, be heated up to the same temperature as the heating surface, and would thereby be injured. This was one of the drawbacks connected with former plans of drying; but it does not occur in the regular working of the vacuum apparatus, because such substances as beer grains or distillery grains, oats, barley, &c., are never completely dried, but are always taken out of the apparatus while still retaining from seven to twelve per cent of moisture. Even if they contained less, they would rapidly absorb again from the atmosphere such a quantity of moisture as their chemical composition allows.

Practical Applications.—This plan of drying is already in use for various solid substances, and the result has in every case been remarkably satisfactory. Wet grains from a brewery or distillery, containing from 75 per cent to 78 per cent of water, have by this drying process been converted in some localities from a worthless incumbrance into a food-stuff highly valued and sought after. The water is removed by evaporation only, no previous mechanical pressing being resorted to; hence absolutely the whole of the solid matter is retained, of which, in any process of pressing, a large proportion would have been carried off in a dissolved state in the water. The result is a dry food-stuff, rich in quality and good in appearance.

From malt the removal of the moisture which it contains has to be effected very carefully, and required in the old-fashioned kilns as much as 48 hours, because the low temperature necessary could be secured only by slow combustion. This method was and always is a risky one. In the first stages of the drying of malt the temperature has to be kept very low; and in the vacuum apparatus, therefore, hot water, of which the temperature is easily regulated by a thermometer, is used instead of steam as the heating agent at the outset, while at the same time as high a vacuum as possible is created in the drying cylinders by an air pump of special construction. The exhausting apparatus employed is an air pump consisting of a pair of vertical single-acting pumps, worked from opposite ends of a crank shaft, which is driven by a steam cylinder and controlled by a pair of heavy flywheels; it gives a vacuum of 29in. of mercury. Even at so low a temperature as only 87 deg. Fah. or 30 deg Cent. vapour already rises from the malt and is carried off by the air pump. After two hours' drying at this low temperature the malt is dry enough for steam to be used instead of hot water, without incurring the danger of overheating the malt and thereby forming inside the grains a hard or horny yellowish substance called glass malt, which is unfit for the production of beer or alcohol, and displaces part of the soft powdery flour that otherwise constitutes the whole contents of the grains. After another hour or two the malt is quite dry, the complete drying thus occupying only from three to four hours, instead of the forty-eight usually necessary in the old kilns. When dry, a still higher heat is applied to the malt for a short time, in order to give it the appearance which it is considered good malt for brewing ought to possess. In some cases it would be practicable for a brewery which does its own malting to use apparatus of this kind in the hot summer months for the drying of beer grains, and during the winter for malting. But if the apparatus is intended to be used for malting only, a few modifications are advisable; and in most cases it pays better to dry the beer grains all the year round, because in a wet state

APPARATUS FOR DRYING IN VACUUM.

DESIGNED BY MR. EMIL PASSBURG, ENGINEER, BRESLAU.

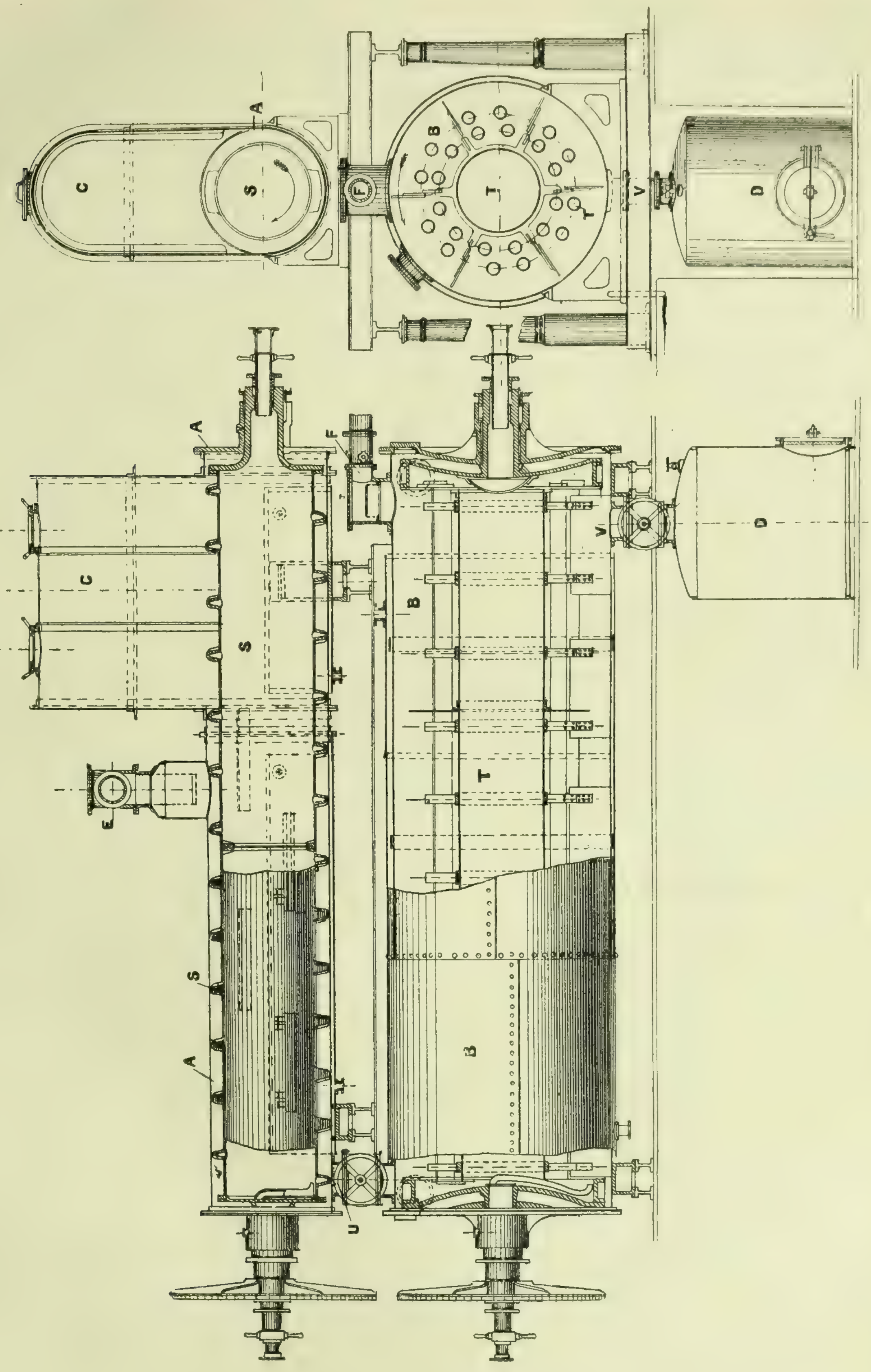

FIG. 2.

FIG. 1.

they do not fetch a price approaching what they do after being dried. Wet grains can be given only to milch cows or to cattle for fattening; whilst dry grains, being a splendid substitute for oats, can be given to horses, and also to sheep, &c., for which they have hitherto been unavailable.

At Messrs. Guinness' brewery in Dublin the members had the opportunity at the last summer meeting of seeing the two machines there employed. In each of these the top cylinder is 20ft. 4in. long and 2ft. 8in. diameter, and the screw working inside it makes 7 revolutions per minute; the bottom cylinder is 19ft. 2in. long and 5ft. 4in. diameter, and the drum of tubes inside it makes 5 revolutions per minute. The drying surfaces of the two cylinders amount together to a total area of about 1,000 square feet, of which about 40 per cent is heated by exhaust steam, and 60 per cent by live steam direct from the boiler. There is only one air pump, which is made large enough for three machines. It is horizontal, and has only one air cylinder, which is double-acting, 17¾in. diameter and 17¾in. stroke, and it is driven at about 45 revolutions per minute. As the result of about eight months' experience up to the beginning of the present year, the two machines were found to have been working quite satisfactorily, and to have been drying the wet grains from about 500 cwt. of malt per day of 24 hours, which is in excess of the estimated and guaranteed quantity.

Roughly speaking, 3 cwt. of malt give 4 cwt. of wet grains, and the latter yield 1 cwt. of dried grains; 500 cwt. of malt will therefore yield about 670 cwt. of wet grains, or 335 cwt. per machine. The quantity of water to be evaporated from the wet grains is from 75 to 78 per cent of their total weight, or say about 512 cwt. altogether, being 256 cwt. per machine. Instead, however, of obtaining only one-third of the malt in the shape of dried grains, the author often gets 38 per cent, or more, according to the system of brewing. While the value of the grains before and after drying depends, of course, very much upon the local markets, the following figures are believed by the author to represent a fair average for this country: wet grains fetch from 1s. 6d. to 1s. 9d. per quarter of mashed malt (3 cwts.), whilst dried grains are sold at from 4s. 6d. to 6s. 6d. and upwards per cwt., which represents about one quarter of mashed malt.

Grain damaged at sea can be dried by this apparatus with the greatest advantage and economy; as can also grain harvested in a wet season, and containing too much moisture to be stored at once, as is often the case with barley, oats, wheat, rye, &c., for which hitherto kiln-drying has had to be resorted to. In such cases the water only adheres externally, and is not contained within the grains themselves, as it is in brewery or distillery grains; it is therefore evaporated rapidly, and thus the drying capacity of the apparatus is largely increased. In general the quantity of water to be removed is not more than from 20 to 30 per cent of the whole weight of the wetted material; hence an apparatus which evaporates 20 tons of water out of beer grains in 24 hours dries easily in the same time 200 tons of grain containing only 20 to 30 per cent of moisture. Of course an alteration in the mode of charging and discharging becomes necessary, in order to render the drying process altogether continuous; and this is easily arranged by means of perforated revolving plates or discs, or other similar appliances.

The above examples are only a few of those in which this plan of drying can be applied with great advantage and with the best results. Chemicals also offer a large field, in which this method of drying in vacuum could be introduced with good effect.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

THE STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

SIR,—As Mr. W. H. Booth admits the statement in his recent articles "that water tubes have no effect in stiffening flues against collapse," i not quite correct, it may appear unnecessary that I should further occupy your valuable space on the subject, and I only do so in order to show that his admission "that cross tubes may prevent distortion in flues having a lack of true circularity in cross section" is much more comprehensive than might at first sight appear, in so far that true circularity of cross section is seldom or never found in practice. Even Brown's ribbed furnaces and those of the flanged description supplied by Howden, and tested by the Board of Trade in December, 1887, particulars of which appeared in your columns during October and November, 1888, show that new tubes, specially prepared for testing, deviated in some cases as much as ¼in. and ⅜in. from the cylindrical form. As these furnaces sustained pressures of 600lb. to over 800lb. per square inch, and, as stated in Mr. Traill's recent work on boilers, none of the 27,000 corrugated furnaces, most of which are working at high pressures, have been known to give rise to a serious casualty from collapse, Mr. Booth will see that the furnace for all practical pressures need not be the ½in. link in the chain. Whilst I do not maintain that the use of cross tubes alone is the best method of stiffening flues in new boilers intended to work at high pressures, Mr. Booth's statement, if left unqualified, could scarcely fail to have a startling effect on the owners of thousands of boilers working at medium pressures, where, on account of longitudinal lap seams, the flues deviate more or less from the cylindrical form, with no other support against collapse. His reference to the Galloway boiler shows that this highly efficient and deservedly popular type has not yet reached a state of perfection, but his recommendations for its improvement may be safely left between the Messrs. Galloway and the public, as steam users who prefer this type are not generally deficient in common sense. It is not quite so certain, however, that water tubes have a bad effect on combustion, as we have still some few authorities—such as Wilson, Rankine, Jamieson, &c.—who assert that water tubes not only stiffen the flues, but add to the efficiency of the boiler as well. With a well-designed boiler, properly set, it will be difficult to convince most people that the moderate use of water tubes has a destructively injurious effect on combustion, especially where bituminous coal is used; as they have only to remove a brick or two to see the flames of active combustion (having run the gauntlet of the water tubes) flowing along the bottom or sides on their all too rapid course to the chimney. Where anthracite or non-flaming coal is used this will not be seen, but it must not be assumed on that account as due to the bad effect of tubes. Where the draught is so sluggish that the temperature in the furnace is only just sufficient to enable the gases to combine, the presence of water tubes in the flue will undoubtedly have a bad effect, and may smother the flame, not so much from buffeting as by a reduction of temperature; but where this is met with common sense has not guided the engineer who designed the work.—Yours, &c., BOILER.

To the Editor of "The Practical Engineer."

SIR,—"Chalkline" may be entirely right in referring to the flotation of flue tubes as a probable cause of their collapse on the bottom side. This view is worth consideration. The action pointed out is curtailed, however, by the resistance of the end plates, which place the under sides somewhat in the position of a beam fixed at both ends.

While I can perfectly understand "Chalkline" upholding cross tubes, I am not prepared to accept the fact that they are still made and sold as an index of their survival as "fittest." The Galloway boiler exists, as he points out, and asks me why it does so. Well, the Galloway boiler has always two good Lancashire furnaces, and though terribly cut up by side pockets, still has remaining two semi-cylindrical portions in its tube chamber, in which tubes do not find a place. Now, "Chalkline" is wrong entirely when he implies that tubes are not in or near the fire in Lancashire or Galloway boilers, for he surely knows that cross tubes frequently project half into the bridge.

Again: "Combustion of fuel may be complete before the tubes or pockets." This may be true of the solid portions of the fuel, but it is entirely untrue of the gases evolved from the fresh charges of coal. No doubt "Chalkline" himself has seen the flames curl into the bottom or side flues, and it was in respect to the gaseous portion of bituminous fuels that my condemnation of cross tubes was based. For the coked fuel the Galloway boiler is no doubt a good heat absorbent, and may indeed largely recoup what it has lost by the gaseous fuel. The illustration of three Galloway 8ft. boilers doing the work of seven Lancashire boilers, whose size and pressure is kept back, is no argument. "Chalkline" says nothing of the new engines. I saw, myself, at Garfield Mill, two Lancashire boilers, not up to 90lb. per square inch, driving the whole mill; and have been informed that a 7ft. Mirfield and Nield boiler developed 450 I.H.P.

Grooving may be reduced in cross-tube boilers, but is not "Chalkline' prepared himself to acknowledge that cross tubes add so much weight to a flue, and at the same time diminish its displacement, and therefore reduce its flotation. Now, flotation is a very probable cause or aid to grooving, and as regards this point the cross tubes, if it be granted that they have this action, act by gravity, just as a few lumps of pig iron might do.

Finally, as regards the law of the survival of the fittest. Is it not acknowledged that artificial civilisation has brought about in human affairs a state of survival of the unfittest, or lowest types, and mankind is tending to two great divisions, the one highly favoured by circumstances and the other puny and ill-favoured—only allowed to exist to minister to the comfort of the highly favoured.

In mechanical matters similar instances occur, and he would be bold who can proclaim that it is always the fittest which survives, though I am myself inclined to argue this for the plain Lancashire boiler. My argument against tubes, however, is chiefly based on their smoke-making qualities, which seems to me to outweigh all their claimed advantages, and I am prepared, as steam pressures are increasing, to leave "Chalkline's" natural law of survival to determine the question of the best form for flue tubes, circular or flat, for their final form will be determined as a question of strength, not of surface.—Yours, &c.,

W. H. BOOTH.

QUERIES AND REPLIES.

56. MOST ECONOMICAL STEAM BOILER.—I wish to put down a boiler to drive a 12 horse-power high-pressure engine using pressure at 100lb. per square inch. What is the most economical boiler to use? I would prefer one which requires no brickwork. What evaporation per pound of fuel can be obtained with the boiler recommended?—J. T. M.

Answer.—I should recommend a locomotive multitubular type of boiler, with steel shell and Lowmoor iron firebox for this purpose: it requires no brickwork setting, but simply rests on a cast or wrought-iron ashpan at the firebox end, and a wrought-iron standard at the smokebox end. If the feed-water is heated, and the exhaust steam from the engine is conducted into the smokebox in a proper position for creating a good blast, such a boiler will evaporate from 9lbs. to 11lbs. of water per pound of coal, the exact quantity depending upon the quality of the coal and the skill of the stoker. For this class of boiler the feed water should be clean and good, and care must be exercised to prevent tallow being mixed with the feed. The boiler should be washed out frequently, or the firebox will soon give trouble. The shell of the boiler should be covered with some good non-conducting composition, 2in. thick. A firebrick arch in the firebox would help to consume the smoke. Shall be pleased to give "J. T. M." more particulars if necessary.—F.

59. Power of Winch.—A wagon loaded, weighing one ton, is to be drawn up an incline 1 in 5 with a winch, by two men. If some reader of *The Practical Engineer* will give me a formula showing how to get the diameter of the gears, also the diameter of drum and radius of handles, and the power each man would have to exert on the same, he would greatly oblige.—Chatham.

Answer.—We may allow 16lb. as the power each of the two men would exert on the crab handle, which we may assume to have a radius of 16in., or sweep diameter of 32in.; and say the friction of the whole moving parts be 10 per cent of the load, then 2,240lb. + 224lb. = 2,464lb., total force required. Then, say diameter of driving pinion be about 6in., and pitch of teeth 1¼in. to 1½in., and the diameter of the driven cogwheel on the crab barrel be about 24in., and diameter of barrel about 8in.—then

$$\frac{32\text{lb. on handles} \times 32\text{in. sweep} \times 24\text{in. diam. of wheel} \times 5 \text{ grade of incline}}{6\text{in. diam. of pinion} \times 8\text{in. diam. of barrel}}$$

= 2,560lb., the force exerted.—Yours, &c., W. A.

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41. Hot-water Pipes.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse?—Water-heater.

50. Small Air Pump.—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

52. Details of Oliver.—Can any reader oblige me with details of an oliver, to work by foot, for making bolts from ⅝in. to 1in., with dimensions?—H. C., Egypt.

53. Dash Pots.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made and what is the approximate cost?—Crank Pin.

55. Testing Lubricating Oils.—I wish to know the methods of chemically testing the purity of lubricating oils. Is there any simple mode easily applied by an engineer?—Lubricator.

60. Set Pins.—Will you kindly permit me through the medium of your valuable paper to ask any of your correspondents if it is possible to get hexagonal-headed set pins $\frac{1}{16}$in. diameter, to buy, and where?—Model.

61. Centrifugal Force.—I have been attempting to analyse the formula $\frac{W v^2}{g r}$, and have met with a doubt, which a brother subscriber will perhaps be kind enough to clear up.

A body moves in a circular path in a horizontal plane, and with a given angular velocity, and is maintained in that path by a string, whose length is equal to the radius of the circle. Required, the tension in that string, expressed in pounds.

First, I learn that, taking a very small arc of the circular path, I may without sensible error consider the body to be moving along the chord of that arc, and in so doing being pulled centripetally along the smallest side of a right-angled triangle, whose hypotenuse is the chord aforesaid; whence I understand that the speed "set up," as it were, by the centripetal pull bears the same relation to the speed along the chord as the latter ("v") in turn bears to $2 r$. Would it then be allowable to reason as follows: The force of gravity, acting for one second, produces in a unit mass a speed of 16·1ft. per second by exerting upon that unit a pull of one pound. Each unit mass in my circular-travelling body is travelling at $\frac{v}{2 r}$ feet per second, a speed which is x times greater than 16·1ft. per second; hence the pull which produced that speed must be x times greater than one pound, and must equal y pounds for each unit of mass in the body. If my reasoning is thus far correct, I have eliminated $\frac{W v}{r \underbrace{2 \times 16{\cdot}1}_{\text{“}g\text{”}}}$, and I can easily see that the pull in my string in pounds, arrived at by those elements of the formula, will increase with the speed in the proportion $\frac{\text{new speed}^2}{\text{original speed}^2}$

I want to feel assured that to get the pull in my string in pounds for a body whose W = 64lb., for example, moving in a circle of 2ft. radius, at a velocity of 100ft. per second $= \frac{m v}{g r} = 3\frac{1}{8}$lb.; and under similar conditions, except that the velocity is 200ft. per second, the pull will be

$$3\tfrac{1}{8}\text{lb.} \times \frac{\text{new speed}^2}{\text{original speed}^2} = 12\tfrac{1}{2}\text{lb.};$$

whereas, if I use $\frac{W v^2}{g r}$ in both cases, I simply obtain comparative values, represented by 1 and 4 respectively, and these are no guide as to the actua pull in my string. The formula last quoted is used most recklessly at examinations, and the resulting values are pressed into service as pounds, tons, anythings, because one is not told that the results are merely numerical comparisons, and not actual values expressed in any one system of units. Shiny Boots.

62. Boring Roll Cylinder.—I should feel much obliged for assistance from you, or any of your numerous readers, with the following: I have a cylinder for a roll; its length is 8ft., inside diameter 25in., and its thickness in rough metal about ¾in. I wish it bored out at the ends about 5in. or 6in., so as I can fit in arms and shaft, and to run pretty fair for outside turning. Can it be done in the lathe with any arrangement, or how would you advise me for cheapest and best, as my appliances are very limited?—Primrose.

63. Screwing Machine Dies.—Can any reader inform me of the best way of advancing and withdrawing dies in a screwing machine, with three die bits? The machine I have at present has four dies and cuts badly, besides making an unequal thread.—D. W.

TO CORRESPONDENTS.

Inquirer, Sandal.—Main shafting in works is often driven direct from a separate wall engine, but where the power required is so considerable as in spinning mills, this would be impracticable; the engines are much too heavy to be placed directly to their work. As the shafting requires to run much faster than the engine, it is much better to drive by belt or gear. Your proposal could be put into practice, no doubt, but with grave disadvantages as compared with the present system.

MISCELLANEA.

A mill has been established at Ottawa, Ontario, which makes paper pulp out of sawdust. The paper made wholly from sawdust is said to form an admirable sheathing that is fit for building after being tarred and dried.

Messrs. Neilson and Co., of the Hyde Park Locomotive Works, Glasgow, have secured an order to construct fifty engines and tenders for the Midland Railway of India, and it is said that the orders will be executed on very moderate terms.

New Line Steamers.—Messrs. Anderson, the managers of the Orient line of steamers to Australia, have entered into a contract with the Canadian Government to provide a weekly service of express steamers between England and Canada. The subsidy is £100,000 yearly, and the steamers are guaranteed to be of 19 knots speed and to complete the passage within six days. They will sail from London for Cherbourg, making Plymouth the final port of call before steaming away for Montreal or Halifax. The steaming time will be taken from or arriving at Plymouth, which will be the first and final port of call. It will be fully 12 months before the arrangements are sufficiently complete to permit of the service being started. It is stated that this route has been started in conjunction with the Canadian Pacific Railway.

Improved Machinery for Making Screws.—Improved machinery is being employed in screw manufacture by the firm of Nettlefolds, Birmingham. The manufacture of screws is indeed passing through so great changes that if any man who had been engaged upon it as lately as even six or eight years ago were now to set about making a machine which should be an improvement upon what he knew to be then in vogue, he would find himself altogether at a loss, and his improvement would turn out to be very old-fashioned. From very long experience and superior practice, Messrs. Nettlefolds are indeed frequently able to anticipate modes of working which outside inventors have brought to them. At this moment there is being shown at the Paris Exhibition a machine for making screws, which was brought to them a short time ago, but which they at once declined, because they possessed already machinery that produced exactly the same results and something more.

Yet another wonderful new nail-making machine is reported from the States. It is said to be capable of making 12,000 nails a minute, equal to three tons a day. The significance of this statement will be seen when we state that ordinary machines now in use, which operate in the same manner as a pair of shears, making 250 nails per minute, and compound machines, consisting of several sets of shears working in what is called a vibrator, are able to turn out 1,250 nails per minute. Simplicity is said to be a leading feature of the new contrivance. Instead of having separate shear-like cutters through which to feed the strips, the cutters consist of small tempered steel dies imbedded into two narrow cylindrical rollers, which have much the appearance of cog wheels, with diminutive cogs. Between these rolls the strip of metal is fed, and the dies or cogs cut the nails.

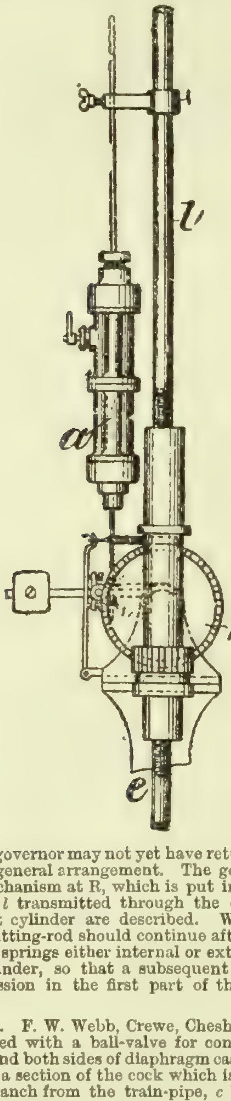
The Colliers and the Use of Roburite in Mines.—A special committee, appointed by the Lancashire Miners' Federation to consider a medical report recently issued with regard to the alleged injurious effects caused by the use of roburite for shot-firing purposes in mines, was held last week at the Young Men's Christian Association, Manchester. The committee consisted of Mr. S. Woods, the president of the Lancashire Miners' Federation, who occupied the chair; Mr. T. Ashton, the secretary; Mr. T. Aspinall, of Wigan; and four colliers. The chairman and Mr. Aspinall presented reports dealing with the injurious effects stated to result from the use of roburite for mining purposes. A long discussion followed, and it was resolved that both reports should be printed and issued to the members of the committee, after which a further meeting should be held, when a report upon the whole matter should be agreed upon for presentation to the Lancashire Miners' Federation.

Edinburgh Electrical Exhibition.—The first public meeting of the promoters of the Electrical Engineering and Inventors' Exhibition, which it is proposed to hold in Edinburgh next year, has now taken place under the presidency of Sir Thomas Clark, Bart. The Chairman moved a resolution remitting the matter to an executive committee to carry out the scheme, and to report progress to a future meeting of the promoters, which was adopted. The chairman said he hoped they would succeed in getting the project into proper shape. There could be no doubt that such an exhibition would be very useful, for they could not conceal from themselves the fact that electricity was to be a very important force in the future as it had to an extent been in the past. Mr. Hall Blyth, in seconding, said he thought a much nearer site than that proposed at Gorgie should be obtained. Mr. A. R. Bennett expressed the view that the proposed site possessed exceptional advantages. It was centrally situated for the railways and tramways, while the Union Canal would afford a means of illustrating water power. Mr. Hall Blyth said the site would be the life or death of the exhibition, and the question should be remitted to the executive committee to consider very carefully. This was agreed to, and the proceedings terminated.

ILLUSTRATED PATENTS.

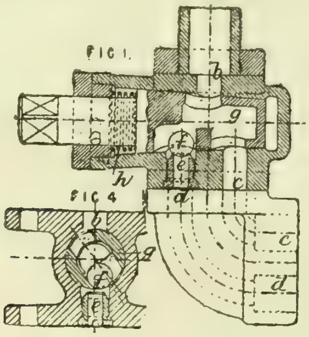
1678. Speed Regulators for Steam Engines, E. C. Mills, 49, Victoria Buildings, Manchester.

Consists in apparatus for avoiding over correction by the governor in cases where any deviation of the governor from the normal gives rise to a permanent alteration in the length of the rod controlling the throttle-valve or cut-off. To this end the power required for putting into gear the mechanism for altering the rod is transmitted from the governor through a cataract cylinder. By this means, as soon as the equilibrium is established in the cataract cylinder, the altering of the rod ceases, although the governor may not yet have returned to its normal position The drawing shows the general arrangement. The governor-rod is denoted at *l* with its lengthening mechanism at R, which is put into and out of gear by the movements of the rod *l* transmitted through the cataract cylinder *a*. Two special forms of cataract cylinder are described. When it is desired that the alteration of the transmitting-rod should continue after the cataract cylinder has attained to equilibrium, springs either internal or external, are inserted between the piston-rod and cylinder, so that a subsequent residual movement occurs owing to their compression in the first part of the movement.—February 4, 1888. [8½.]



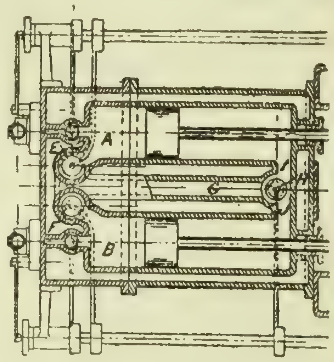
1686. Railway Brakes. F. W. Webb, Crewe, Cheshire.

This is a cock combined with a ball-valve for controlling the passage of air between the train-pipe and both sides of diaphragm casing or cylinder of a vacuum brake system. Fig. 1 is a section of the cock which is provided with three ports, viz.: *b* connected to a branch from the train-pipe, *c* leading to one side of the diaphragm casing, and *d* leading to the other side of the diaphragm casing and to the reservoir. In the port *d* is screwed a thimble *e*, which forms a seat for a ball-valve *f*. The plug *g* of the cock is held to its seating by a spring *h*. The action is as follows: In the position of the cock shown, the air can be exhausted through the train-pipe from both sides of the diaphragm cases and the reservoir. To apply the brakes, air being admitted to the train-pipe passes through the port C to one side of the diaphragm casing, and acts in the usual way. The release of the brakes is effected in the ordinary manner. To shunt a vehicle forming part of a train fitted with the apparatus, it is necessary to destroy the vacuum on the reservoir side of the diaphragm casing, and for this purpose the plug *g* of the cock is turned to the position shown in Fig. 4, so that the ball *f* is lifted off its seat, and allows the air to pass from the train-pipe port *b* to the reservoir. To cut off any particular carriage from the brake system, the plug of the cock is turned to close all the three ports.—February 4, 1888. [8½d.]



1705. Compound Gas Engine, W. J. Crossley, Openshaw, Manchester.

General arrangement.—Two engines are arranged side by side and a cycle of operations of the "Otto" type are performed alternately in each, one making its suction outstroke as the other is making its power outstroke, and one performing its exhaust stroke while the other is performing its compression stroke. The products from each cylinder further expand in the front ends of both cylinders. In the engine shown in sectional plan the "Otto" cycle is performed in the back ends A and B of the cylinders and the products are expelled through the valves E and F, and the pipe G, and the ports I and J to the front ends of the cylinders; after the second expansion they are expelled to the atmosphere through the valve H, which also acts as a relief valve.—February 4th, 1888. [11½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

June 24th.

10250	Printing Presses, J. Jordan and E. Howard, London.
10251	Filters, T. Gentzen and A. Wegener, London.*
10256	Gas, A. J. Boult, Middlesex. (W. G. Wood, Canada.)*
10260	Propelling Boats, W. J. Griffiths, London.
10261	Steel Ladders, Richard de Soldenhoff, Middlesex.
10262	Pipe Joint, H. J. Morriss, Brockley.
10271	Fire Escapes, E. H. Bayley, London.
10273	Polishing Stone, J. McEnerney and W. H. Demorest, London.
10276	Rotary Motion, F. Wheeler, London.
10277	Mineral Oils, J. Dewar and B. Redwood, London.
10278	Connecting Rod Gear, C. D. Able, London. (Roman Abt., Switzerland.)
10286	Gas Engines, N. Rogers and J. A. Wharry, London.

June 25th.

10301	Furnaces, J. Grime, Halifax.
10309	Draught in Furnaces, H. Williams, Glasgow.
10311	Scrapers, R. Hundleby, Sheffield.
10315	Lathes, T. S. McInnes, Glasgow.
10316	Cycle Driving Chains, R. Blacklock, Sunderland.
10323	Water-gas Generators, S. Fox, London. (E. Blass, Prussia.)*
10349	Steam Generators, A. Hasbrouck, London.*
10351	Steam Engines, C. F. Wennberg, London.*

June 26th.

10376	Explosives, C. O. Lundholm and J. Sayers, Glasgow.
10381	Machine Guns, B. Burton, London.
10392	Liquid Fuel, H. J. Haddan, London. (F. F. Amoroso, Italy.)
10403	Hot Liquid Motor, M. Honigmann, London.
10407	Water Gauge Cocks, N. A, Svensson and P. Russ, London.*

June 27th.

10409	Brick Kilns, C. H. Scott, Sheffield.
10412	Electric Railway, Cars, J. J. Butcher, Delaware, United States.
10413	Rock-boring Machinery, W. McNeill, London.
10423	Hydrometers, J. V. Divis, London.*
10424	Callipers, H. Rickinson, London.
10429	Steering Gear, W. Thomson, Glasgow.
10430	Reaction Engines, J. Monteith, Glasgow.
10431	Braking Tramway Cars, J. Monteith, Glasgow.
10432	Machine Bands, M. Bird, London.
10444	Wheel Tyres, F. Schütz, London.*
10447	Gas Lamps, E. Fullford and H. Theodore van Laun, London.
10448	Carding Engines, J. Leslie, London.
10457	Heating Water, R. M. Ritchie, Glasgow.
10461	Signalling Apparatus, H. Brocklehurst and H. Constien, London.
10462	Planing Machines, E. R. Hyde, London.*
10470	Metal Tubes, J. Y. Johnson, London. (J. P. Serve, France.)
10471	Moulding Cores, J. Y. Johnson, London. (J. P. Serve, France.)
10472	Armour Plates, J. Y. Johnson, London. (Carl Pieper, Germany.)

June 28th.

10488	Gas, J. H. R. Dinsmore, Liverpool.
10492	Gas Engines, C. T. Linford, Birmingham.
10494	Brake, W. E. Carmont, Manchester.
10509	Nails and Bolts, F. Tomlins, London.
10510	Tyres, J. F. Sadler, London.
10513	Steam Generators, J. Hockey, London.
10514	Block Fuel, F. Hulwa, London.
10516	Lathes, F. A. Dwyer, London.
10519	Electro-motors, E. C. S. Moore, London. (R. F. Moore, India.)

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER,

JULY 19TH, 1889.

A COMMON DEFECT IN PATENT SPECIFICATIONS.

ONE portion of Lord Trayner's judgment in the recent patent case, concerning compound winding in dynamos, emphasises a defect of a fatal nature which is far too common in patent specifications. We refer to the question of conformity of the final with the provisional specification. In the Brush patent of 1878, under discussion, the provisional specification describes a certain invention intended to simplify the construction of cylindrical commutators, while in the final specification there is claimed and described a cylindrical commutator certainly, but one which goes far beyond the description of the advantages indicated in the provisional. The invention, as fully described and claimed, was admitted to be indisputably advantageous and novel, yet, because it was not indicated at first, the judge came to the conclusion that, from this cause alone, the patent was invalid. And this has been the almost uniform decision of the judges when such points have come up in previous cases. At first sight it does seem an injustice that an apparently purely technical and legal point should destroy an inventor's claim to a sound invention; but we think a little consideration will show that it is a necessary and just provision of the law. In any case, just or unjust, it is the present law of England, and we are of opinion that inventors, and those of our readers otherwise interested in patents, should understand it fully. Unless an inventor appreciates this point, he is very apt to run serious risk in instructing his patent agent or in drafting his own claims. We regret to find that many patent agents do not seem to realise the necessity of care on this point, and quite a number of patents which we have recently had occasion to examine are entirely valueless from this cause. Alike in the interests of inventors and manufacturers, it is important that this should be fully understood, as in the first case the inventor is liable to lose the commercial advantage of his invention, while in the latter case, many manufacturers, we do not doubt, pay royalty for inventions of which the patents are invalid, and therefore open to public use without compensation. When an inventor applies for provisional protection, it is naturally supposed that he has made his invention; he may not have elaborated his details, but in its essentials he is assumed to have practically completed the invention, or to have discovered some new and useful idea or mode of manufacture.

The provisional specification is supposed to describe the mode of carrying the new idea or discovery into practical use, but only in general terms. The general terms, however, must clearly indicate the nature, purpose, and scope of the invention. The final specification is supposed to describe the same invention, but with such particularity that a workman, skilled in the industry to which it refers, can, from that description only, carry the invention into practical effect. It is not necessary that all the details described in the final should be indicated in the provisional—although it is highly advisable that they should be so indicated—as the time elapsing between the filing of the provisional and final is supposed to be employed by the inventor in developing and perfecting the details of his invention. Any detail, therefore, which is a legitimate outcome of the original description, or which may be fairly held to be described in a general way there, may be safely considered as a part of the invention, and claimed in the claiming clauses. But if, in the course of the interval allowed by the patent law, the inventor departs entirely from his original ideas, and develops an invention of which he has had no idea at first, then, if that new invention be described and filed as the final specification, the patent obtained will be invalid, and consequently useless as a means of protection; and this will be so even if the invention described latterly is quite new and useful.

New matter may be added in the final, provided that it is not claimed in the claiming clauses, but the original invention must be described, and the novel points clearly claimed, if the patent is to be good and valid. Inventors are often very much to blame themselves for this particular defect in their patents, as they are apt, during the course of experiment, to forget the precise limits defined by themselves to start with, and sometimes even deviate entirely from the very spirit of the invention which they at first propose. Accordingly, they seek to include and claim entirely new points in their final specification, even against the advice of their agents in the matter. A good agent should firmly resist this liability to err on the part of his client, both in the inventor's interest and his own. In the end it is vastly preferable to make a fresh application than to attempt to embody an invention not at first described.

The fact that the date of the provisional specification gives the right to priority of claim makes it very necessary that the law should be firm and definite upon this point of a reasonable conformity between the two parts of a patent specification. It would be obviously unjust that an inventor who has obtained provisional protection for an invention, say in January, should be able to embody and claim an entirely different invention six months later, as it is quite possible that some other inventor may have described the later invention, and provisionally patented it in February. It is the intention of the law to grant a patent only to the true and first inventor, and to those whom he may choose as associates; and it is quite apparent that endless confusion and injustice would arise if the complete description were allowed to vary in essential particulars from the general or provisional description. Accordingly the law determines that provisional and final specifications must conform—or, in other words, must substantially describe the same invention; and without inquiring whether in the interval some other inventor has proposed the later invention, it at once disallows the patent, and liberates whatever novelty it may contain to the general use of the world.

So far as the world at large is concerned, this is not an undesirable consummation, but for the unfortunate inventor or the manufacturer who has taken up the invention and invested large sums of money in plant and possibly experiments, it is most disastrous. In the case of the Brush patent, already referred to, all that it contains of novelty would have been liberated from this defect alone; but as it happened, there were other defects equally serious, the main being the vital one of want of novelty, and in this connection the case supplies a very clear and striking instance of another effect of including in a patent matter not claimed in the claiming clauses. Such additional matter is generally present in specifications to some extent, as it is necessary to make the descriptions quite clear and intelligible, and it occasionally happens that in the end some of it is found to be novel, and in some cases of much greater importance than the supposed valuable part of the specification. Although new points may not be described and claimed in a final specification, yet the description there, if sufficiently full, is quite sufficient to prevent that point being validly patented by a future inventor. In this case, Mr. Varley clearly described compound winding, both in provisional and final specifications, and yet did not claim it. How disappointed he must now feel when the whole world of electrical engineers use his method of arranging their dynamos, whilst he failed to see the great importancee of the invention he then made.

In conclusion, we would impress on inventors the necessity of comparing their provisional with their final specification before filing the latter, and the necessity of rejecting all matter, so far as claims are concerned, which deviates to any considerable extent from the provisional specification. If it be valuable, it should be described in a new specification; if of no great value, care should be taken to avoid claiming it if it is desired to maintain claims to the essential features in any efficient way. Manufacturers, too, should be careful as to the conformity of the specifications of patents upon which they propose to risk any considerable capital, as any defect of this kind will cause them to experiment only for the benefit of their commercial rivals.

A NEW PETROLEUM ENGINE.

We had the pleasure of examining and testing a new petroleum engine last week, designed and made by Messrs. Hartley, Arnoux, and Fanning, engineers, Stoke-on-Trent. As we have frequently stated in these columns, there is great difficulty in designing petroleum engines to use heavy or non-volatile oils, and although several engines have appeared in the market, yet so far not one of them has proved a genuine commercial success, from various causes. One important source of trouble has been the use of the electric spark for igniting the inflammable mixture within the cylinder; this method has caused uniform failure when applied to gas engines, and although it has been somewhat popular among inventors on the Continent, as we observe from the engines at the Paris Exhibition, yet it is not adopted by the best makers. In fact, only those firms whose experience of such engines in the hands of the public is comparatively slight are sanguine enough to adopt it. Electrical igniters work well enough in the hands of the designers of the engines, or while the engines remain at the works in charge of competent workmen; but they are far too delicate for the general public or the ordinary attendants on gas and petroleum engines.

In the new petroleum engine we were pleased to find that the best gas engine practice is followed to the extent at least of adopting the incandescent tube igniter, and although ingenious departures are made from gas engine valve arrangements, yet they are necessary to form inflammable mixtures with air from heavy petroleum. The vaporising arrangements are exceedingly ingenious, and at the same time remarkably simple and efficient. For the present, however, we shall not describe them, but hope to do so on a future occasion. We may state, however, that although the engine was small—only 6in. cylinder and 12in. stroke—it developed over three horse power on the brake during a test of several hours, giving an average available pressure of over 50lb. per square inch, and the consumption was 0·166 gallons of petroleum per brake horse power per hour, and 0·125 gallons per indicated horse power per hour.

The specific gravity of the oil used was 0·821. We consider this a most favourable result for an engine giving three horse. The average pressure obtained compares favourably with that common in gas engines, and is far above the available pressure usually got with heavy oil petroleum engines, while the economy for an engine of the dimensions named is very satisfactory.

THE ZALINSKI PNEUMATIC GUN.

Captain E. L. Zalinski, of the United States Artillery, has delivered an important and interesting lecture upon the pneumatic torpedo gun with which his name is so widely and honourably associated. Lord Wolseley presided, and among an appreciative and distinguished audience vitally interested in the subject, were General Sir L. Simmons, General Goodenough, Admiral Boys, Captain Colomb, and Majors Lewis and Walker, besides numerous officers officially connected with our national and Imperial defences. The lecturer claimed that the pneumatic gun is now sufficiently developed to throw accurately heavy charges of high explosives to points greatly beyond the range of movable, or rather self-moving, torpedoes, and he pointed out that at present ironclads are far more in danger from under-water attack than in above-water positions. He traced the origin and development of the pneumatic gun, and stated that its idea was first proposed by Mr. Mefford, of Ohio, but that it was only after endless experiments, conducted in America mainly by himself and Colonel Hamilton, that it had arrived at its present state of comparative perfection. Proceeding, he described the various constructions of guns, both for land batteries and for those afloat. The Vesuvius, U.S. navy, is armed with the 15in. pneumatic gun, but has not yet been tested afloat. After much trial, he had selected uncamphorated explosive gelatine as the high explosive best adapted to the work, and he considered that if well made and carefully stored in the dark, at a temperature not to exceed 80 deg. Fah., it was perfectly safe both from deterioration and shock.

So far as accuracy of fire was concerned, he considered the absolute control over air pressure to make its long range firing far superior to anything effected by gunpowder. He deprecated attempts to fire charges of high explosives from guns by explosion, and stated that even with air pressure such duty was quite dangerous enough. The lecturer concluded by comparing the pneumatic gun system with the Brennen torpedo, much to the disadvantage of the latter.

A short discussion followed, in which Admirals Colomb and Boys took part, together with Colonel Walford and Lord Wolseley, but nothing of importance was elicited. This was to be expected, as Captain Zalinski is one of the very few who have any experience in the matter. In this country we have much to learn on this subject, and it is to be hoped that our naval and military authorities will lose no time in acquiring the necessary knowledge. We observed a patent a short time ago by Maxim, which may after a time greatly simplify and cheapen the action of such guns. We refer to the use of petroleum vapour to make the air explosive, and so obtain a gentle explosive to diminish the amount of air required. At present quite a large plant is needed to compress and store the air used to propel the shot, and this of course is a great objection.

THE PARIS EXHIBITION.

(*From Our Own Correspondent.*)

The exhibits of the British Section in the Machinery Hall, including the floor space and the space in the gallery above, cover in all 66,000 square feet area, and of this total nearly a third occupiest he gallery, where but comparatively few visitors find their way. During our visits the great hall was intensely hot even on the floor, and in the gallery it was hardly bearable; accordingly there is ample room and freedom from crush, and but for the heat we could enjoy an uninterrupted view of the scene beneath. On a bright and cloudless day the sun strikes through the immense glass roof and heats up all the air within to hot-house temperature, and this, added to the heat ascending from the almost innumerable engines below, makes it quite a task to take an interest in anything there during the hottest part of the day. We feel much inclined to walk through the long avenues of beautifully finished locomotives under the external galleries forming the sides of the Machinery Hall, where, because of a roof above us, it is on the whole comparatively cool. All the machinery in motion is on the floor space, the gallery being occupied mainly with models and samples of varying engineering interest.

The steam engine, so far as England is concerned, is but poorly represented; the quality is admirable, but the quantity is insignificant. Messrs. Davey, Paxman, and Co., of Colchester, have the only considerable exhibit of British steam engines. Their engines drive the shafts supplying power to the British section, and their boilers supply the steam required by the British exhibits. They have at work one coupled girder compound engine of 500 I.H.P. one Colchester compound engine of 200 I.H.P., and also one of 140 I.H.P. They have also one horizontal high-pressure non-condensing engine, indicating 140 horse power, and likewise a coupled girder compound of the same power; altogether five fairly large steam engines, which work most satisfactorily, and are finished in the well-known style of the firm. Three of these engines are at work in the Machinery Hall, and the others in the electric lighting shed. In their stand at the Machinery Hall we examined two 8 horse power portable engines, one of them compound, which we were informed were those used at the recent Society of Arts' trials and the Royal Agricultural Society's trials of last year. These engines are most interesting to us because of the admirable results obtained in both of those well-known tests. The action of the governor on the gridiron expansion valve is clearly shown by a working model, which can be moved round by hand.

The principal examples of stationary steam engines by other makers are those of Mr. P. Brotherhood at Mr. Henry Chapman's stand, where his well-known three-cylinder engine is shown, as well as a set of inverted compound pumping engines, by the Hydraulic Engineering Company, Chester, which have three steam-jacketed cylinders, one high pressure of 5in. diameter, and two low pressure of 6½in. diameter, each with 6in. stroke, working on cranks set at 120 degrees one to the other. Each cylinder drives one single-acting pump, which is fixed between the crank shaft and the crosshead guides. Mr. E. S. Hindley, of Dorset, shows two of his very neat and now well-known engines with their boilers. Messrs. Simpson, Strickland, and Co., Dartmouth, show four of Kingdon's patent launch engines, one of which is completed ready for a small launch, with its boiler. There are several portable engines by English makers, and among them two very nicely finished examples by Messrs. Aveling and Porter, one of them fitted with a dynamo mounted upon the boiler and ready for electric lighting.

Messrs. Galloway, of Manchester, besides their installation in connection with the illuminated fountains in the gardens, have a very instructive exhibit showing the arrangement of their well-known boiler. It is a full-size boiler, 30ft. long by 8ft. diameter, intended to supply 500 I.H.P. at 100lb. working pressure; but only the ends have been completed, and consequently the flues, cross tubes, and pockets are clearly seen. They have also a small copper model of the same nature, and a trophy of Galloway tubes.

The Leeds Forge Company exhibit a number of their Fox's corrugated flues, and a splendid example of a steel boiler front in one piece, just as it left the press; they also show wagon under-frames, each in one piece, having all its parts flanged at one operation. This stand is beautifully got up, and the name of the firm displayed in flowers and leaves forged in iron; the whole effect is most tasteful and pleasant. The exhibit is at the extreme end of the British Section, at one end of the Machinery Hall.

The steam-engine exhibit, as we have said, is very limited, and not at all representative of Great Britain. It is very disappointing to find no really large engines.

Messrs. Crossley Brothers have an excellent show of their renowned Otto gas engines, nicely finished, and all working well, ranging in power from 5 man to 14 horse nominal. Two of these engines have the tube igniter attached instead of the slide. As we intend to describe them more fully again, we shall not further refer to them here. We may state, however, that we much prefer the Messrs. Crossley's designs to those of the French makers of the Otto engine; there is a solidity and simplicity of appearance in them which are wanting in the French. We found it interesting to look at the Otto engines of Messrs. Crossley, and, with their details and appearance fresh in our minds, to walk over to the stand of the French makers of the same engine in another part of the hall. The comparison is interesting as showing the practice of two nationalities in carrying out the same invention. The French makers show one very large gas engine intended to give over 100 horse power. It has four cylinders—two pairs side by side, and opposing each other so that two rods connect each to one crank. The usual valves for the admission of the charge, ignition, and exhaust are fitted to each cylinder, and side shafts, driven by skew gearing from the main shaft, carry cams, which control those valves. In this way the engine is arranged to give two impulses for every revolution.

There are gas engines by three other makers in the British Section—the Griffin engine by Messrs. Dick, Kerr, and Co., the so-called Midland gas engine by Messrs. Taylor and Sons, Nottingham, and the Martini gas engine by Mr. W. C. Horne, of London. The latter engine is on the well-known Otto cycle, and the principal novelty is in the use of an electro-magnetic igniter, which, by the way, seemed to be out of order when we saw the engine, so that we could not judge fairly of its performance. Messrs. Dick, Kerr, and Co.'s engine is of the three cycle type, which differs from the Otto in giving an ignition at every three revolutions instead of every two. The Midland gas engine is on the well-known "Clerk" cycle, in which the exhaust gases are displaced by the entering charge from a separate pump or displacer. We could find no feature of novelty in its arrangement.

The Crossley exhibit of gas engines is in every way superior to the others, and worthily represents English gas engine practice.

Leaving the British Section for a moment, we were surprised to find in the very centre of the Machinery Hall a veritable example of perpetual motion apparatus in the shape of a curious looking bicycle. The front wheel, which was the driving wheel was constructed with a flexible rim—we can hardly call it a tire—of thin steel. This was supported from an inner ring by a series of flat springs ; the crank had attached to it four air cylinders, and the crank centre rotated independently of the wheel centre, but was connected by the air pistons. The inventor evidently imagined it possible to utilise the weight of the rider to compress air, and so drive the machine without the exercise of muscular energy. He seems to have expected the necessity of some exertion, as he provided treadles, but the weight of the rider was expected to give most of the power. We need not say that the machine was not in action. It is no doubt impossible to avoid the intrusion of some mechanical absurdities in a huge exhibition like this, but surely a little care would have excluded an attempt so obviously behind the present state of mechanical enlightenment. Beside this exhibit, we examined a steam tricycle of somewhat complex construction. We hardly think such an invention likely to find favour among our countrymen, as, after all, the great charm of the bicycle and tricycle is the exercise it affords.

SCOTT'S PATENT HIGH-SPEED ENGINE.

Messrs. John Fowler and Co., Limited, engineers, Leeds, recently exhibited an interesting form of single-acting high-speed engine, which insures a constant pressure upon the crank-pin, and at the same time secures a very rapid cut-off in the high-pressure cylinder, while dispensing entirely with the use of two eccentrics. That the action is exceedingly good is evident from the indicator diagram. Fig. 1 is a section of the single crank engine, and figs. 2 and 3 are indicator diagrams taken under different conditions.

Fig. 2 shows the three cards taken with the brake on with the Crosby indicator, when the boiler pressure was 140lb. per square inch, the revolutions 400 per minute, and the power indicated 50 horse. The set (fig. 3) were taken with a boiler pressure of 82lb., revolutions 336 per minute, and the indicated power 24 horse, by Messrs. Schaffer and Budenberg's indicator. The engine was then driving dynamos to light one of Messrs. Fowler's shops. Referring to our illustration, fig. 1 shows the single-crank engine exhibited in the position of top stroke. Steam is admitted through S, so as to maintain a constant pressure on the top of the high-pressure piston H. When the pistons arrive at bottom stroke the valve V has descended so that steam may pass through the ports p^1 and p^2, from the upper to the lower side of the high-pressure piston. The pressure thus continues on both sides of the piston until about half-stroke, when the piston closes the port p^1, giving a sharp cut-off to the supply of steam to the under or working side of the piston. The pressure below then falls towards top stroke, so that the greater pressure above fully balances the momentum of the pistons and connecting rod, and there is, consequently, no knock at the brasses. When the pistons arrive at top stroke again, the valve V, rising, uncovers p^2 and allows the already expanded steam below the high-pressure piston to further expand into the low-pressure cylinder L by means of the ports p^2 and p^3 until the valve descends and closes p^2. At bottom stroke the steam from the upper or working side of the low-pressure piston L may be exhausted direct, or, as in the engine exhibited (to avoid cooling of the upper end of the cylinder and piston), be admitted at the terminal pressure by the valve V^2 to the underside of the piston during the upstroke, through the ports p^3 and p^4, and be passed away from the underside next downstroke by the port p^4 to the exhaust E.

The governor *xx*, fixed in the flywheel, operates the valve T, which regulates the supply of steam to the underside of the high-pressure piston. A spring on the rod R allows of a limited amount of adjustment. The piston rods pass through metallic stuffing boxes Z and Z^1. An arrangement is provided at the back of the engine for regulating the height of the water and oil in the crank chamber.

The engine is, in our opinion, most ingenious, and it runs with great smoothness at very high speeds. It is made by Messrs. Fowler in sizes ranging from 14 to 64 indicated horse power, at 140lb. per square inch pressure, and both single and double crank.

COMPOUNDING OF LOCOMOTIVES BURNING PETROLEUM REFUSE IN RUSSIA.*

In fulfilment of his promise, made in a former discussion upon the compounding of locomotives (Proceedings, 1886, page 391), the author has much pleasure in now communicating to the institution the results of the experience he has thus far acquired in the compounding of existing petroleum-burning locomotives on the Grazi and Tsaritsin Railway in South-East Russia.

Amongst the conflicting opinions entertained as to the utility of compounding in locomotives, the author, like many others, had his doubts on the subject in 1886. In order to satisfy himself on the question, he obtained the sanction of the Government for altering one locomotive, by way of experiment, according to his own plans. The altered goods engine, No. 35, was put to work on 1st September, 1887 ; and after some modifications in the valve gear, suggested by indicator diagrams taken in preliminary trials, it was finally completed, and the driver was allowed over a month's running to get fully acquainted with the handling in regular service. Comparative trials were then made of the compound against a non-compound with the same weight of train on the same days, the two trains being run one after the other, with an hour's interval between, so as to expose them both to the same circumstances in regard to weather. It was proved without doubt that the compound burnt 22 per cent less of the petroleum refuse used as fuel than the non-compound.

In consequence of this very favourable result, the compounding of other locomotives was at once proceeded with. At the present time (May, 1889) there are already in daily use in the regular train service on this line six compound goods engines with six wheels coupled, and one compound passenger engine with four wheels coupled ; and in the shops, in course of reconstruction, two passenger and four goods engines. It is intended to go on altering the rest of the locomotives to the compound plan as fast as the limited means in the railway works at Borisoglebsk will admit of this being done.

Economy of Compounding.—The fuel economy in the passenger engine the author believes cannot be less than 20 per cent in the second or third notch, though there are not yet data enough for confirming this opinion with absolute certainty ; i will be greater when the driver manages the engine better. Th mean economy in the six goods engines is now found to be 18 per cent, which is a very good result, though less than what wa got in the actual trial of the first one compounded. Including the passenger engine, therefore, the fuel economy in the compounded engines may be now safely taken at 18½ per cent in comparison with ordinary locomotives. Last winter, 1888-89, was exceptionally severe, with from 55 deg. to 65 deg. Fah. of frost ; but the compounds ran equally well with the other engines, giving no inconvenience on account of the great cold.

Dimensions of Engines.—During the progress of these alterations and of the author's observations on the working of the altered engines several difficulties developed themselves, for which remedies had to be devised ; these will no doubt interest all engineers concerned in the adoption of compound locomotives. One of the altered six-wheel coupled 36-ton goods engines has the following main dimensions affecting the compounding : Cylinders, 18½in. and 25⅝in. diameter, and 24in. stroke ; ratio of areas, 1·000 to 1·912. Slide valves, maximum travel, 4¾in. ; angle of advance of eccentrics, 20 deg. ; high-pressure valve, outside lap, 0 81in., inside clearance 0·08in. ; low-pressure valve, outside lap, 0.67in., inside clearance *nil*. Stephenson link-motion. Receiver, capacity, 3·28 cubic feet ; surface exposed to smoke-box heat, 11·52 square feet. Boiler pressure, 9 atm. = 135lb. per square inch above atmosphere. Six wheels, all coupled, 4ft. 3in. diameter. Adhesion weight, 36 tons. Tubes, number 151, outside diameter 2⅛in. ; length between tube plates, 13ft. 10⅛in. Heating surface, tubes, 1,164 square feet ; fire-box, 67 square feet ; total, 1,231 square feet. Fire-grate area, 17 square feet, prior to burning petroleum, but no fire-grate is now used.

The diameter of the high-pressure cylinder is 18½in., and of the low-pressure 25⅝in., the piston areas being consequently 269 and 516 square inches, or in the ratio of about one to two. The original stroke of 24in. is retained unaltered, and the boiler pressure is 135lb. per square inch above the atmosphere. On first testing the engine with the original eccentrics, giving the valves a maximum travel of 4½in., and having an angle of advance of 30 deg., it was found from the indicator diagrams that very excessive compression took place in the high-pressure cylinder, and too early a cut-off in both cylinders. The new eccentrics

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* Paper read by Mr. Thomas Urquhart, Locomotive Superintendent, Grazi and Tsaritsin Railway, South-East Russia, at the Institute of Mechanical Engineers, Paris meeting.

SCOTT'S PATENT HIGH-SPEED ENGINE.

CONSTRUCTED BY MESSRS. J. FOWLER AND CO., ENGINEERS, LEEDS.

(For description see page 492.)

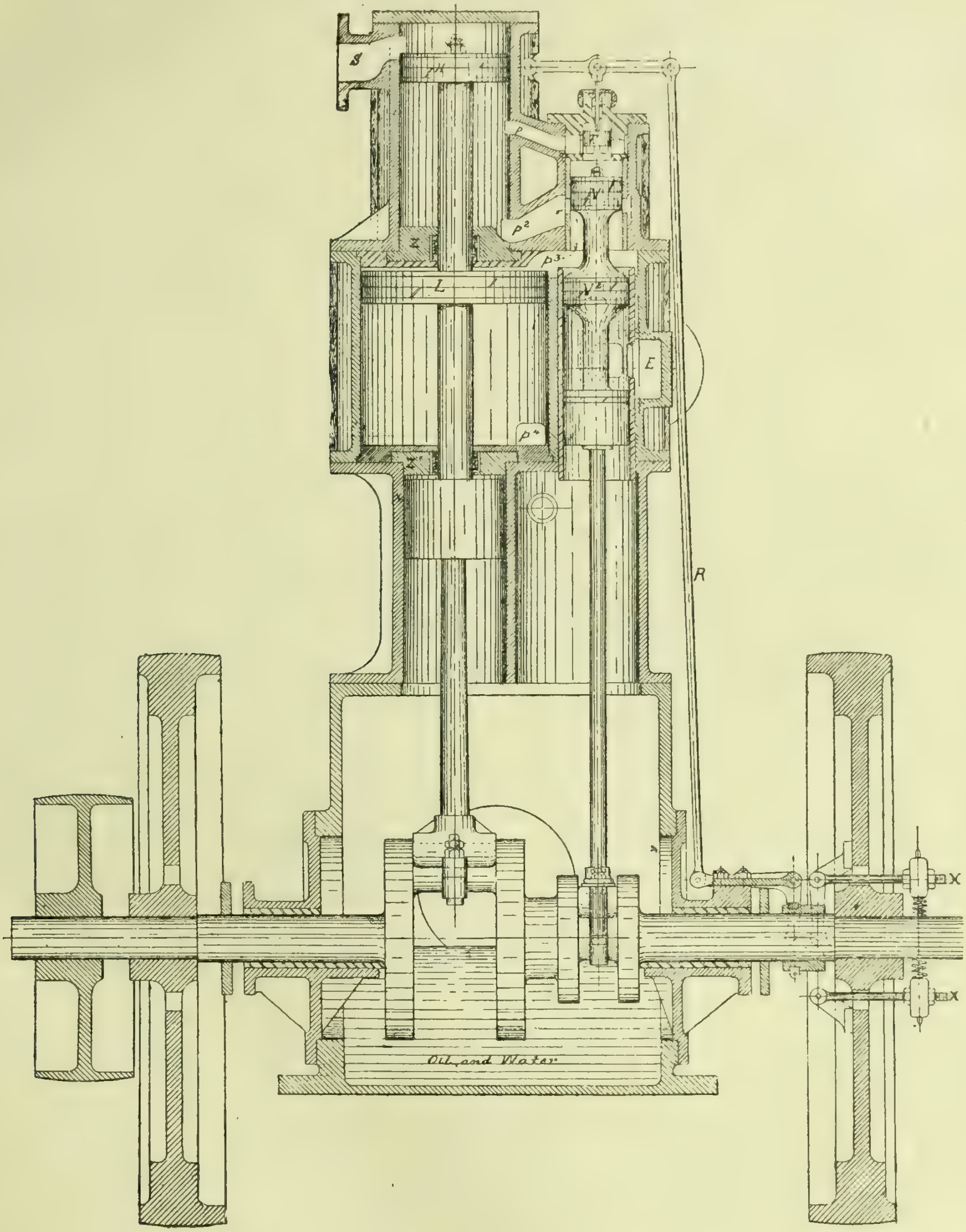


FIG. 1

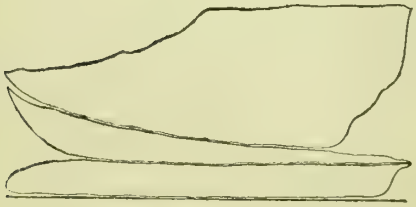


FIG. 2.

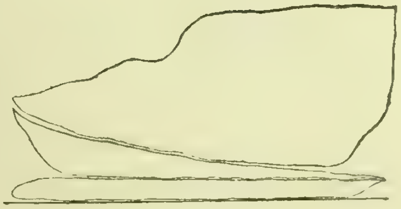


FIG. 3.

now used for all the compounded locomotives give the valves an increased travel of 4¾in., and have angles of advance of 20 deg. The indicator diagrams, taken in forward gear since these alterations were made, show an improved distribution of steam, the engine giving out ample power in the third and fourth notches for the heaviest trains up the steepest gradients on the line of 1 in 125 ; in fact, so far as the power of the engines is concerned, the compounds take their regular turns in the service, drawing the same number of trucks as the non-compounds, and keeping punctual time. The trial trains, as well as the ordinary trains in summer, consist of thirty loaded trucks of 16 tons each, or a total load of 480 tons, exclusive of engine and tender. In these indicator diagrams 10 per cent has been added to the mean pressure in each cylinder, in order to allow for the effect of the pipe connection from the cylinder to the indicator. All the engines have screw reversing gear, enabling the driver to use any degree of expansion intermediate between the extreme limits of mid gear and full gear ; and the four notches mentioned on the diagrams and in the appended Tables 1 to 6 are given merely for comparison with the ordinary nomenclature when a reversing lever and a sector with four notches are used.

TABLE I.—Mean Steam Pressures and Temperatures of Steam in Six-wheel Coupled 36-ton Compound Goods Locomotive, No. 35.—High-pressure Crank Leading in Forward Running.

See Indicator Diagrams, Fig. 9.

Cylinder	Cut-off.		Steam Pressures, lbs. per square inch.					Temperatures of Steam.			
	No. of Notch.	† Percentage of Stroke.	Valve Chest.	Mean Forward.	Mean Back.	* Mean Effective. D	D × 1·1	Beginning of Stroke.	End of Expansion.	Utilised in Expansion.	Utilised in both Cyls.
	No.	Per cent.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Fah.	Fah.	Fah.	Fah.
High-pressure, right hand.	1	47	132·4	92	63	29	32	356°	293°	63°	
	2	60	132·4	110	58	52	57	356°	311°	45°	
	3	72	132·4	119	55	64	70	356°	324°	32°	
	4	82	132·4	127	57	70	77	356°	333°	23°	
Low-pressure, left-hand.	1	49	47·1	27	7·1	19·9	22	295°	237°	58°	119°
	2	67	51·5	34	5 7	28·3	31	298°	257°	41°	99°
	3	79	52·9	41	4·3	36·7	40	300°	273°	27°	83°
	4	86	55·9	48	2·8	45·2	50	302°	284°	18°	72°

† The point of cut-off in percentage of stroke is given as marked from the valve setting.

* The mean effective pressure in column D is the difference between the mean forward and backward pressures; in column D × 1·1 it is increased by 10 per cent to allow for the throttling effect of the indicator pipe and connections.

TABLE 2.—Power Developed by Six-wheel 36-ton Coupled Goods Locomotive, No. 35.

High-pressure Crank leading in forward running.

Grade of Expansion.	Speed of train.	Driving Wheels.	Piston Speed.	Indicat'd Horse Power.	Tractive Power.	Ratio of Tractive Power to Adhesion Weight.	
No. of Notch.	Miles per hour.	Revolutions per min.	Feet per minute.				
No.	Miles.	Revs.	Feet.	I.H.P.	Tons.	Per cent.	Ratio.
1	20	131	524	310	2·655	7·7 =	1 to 13
2	18	117	468	452	4·192	11·9 =	1 to 8·4
3	17	100	400	476	5·543	15·8 =	1 to 6·3
4	13	87	348	475	6·195	17·8 =	1 to 5·6

TABLE 3.—Mean Steam Pressures and Temperatures of Steam in Six-wheel Coupled 36-ton Compound Goods Locomotive, No. 35. Low-pressure Crank Leading in Forward Running.

See Indicator Diagrams, Fig. 10.

Cylinder.	Cut-off.		Steam Pressures, lbs. per square inch.					Temperatures of Steam.			
	No. of Notch.	† Percentage of Stroke.	Valve Chest.	Mean Forward.	Mean Back.	* Mean Effective. D	D × 1·1.	Beginning of Stroke.	End of Expansion.	Utilised in Expansion.	Utilised in both Cyls.
	No.	Per cent.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Fah.	Fah.	Fah.	Fah.
High-pressure, left hand.	1	38	132·4	82	70	12	13	356°	288°	68°	
	2	54	132·4	105	73	32	35	356°	309°	47°	
	3	68	132·4	121	61	60	66	856°	322°	34°	
	4	80	132·4	131	64	67	74	356°	345°	11°	
Low-pressure, right hand.	1	38	55·88	24	11	13	14	302°	225°	77°	131°
	2	55	55·88	37	9	28	31	302°	248°	54°	108°
	3	68	55·88	43	4	39	43	302°	266°	36°	90°
	4	80	55·88	51	4	47	52	302°	286°	16°	70°

† The point of cut-off in percentage of stroke is given as marked from the valve setting.

* The mean effective pressure in column D is the difference between the mean forward and backward pressures; in column D × 1·1 it is increased by 10 per cent to allow for the throttling effect of the indicator pipe and connections.

Sequence of Cranks.—The first four compounded engines turned out of the shops had their high-pressure crank leading and low-pressure following in forward running ; and in Tables 1 and 2 are given the corresponding mean steam pressures, and temperatures of steam, and power developed. In order to test the effect of the reverse sequence of cranks, one goods engine (No. 53) was altered to have the low-pressure crank leading and the high-pressure crank following in forward running ; and in Tables 3 and 4 are given the corresponding particulars for comparison with Tables 1 and 2. From the indicator diagrams taken in forward gear with the latter arrangement, it was noticed that inconvenient and very excessive compression takes place at the first notch in the high-pressure cylinder, so much so indeed that this notch is not used ; but in all the other notches a good distribution takes place. In the low-pressure cylinder a much better distribution takes place at all notches compared with engines having the high-pressure crank leading; and this engine with the low-pressure crank leading, which has only recently been put to work, seems to develop more power and to burn less fuel than the others having the high-pressure crank leading. This is the first time, so far as the author is aware, that the sequence of cranks in compound locomotives has been taken into consideration. The receiver capacity is equal to that of the high-pressure cylinder; and all the dimensions are the same in both the above cases.

(To be continued.)

ENGINE PATTERNS.—IV.

My present article illustrates a cylinder, figs. 19 and 21, which is used upon certain types of steam cranes. It is bolted to the side frames or cheeks, with its longitudinal axis in the vertical direction, the crank shaft being above. The cylinders are used in pairs, on opposite side frames, and the crank pins are at right angles, no flywheel, of course, being used. The peculiar design of the cylinders is due to the requirements of the mechanism of the crane. The feet A, figs. 20 and 21, are bolted to the side frames, and the steam chest B projects within openings in the frames; so that while the piston rods are situated outside the frames, the valve rods and reversing gear are inside. The position of the steam chest, set very much towards the upper end of the cylinder, results from the endeavour to keep the cylinder as low down on the frames as possible, to obtain length for the connecting rods; but the steam chest cannot be kept correspondingly low, because it so happens that a cross frame, which carries slewing friction rollers, running round the central post of the crane, blocks the way. Throwing the steam chest up so high necessitates the bringing down of the outlet of the exhaust diagonally, involving a rather peculiar construction of the core box. It also makes the steam passages of unequal length and of different outlines.

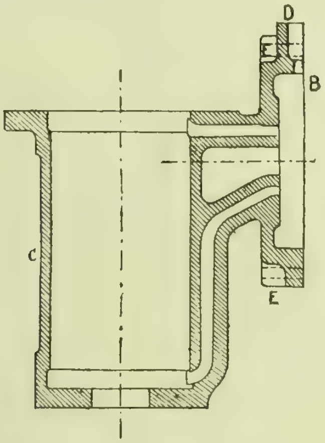


Fig. 19.—Longitudinal Section.

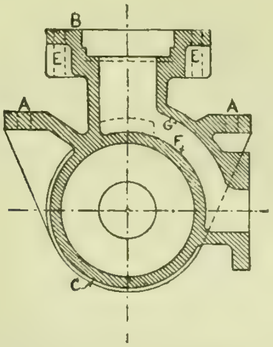


Fig. 20.—Section through Exhaust.

In figs. 19 and 21, C is the cylinder body. One end is cast blank but for a hole through which the nut of the piston rod projects, and the bottom cover is of the same diameter as the cylinder body, and is only fastened with studs. The steam chest is divided through the valve rod stuffing box D, the portion which is bolted on being a counterpart of that cast on the cylinders. The lugs E afford strength around the bolts.

The pattern, figs. 22 and 23, is moulded with the valve face downwards instead of sideways, as in the previous examples. This requires the dowelling on of the steam chest, the division being made along the face A A. The feet B are left loose also in the body C, the alternative being to core out the portion D. Being left loose, drawback plates are used. The plates are bedded down just beyond the outer edges of the feet, and prongs cast unto them are bent over to hold the sand in the space D. The feet are not dowelled, but screwed from the inside of the cylinder body, the screws being withdrawn after the ramming up is completed, and before the cylinder body is withdrawn. The body C of the cylinder is lagged up, as in previous examples, and grooved for the top flange. The brackets F are fitted between the feet and the cylinder body at one end, and between the feet and flange E at the other, and are fastened to B to deliver with it.

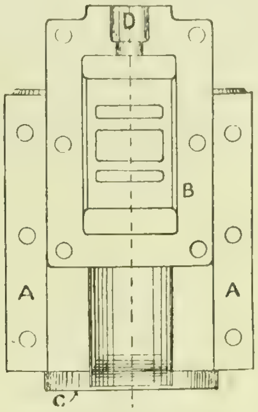


Fig. 21.—Steam Chest Face.

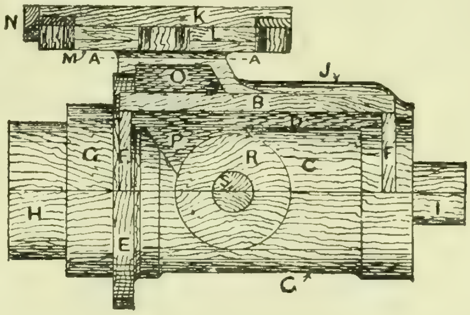


Fig. 22.—Side View.

The flange is turned with a hollow, as usual. The head metal G is next the top flange. There is a large print H, and a small one I.

The passage block J is fitted between the flanges to the curvature of the cylinder, and rounded as seen in fig. 23, and cut in the longitudinal direction to the outlines seen in fig. 22. That half of the pattern to which this is fitted is laid with its joint face upon a joint board, and the distance of the face A A from and its parallelism with the face of the joint board is tested carefully with a straightedge and rule or calipers. So also, when the steam chest K is dowelled, the truth of its top face is similarly tested. This chest is framed together in strips L, and a back M is nailed on, out of whose thickness the hollow is worked. The flange K is framed with half-lapped joints, and

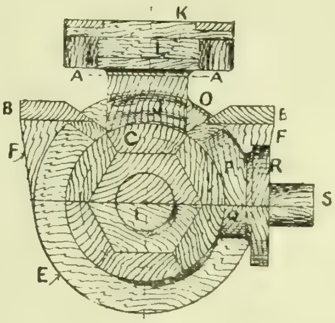


Fig. 23.—End View.

nailed upon the strips. Within the pattern of the steam chest are nailed, or dowelled, pieces composing the valve face and edges, and the three prints for the passage core, whose relations are shown in figs. 19 to 21. That moiety of the stuffing box N which comes on this part of the steam chest has the centre line of its bolts in a diagonal direction, so that one gland bolt is tapped into the cylinder casting, and the other into the casting of the steam-chest cover. Bosses for the bolts are worked and nailed on.

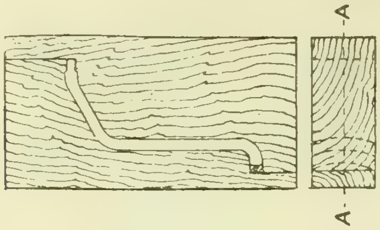


Fig. 24.--Section A A.

The exhaust branch is fitted in three pieces, one portion O between the foot and passage block, another P outside the foot, another Q on the opposite half of the pattern. There is the flange R fitted in two pieces, and the round print also S in two portions. All these parts are loose, being screwed from the inside of the pattern, or otherwise held with skewers, because they have to be drawn into the mould similarly to the feet.

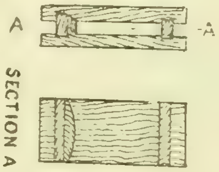


Fig. 25.—Section A A.

The steam passage core boxes are of single construction. They are shown in figs 24 and 25, and the figures are self-explanatory. But the exhaust box, fig. 26, is more troublesome, and it is as well to note the correspondence of the first core with the mould, and alter the box or pattern, otherwise the metal will be thicker in some places than in others. The best way to make the box is to obtain flat faces A A at a distance apart from one another corresponding with the distance apart of the centres of the exhaust port opening and of the hole in the branch. The port opening and the round hole will be marked upon the faces B and C respectively of the core box, and then worked inwards. Afterwards the curved passage will be worked from one portion to the other. The diagonal joint face D is simply a rough mean between the curvatures of the passage. The radii D and E of the passage correspond with F and G respectively in fig. 20, and the intersection of the centre lines F F and G G in fig. 26 gives a centre H corresponding with the centre of the cylinder, from which centre the curves D and E are struck. The curvature in the other direction is worked partly by templates, partly by the eye, and the first core is tried in place and altered if the thickness of metal are not uniform.

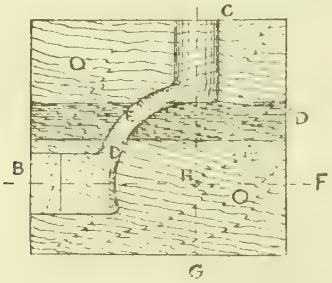


Fig. 26.—Plan of Joint Face.

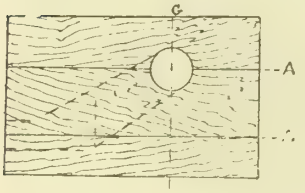


Fig. 26.—Side View.

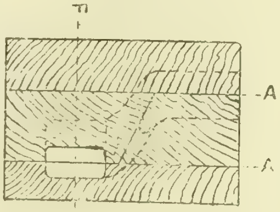


Fig. 26.—End View.

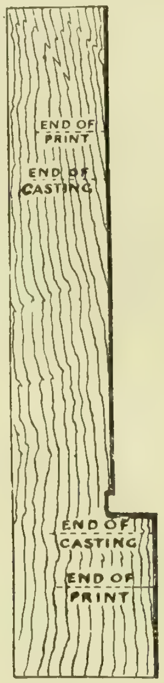


Fig. 27.

Fig. 27 shows the board used for striking up the main core. Its correspondence with the casting is clear by a comparison with fig. 19, and the lettering shows the usual method of stamping these boards. The diameters are also either stamped or struck upon the board face, though not shown here.

J. H.

THE CAPACITY OF AIR PUMPS.

(Continued from page 467.)

When the air and water are subject to say a pressure of 160lb. per square inch, the difference in their density is much less than when under atmospheric pressure. It will result that the upward velocity of the bubbles will be much less under these conditions, and it may happen that the horizontal currents will carry the bubbles along so fast that they will not have time to rise above the level of the top of the outlet pipes before arriving at its mouth. Attention should be paid to this fact in designing air vessels, as it is better for all the undissolved air to be liberated in them. As an example of how air in the feed water will affect the vacuum, suppose the water going along the pipes to the boilers to contain the maximum quantity of dissolved air possible under the temperature and pressure conditions existing in the pipes. This would be at a temperature of 102 degrees, and under atmospheric pressure 1·52 per cent by volume, but if the pressure be 165lb. per square inch, or an absolute pressure of 12 atmospheres, the quantity would be 18·24 per cent by volume after the air is reduced to atmospheric pressure. If the air pressure in the air pump be $\frac{1}{60}$th of an atmosphere, the above would expand to 1,094·4 per cent, or the volume of the air would be about 11 times the volume of the condensed steam. If the volume of the condensed steam be taken as ·000,983V, the air pump would have to remove a volume = ·0118V per revolution ; that is to say, its capacity should be about $\frac{1}{90}$th of that of the low-pressure cylinder. It is not suggested that this is an accurate representation of what occurs generally, but serves to show how small a quantity of air introduced by the feed pump affects the vacuum. If the feed arrangements preclude a possibility of any air being introduced except such as may be taken into solution in the hot well (and this would be a very small quantity, probably not more than 1 per cent by volume at atmospheric pressure), the only manner in which air can find its way into the condenser would be by leakage.

It is possible that the decomposition of the cylinder lubricant may evolve some permanent gases, but there does not seem to be any information on this point. If the air pump does not maintain a good vacuum when made of sufficient size and having sufficient area through the valves, the result must be due to leakage into the pumps or into the condenser and parts in communication with the latter. It is, of course, impossible to predict what will be the loss by leakage, but it may not be without interest to glance at the various places in which it may occur. In the pumps shown in figs. 1 and 2, page 444, the discharge valves and joints of their seats are well covered with water, so that there will be no air leakage at these places. There is a possibility of leakage at the end cover, but these joints are easily made tight. Leakage at the gland would be nearly sure to take place unless a water seal is used. The vertical single-acting pumps shown in figs. 3 and 4, page 444, are in the same way liable to leakage at the joints between the condenser and pump and at the lower doors, but these joints are likewise easily made tight. In the pump shown in fig. 4, page 444, however, there is a chance of leakage at the joint A. The air would pass down between the inner and outer casing and into the space below the foot valves. It is also likely that there would be leakage at the joint B into the space above the bucket, and although this would not affect the vacuum, it ought to be avoided as increasing the work which the pump has to do. Both of these defects might be remedied by making the retaining lip C an extension of the cast-iron casing, as shown by dotted lines, instead of casting it on the delivery valve seating, or, if it is necessary to give stiffness to the latter, the cast-iron extension may be used in addition.

A similar provision is of much more importance when the pump is without foot valves, as any leakage in the space above the bucket affects the vacuum. The water should also have access to the rod below the stuffing box, as there is a danger that if the joints between the cover and the valve guard, and between valve guard and valve seating, are water-tight, there will be an air leakage from the stuffing box between the surface of the rod and the various parts it passes through. An air pump in which there does not seem to have been provision made for this purpose, and in which the retaining lip was cast on the delivery valve seat, kept a tolerably good vacuum, 26in. at full speed, 88 revolutions, but when running at 40 revolutions the vacuum fell to 16in., a result no doubt due chiefly to leakage, though, as we have seen, the speed may, independently of that, be a factor in determining the efficiency of such an air pump. If the speed of the engine be varied without varying the point of cut-off or throttling so as to give the same steam lines on the indicator card, and if the temperature of the discharge from air pump be kept the same, then, the leakage per unit time being supposed to diminish as the difference between the atmospheric and internal pressures is decreased, the loss by leakage should be at one-half full speed; that is, if the pressure in the condenser or pump be raised by ½in. by leakage when the engine is going full speed, then the pressure would be raised by very nearly 1in. when going one-half full speed.

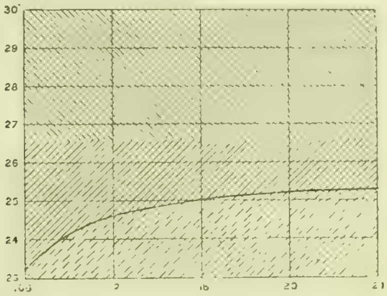
Such a set of conditions, however, is not likely to be fulfilled, as the steam has usually to be throttled or cut off earlier to reduce the speed. Now, in this case the leakage at the low speed may be greater than above indicated, for the steam line on the low-pressure card will fall below the atmospheric line sooner; and if any of the leakage takes place at the low-pressure piston rod gland, the leakage into the cylinder will begin at an earlier point in the stroke, and be more rapid also, since the steam line falls more quickly. The loss by leakage in such a case would be more than twice as much at one-half as it would be at full speed.

The depreciation of the vacuum by lowering the speed is, then, generally a sign of leakage if the fall is due to an increased pressure of air. It must be kept in mind that in the case of an injection condenser, when the speed of the engine is lowered without altering the injection valve opening, that the flow of injection water being approximately constant, and the terminal pressure of the steam lower, while the volume passed into the condenser per unit of time is also diminished, the temperature of the discharge, and consequently vapour pressure, will be less than at full speed, and this will tend to increase the vacuum. On the other hand, the quantity of water and air to be removed per stroke of the pump will be greater, and the air pressure will rise on this account and lower the vacuum. Such effects must, of course, be allowed for before it is determined whether the fall in the vacuum is due to leakage or not.

Similarly, if the speed of an engine exhausting into a surface condenser be reduced, the temperature of the discharge will be altered, for not only is the terminal pressure of the steam lower, but in passing over the tubes it remains longer in contact with them; so that, even if the quantity of water passing through the tubes were reduced in the same proportion as the weight of steam to be condensed, the temperature of the vapour would be lower, and a better vacuum would be obtained. In most cases, however, the quantity of circulating water will not diminish in proportion to the speed, even when the circulating pump is driven by the main engine, for, if the inlet to the circulating pump be throttled, it will not take a full charge at the high speed, though it may at the low. This would further increase the vacuum by lowering the temperature, and consequently the vapour pressure.

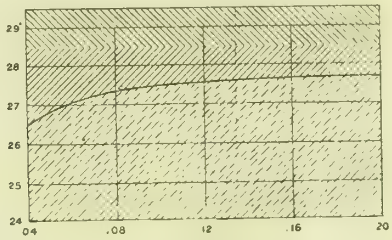
In well-constructed engines there does not appear to be much loss by leakage, and constructors who have most confidence in their work and in those who are to have the care of it might reduce the size of air pumps working in connection with surface condensers, since they are unnecessarily large as generally made. It is believed that if the leakage be slight, the smaller limit to the usual practice (viz., one-tenth to one-eighteenth of the low-pressure cylinder capacity) would give good results. With jet condensation the size of the pump may be increased from the lower limit, in usual practice about one-tenth, to the larger one, one-fifth, and in special cases, such as that for which the curve in fig. 10, above, has been calculated, may be made even larger still with advantage.

FIG 10



In calculating the vacuum by the method above given a high terminal steam pressure was assumed, with a view to render the capacity of the air pump suitable to the maximum work which it has to do, but a more usual terminal pressure, at least in compound and triple engines, would be 4lb. to 5lb. absolute, and a condenser temperature of 80 deg. Fah., with injection at 55 deg. Fah., is not uncommon. The air dissolved is also not likely to be more than 3 per cent for spring water. The curve (fig. 11, above) represents the results of calculations made with these data to represent ordinary working conditions.

FIG 11.



(To be continued.)

A FUTURE FIELD FOR ENGINEERS.—A Shanghai correspondent says that although at present the Chinese are suspicious as to the efficacy of European engineering methods, and prefer as a rule to carry out their engineering works themselves, yet they are beginning to admit that the Europeans are superior to them in scientific knowledge. The Chinese Government is now itself responsible for the reconstruction of the embankment of the Hoang Ho River, the bursting of which some time ago caused such enormous disasters to life and property. The assistance of foreign specialists is always, however, welcomed by the Chinese, even when the latter refuse to commit the carrying out of any great work to foreigners. Should the Chinese Government merely reconstruct the embankments, in a comparatively short space of time it will be necessary to keep dredgers and mechanical excavators constantly at work in the deltas of the river, as they are constantly becoming filled up with deposits. Later on it will probably be found that such measures are insufficient, and that it will be absolutely necessary to carry out engineering operations higher up the river. In that case it would be absolutely necessary to employ skilled engineers from Europe, as also to import European engineering and other appliances. Besides the vast tract of country traversed by the Hoang Ho, that along the southern side of the Canton river, and again that portion about Newchwang in the north, will also require to be dealt with scientifically, so as to preclude the recurrence of terrible and disastrous floods.

THE PARIS EXHIBITION.

Messrs. Aveling and Porter's Exhibit.

Messrs. Aveling and Porter, of Rochester, exhibit some very fine examples of their well-known machinery, including steam road rollers, road locomotives, steam crane engines, and steam ploughing machinery. We illustrate here (fig. 1) their new road locomotive steam engine, and their road locomotive crane engine. In this road locomotive steam engine the cylinder is jacketed, and instead of the customary cast or wrought iron brackets bolted to the boiler, the side plates of the firebox are carried upwards and back, in order to form brackets to carry the crank shaft, counter shaft, and driving axle bearings in one plate. The

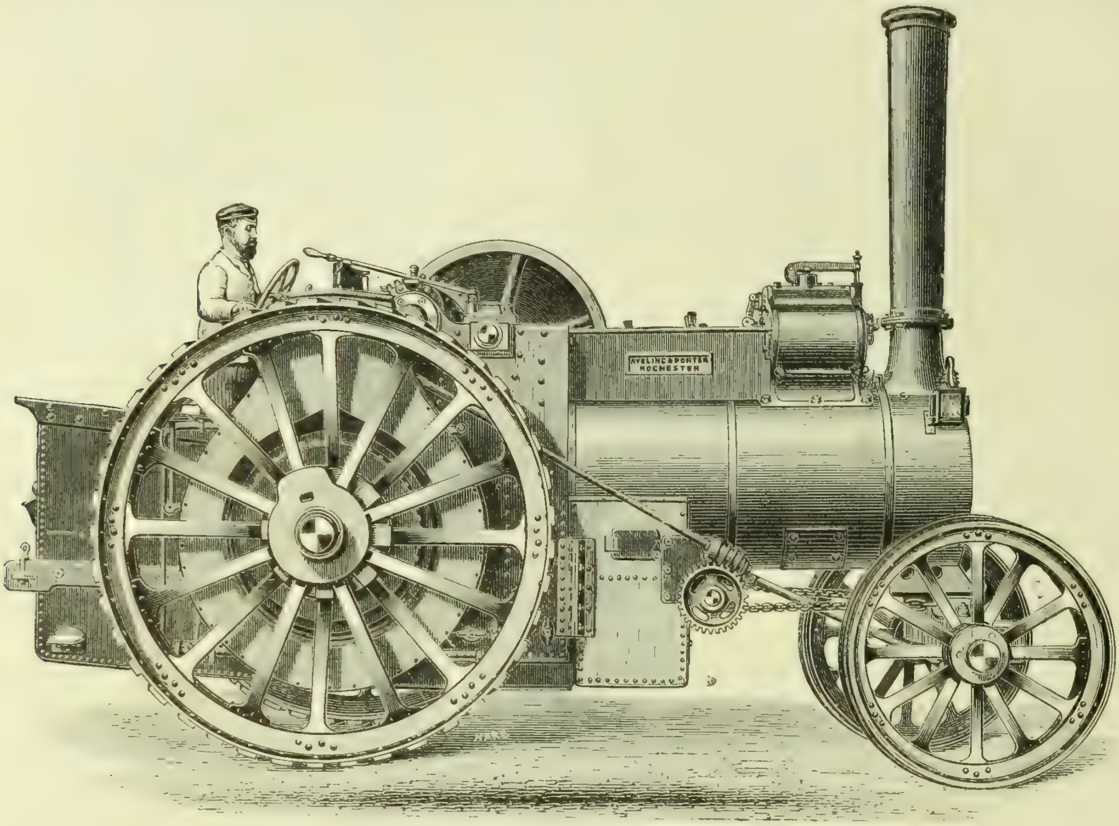


Fig. 1.—Messrs. Aveling and Porter's Road Locomotive Steam Engine.

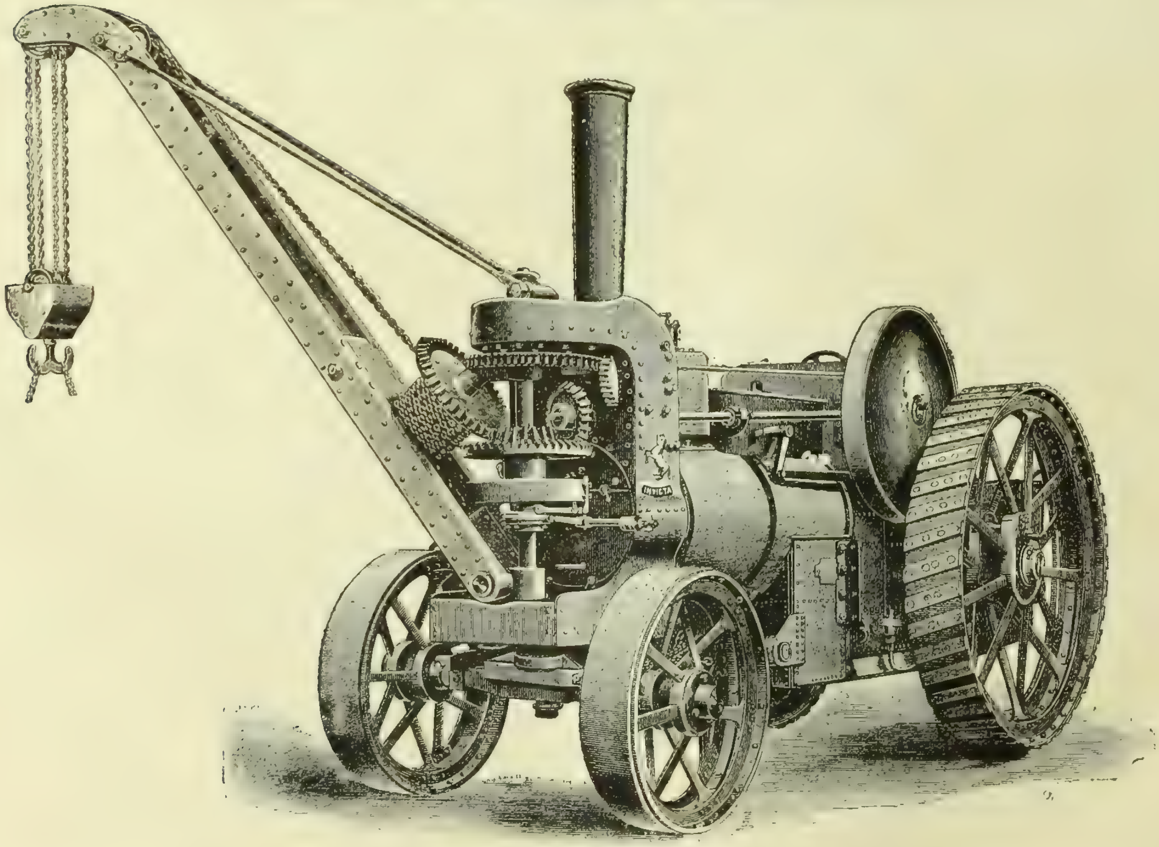


Fig. 2.—Messrs. Aveling and Porter's Road Locomotive Crane Engine.

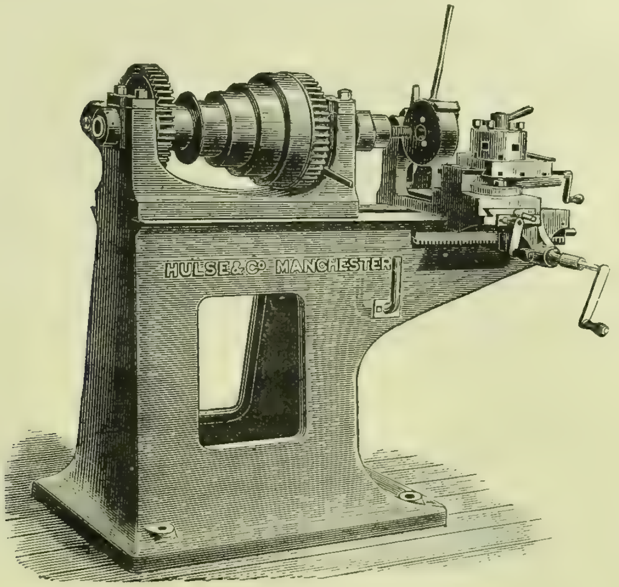
whole of the crank and counter shaft gearing is arranged to work between instead of outside these brackets so formed, and the pinions for two speeds are keyed fast upon the crank shaft, instead of the usual insecure plan of sliding upon feathers. The intermediate shaft is fixed, and serves as a stay to the side plates and the sliding sleeve, which carries the spur wheel, and the fast and slow speed pinions revolve on it. By this design the whole gear is firmly held in what is virtually an integral part of the engine, instead of being merely an attachment to the boiler.

The road locomotive crane engine (fig. 2) is of the same type, so far as the system of carrying the crank shaft and gear is concerned, but it fulfils the additional function of a crane for lifting and carrying heavy weights. It has strong wrought-iron driving wheels, with or without spring tires, and extra wide front wheels. The engine is steered from the footplate, and the entire management—driving, steering, and working the crane—is performed by one person. These locomotives are very handy machines, and are now used by the English and several foreign Governments.

Messrs. Hulse and Co.'s Exhibits.

Messrs. Hulse and Co., engineers, Manchester, have an admirably arranged stand, and show quite a number of their excellent machine tools. We examined with interest one of their patent vertical milling and drilling machines used for milling and drilling great varieties of straight and curvilinear work, such as levers, cranks, connecting-rod ends, brasses, &c., and also for milling the ends, flanges, and ports of cylinders, and drilling the stud holes.

It has a rising and falling spindle carried by and rotating within a hollow square vertical slide, which rises and falls along with the spindle, so that the main bearing of the spindle has a self-acting feed action, similar to that in the vertical drilling machine. The shape and size of the spindle slide are such that the cutter can operate on surfaces of work which could not be got at by the cutter if an ordinary slide were employed. The table for carrying the work consists of longitudinal transverse slides surmounted by a rotary slide, which can be removed so as to allow the work to be fixed to the uppermost of the other two slides when desirable. Each slide has an independent variable self-acting feed action, which can be readily applied, reversed, or suspended as required. The lubricant is contained in a cistern on the standard of the machine, and a centrifugal pump is provided for delivering a constant supply of it to the cutter, the surplus lubricant flowing back into the cistern.



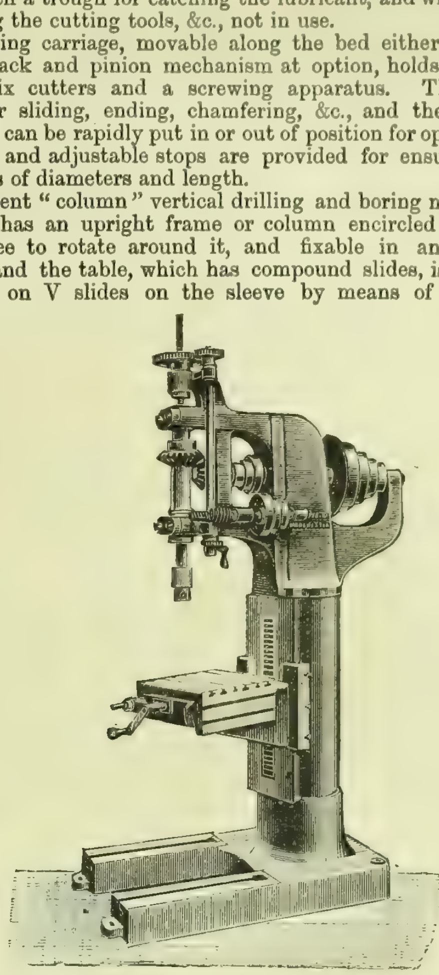
Messrs. Hulse and Co.'s Improved Hollow Spindle Stud Making Lathe.

The machine admits work up to 36in. diameter and 16in. in height when the rotary slide is in position. When this slide is removed, however, objects up to 24in. in height can be operated on.

We illustrate here their improved hollow spindle lathe for turning, screwing, and finishing stud pins, &c., up to 1½in. diameter, out of long bars. The bars are passed through the spindle, which is fitted with a connecting chuck for gripping them while being operated on. Immediately each article is completed and cut off, the bar is released and fed forward, so as to present a fresh portion to the action of the cutting tools. Much time and expense are saved by this system as compared with the old plan of cutting the bar into lengths and then centring each length before putting it into the lathe. The lathe has only one headstock, which is double geared, and is carried upon a bed formed with a trough for catching the lubricant, and with shelves for holding the cutting tools, &c., not in use.

The sliding carriage, movable along the bed either by guide screw or rack and pinion mechanism at option, holds a capstan rest for six cutters and a screwing apparatus. The several cutters for sliding, ending, chamfering, &c., and the screwing apparatus, can be rapidly put in or out of position for operating on this work, and adjustable stops are provided for ensuring exact repetitions of diameters and length.

The patent "column" vertical drilling and boring machine we illustrate has an upright frame or column encircled by a long sleeve, free to rotate around it, and fixable in any required position, and the table, which has compound slides, is traversed vertically on V slides on the sleeve by means of rack and pinion. The spindles, rotated by a long tube running in adjustable bearings, have a variable self-acting screw-feed action, with an adjustable nut for taking up any end play. The machine has a 1½in. spindle, is single geared, and admits work up to 24in. diameter and 3ft. 6in. in height on base plate.



Messrs. Hulse and Co.'s Patent Column Vertical Drilling and Boring Machine.

Messrs. Hulse also exhibit an improved double-geared screw cutting lathe, a five-feed patent radial drilling and boring machine, horizontal double slot drilling machine, a horizontal milling machine, and a universal cutter grinding machine, all of excellent workmanship, and bearing evidence of great experience and thought in design—altogether forming a most creditable collection of the best type of our Manchester machine tools.

AN INTERCHANGEABLE MINERS' LAMP.

A new and improved miners' safety lamp has just been patented and brought out by Mr. Patterson, lamp manufacturer, Newcastle, the object aimed at by the inventor being to save cost and trouble to mine managers, who have now to use several different kinds of safety lamps. To this end, the new lamp has been made interchangeable, and may be said to combine three lamps in one—the bonneted Clanny, the Marsaut, and the bonneted Davy. The condition and requirements of coalmines differ, some having a large amount of gas nearly always present, and requiring the utmost vigilance on the part of the manager and his subordinates, while in other pits gas makes its appearance only now and then, and sometimes at long intervals. Hence several different kinds of lamps are now in use. One kind of lamp is given to the driver and putter, another to the wasteman and the off-handed man, another to the deputy, and another to the hewer in many cases. Thus, large collieries are often driven to keep a heavy stock of different kinds, involving much trouble and great expense. It often happens that no part of one lamp will fit another, but, as all go into the same lamp cabin, there is some danger of mixing up, besides which a stock of spare parts must be held in readiness to meet breakages. Mr. Patterson's attention having been called to this matter, he endeavoured to meet the requirements, and now claims to have produced a standard lamp adaptable to all the varied needs of a large colliery. We understand from the inventor that the new lamp has been subjected to severe tests in different velocities, and has proved in the trials as safe as it is simple and adaptable.

ON OIL-CARRYING STEAMERS.

(Concluded from page 415.)

In practice the number of tanks that may be simultaneously filled increases as the loading proceeds, and the number that may be simultaneously discharged decreases as the vessel rises out of the water. It is not difficult in any given case to draw up regulations ensuring that a vessel may be loaded or discharged with the greatest rapidity consistent with safety. Indeed, in this respect, as well as in respect of her stability at sea, the problem of the oil steamer is much simpler than that of the ordinary cargo-carrying vessel. The latter is engaged as the market demands, seldom carrying two cargoes alike, and frequently shipping mixed cargoes, the scattered arrangement of which it is impossible for the naval architect to anticipate by calculation in any estimate of stability. Rough rules to the effect that a certain proportion of the whole cargo should be stowed in the hold, and the remainder in the 'tween decks—as, for instance two-thirds in the hold and one-third in the 'tween decks—although common with stevedores and others, are very unreliable unless due allowance be made for the nature of the cargo and the method of stowage. Moreover, under such a rule, no cognisance is taken of differences in the breadth of vessels having the same depth, and in that way broad vessels may be made too stiff, and narrow vessels too tender. I well remember a case in which I was engaged that illustrates this point very well. The vessel, as originally laden, mainly with bulk cargo, had rather less than 30 per cent of the weight in the 'tween decks, and in that condition had a metacentric height of 4ft., owing to her great breadth. She met with a disaster before she had been many days at sea, put back, had most of her first cargo taken out, and was restowed with deadweight cargo; but although more than 40 per cent of this was stowed in the 'tween decks, she was found to have the same metacentric height as before. I had a little difficulty in showing the Wreck Commissioner and the Assessors that the vessel was as stiff as before, and that the fact that she was able to carry more than 40 per cent of her cargo in the 'tween decks on the second voyage without being less stiff than on the first, with less than 30 per cent, was entirely due to the fact that while the first cargo practically filled the hold and 'tween decks, the second cargo, being of much smaller bulk, did not rise to a great height either in the hold or 'tween decks. Had the same proportion of the cargo been stowed in the 'tween decks on the second occasion as on the first, the vessel's metacentric height would have been increased by more than a foot, and she would have been made unduly stiff.

While such difficulties as the above make the elaboration of rules for the loading of vessels carrying heterogeneous cargoes of doubtful value, for specified homogeneous cargoes the actual amount of stability may be predicted with great accuracy. The oil steamer is in the position of always carrying a definite amount of homogeneous cargo—oil on the outward voyage and water ballast on the inward—and is therefore capable of having her stability determined with great nicety in each of the conditions in which she is liable to be placed.

In concluding this paper, it may be of interest if I specify the kind of information I supplied for the two vessels to which I have alluded. It consisted of—

1. The number and positions of the tanks to be simultaneously filled at New York, from the commencement of the loading to its completion.
2. The number and positions of the tanks to be simultaneously emptied at the end of the voyage, from the commencement of the discharge to its completion.
3. The number and positions of the tanks to be filled with fresh water for the return journey, so as to give a proper trim and sufficient stability, together with the order in which they should be filled.
4. The order in which the fresh water tanks should be pumped out on arrival at New York.

APPENDIX.—List of Petroleum-carrying Vessels.

Name.	Gross tons.	Dimensions.		
		L.	B.	D.
S.S Fergusons.	1551	250	34	18
,, Bakuin.	1669	260	36	17
,, Raleigh, ex Marzo	1348	244	34	15
,, Cebah	473	148	27	12
,, Chigwell	1824	258	36	18
,, Petriana	1672	260	34	21
,, Charles Howard	1304	249	30	16
,, Marquis Scialuna	1655	260	36	18
,, Looch	1446	255	34	17
,, Era	1851	271	37	15
,, Gluckhauf	2307	300	37	23
,, Willkommen	2896	315	41	23
,, Pollux	1433	245	36	18
,, Chester	2834	311	39	25
,, Ocean	2835	310	39	25
,, Sviet	1827	273	35	21
,, Vorwarts	2466	300	37	23
Bk. Lindesnæs	518	138	29	18
,, Crusader	643	145	31	21
S.S. Hafis	1689	270	36	18
,, Titian.	1249	231	31	23
,, Vindobala	1744	261	34	21
,, Robert Dickinson	1978	278	35	22
,, Oka	3095	334	44	16
,, Charlois	3003	310	39	25
,, Star Rock	new s.s.	310	40	23
,, Palmer and Co.'s No. 610	..	263	37	21
,, Swan and Hunter's No. 134	..	270	38	21
,, Manhattan	new s.s.	329	42	23
,, Bayonne	,,	328	42	23
,, Palmer and Co.'s No. 606	..	278	38	20
,, R. Thompson and Sons' No. 152	..	298	40	21
,, R. Craggs and Sons' No. 81	..	279	37	20
,, Craig, Taylor, and Co.'s No. 13	..	291	37	20
,, Motala Co.'s No. —	..	317	40	28
,, J. Haug's No. —	..	240	36	17
,, Armstrong, Mitchell and Co.'s No. 555	..	292	38	22
,, Palmer and Co.'s No. 615	..	310	40	22
,, The Bremerhaven	new s.s.	338	42	38
,, Palmer and Co.'s No. 629	..	278	37	21
,, Valeria	247	120	23	9
,, Caroline Robert de Massy	1742	256	37	17
,, Hans and Kurt	2153	270	39	21
,, Ville de Calais	1837	260	37	20
,, Minister Mayback	2486	285	40	23
,, Paula	new s.s.	..	..	..
,, Caucase	,,	..	..	..
,, Gutheil	,,	..	..	..
,, Ovelg nne	,,	..	..	..
,, Elbruz	2715	309	40	..
,, Sofia	new s.s.	..	..	..
,, Ararat	,,	..	..	..
,, The Kasbeck	,,	..	..	..
,, Phosphor	,,	..	..	..
,, Armstrong, Mitchell, and Co.'s No. 549	..	294	37	26
,, ,, ,, ,, 550	..	320	42	29
,, ,, ,, ,, 553	..	310	40	28
,, ,, ,, ,, 554	..	310	40	28

ROYAL AGRICULTURAL SOCIETY'S SHOW, WINDSOR.—On the last day of the recent show, when the exhibition appeared to be practically at an end, the Pulsometer Engineering Company had a special intimation that the Queen was coming, and intended to visit their stand on the way to the grand stand and march past of ponies, and accordingly they had the honour of showing Her Majesty the various machines exhibited by them, including the "Pulsometer," "Deane," and other steam pumps, and also the Champion hand ice-making machines, by which ice can be produced in three minutes. Her Majesty appeared to take considerable interest in the company's exhibits.

MAGNETO-ELECTRIC BELL.

THE great disadvantage in connection with ordinary electric signal bells lies in the fact that the battery which, up to the present time, has always been required to operate them is very troublesome to maintain in effective order, and is apt to fail unexpectedly, thereby causing much annoyance. Moreover, apart from this, batteries are necessarily always consuming, and are, therefore, continually incurring expenditure for replenishment. After some months' working they must be re-charged, and in a year or two are worn out, and must be renewed entirely. These operations require skilled labour, often difficult to obtain, and thus lead to considerable expense.

To avoid these difficulties electricians have endeavoured to make use of the well-known principles of the magneto-electric machine, which generates electric currents from the mechanical force required to move a coil of wire in the vicinity of a permanent magnet, without any need for a battery at all ; and appliances arranged on this plan have been employed for telegraphic and telephonic purposes.

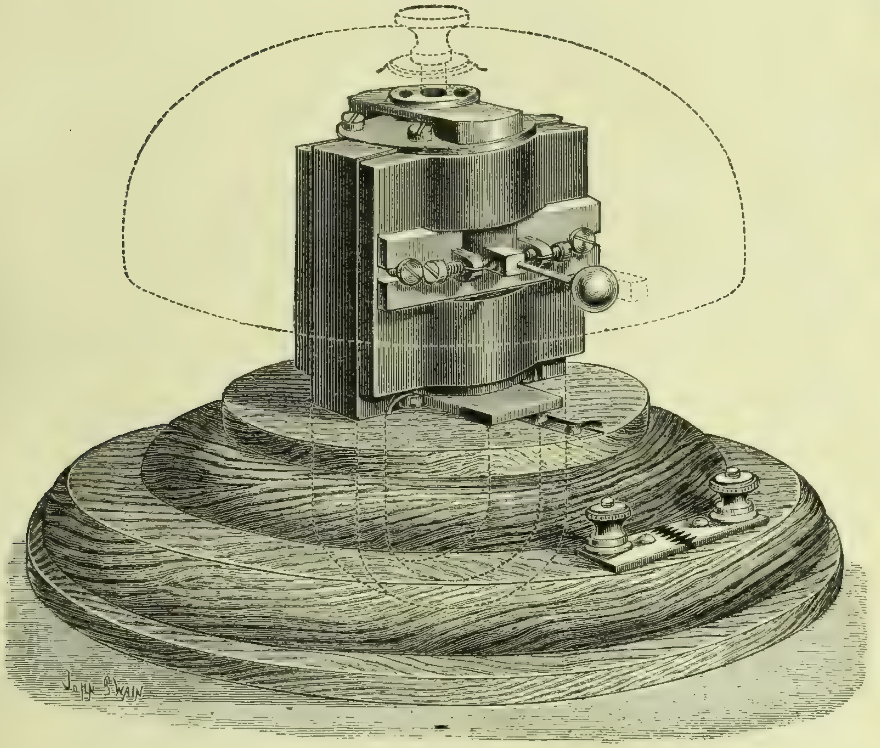


FIG. 1.

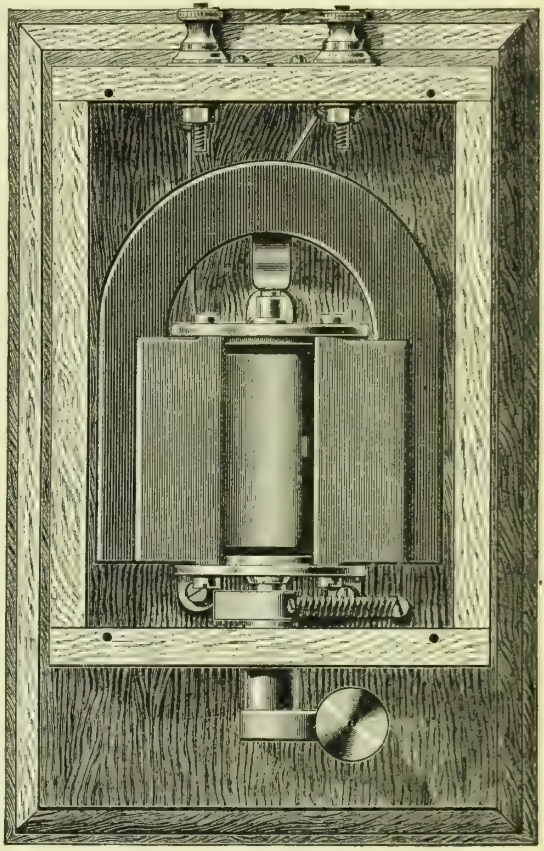


FIG. 2.

The Cox-Walker Swinton signal bells operate on similar principles, but are of an entirely novel design, which renders large sized magneto signal bells practicable for the first time.

The magneto generator, which takes the place of the transmitting key or plunger and the battery, used with ordinary electric bells, is of extreme simplicity. It consists of a compound horseshoe permanent steel magnet fitted with soft iron pole pieces, between which is pivoted an armature composed of a soft iron core in the shape of a shuttle wound longitudinally with insulated copper wire. In connection with this armature is the operating mechanism by means of which the armature is easily rotated backwards and forwards through a small arc, this motion generating electric currents in the armature wire by electromagnetic induction, and thus actuating the bell at the other end of the line.

For single stroke bells the operating mechanism consists of a key similar to the usual tapper or push, which is attached to the armature spindle and causes the latter to rotate against a retractive spring under the pressure of the finger. For operating tremulous bells, on the other hand, a small fish-tail-shaped handle is used, which, when taken between the finger and thumb, and shaken rapidly to and fro, causes the distant bell to ring continuously.

The mechanism of the bell is similar to that of the generator, with the exception that, instead of the key or handle, the pivoted armature is furnished with a hammer that strikes the gong. Referring to our illustrations, fig. 1 shows the bell and fig. 2 the generator in a clear way, readily understood from the preceding description. The bells are introduced by Mr. A. A. Campbell Swinton, Victoria Street, London.

HEAT ENGINES OTHER THAN STEAM.—I.

BY H. GRAHAM HARRIS, M.INST.C.E.*

SIR FREDERICK BRAMWELL, in his presidential address to the members of the British Association, at their meeting at Bath, in September last, made use of the following pregnant words :—

"At the York meeting of our Association, I ventured to predict that unless some substantive improvement were made in the steam engine (of which improvement we have, as yet, no notion), I believed its days for small powers were numbered, and that those who attended the centenary of the British Association, in 1931, would see the present steam engines in museums, treated as things to be respected, and of antiquarian interest to the engineers of those days, such as are the open-topped cylinders of Newcomen and of Smeaton to ourselves. I must say I see no reason, after the seven years which have elapsed since the York meeting, to regret having made that prophecy, or to desire to withdraw it."

As I have said, these are pregnant words, and when I was requested to deliver this course of Cantor Lectures it seemed to me my time would be well spent, and the opportunity which the Council of the Society of Arts gave me would be well utilised, if I made them the text for that which I had to say, and if I endeavoured to bring before those who honoured me with their presence some idea of the theoretical values of the various forms of heat engine already devised and in use, considering these in relation to their practical possibilities, and also describing for each class, as far as time would permit, the mechanical means by which the progress already made has been obtained, pointing out also certain of the difficulties which have to be overcome.

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* Society of Arts Cantor Lectures.—Lecture I., delivered May 6th, 1889.

These words of Sir Frederick were deliberately repeated by him after an interval of seven years, and on so public an occasion (if I may so put it), as his presidential address to the members of the British Association. As I have said, it shall be my task to try to bring before you the various reasons which, after careful consideration, seem to me to render this prophecy certain of fulfilment.

Another justification (if one were needed) for my choice of this subject is, that it is, to some extent at least, popular. This is evidenced by the fact that, in the year 1887, there were some 220 patents taken out in connection with it, and that the numbers per annum are steadily increasing ; thus proving that there are many minds continually at work grappling with and considering the difficulties, with the natural result that there is steady, although it may be slow, improvement.

Let me first try to illustrate to you "graphically" the measure of success that has already been achieved in "Heat engines other than steam," comparing this with that which has been obtained in the steam engine itself.

I will ask you to look at these cubes, and to assume the larger one—that coloured black—represents the amount of heat in a definite quantity of fuel. Then, the smaller one which I am now holding up—which is coloured red—will represent the useful result obtained by aid of that amount of heat in a fairly good steam engine of the present day. You will see how comparatively small it is ; as a fact, its contents are only about 11 per cent of those of the black cube, while this other red cube which I am now holding up represents the useful result obtained by the employment of the same quantity of heat as that shown by the black cube in an ordinary gas engine. See how much larger it is than the other red cube. As a fact, it is nearly twice as large—*i.e.*, its contents are nearly 22 per cent of those of the black cube, which we assumed to represent the amount of heat at our disposal.

I have taken the gas engine as the heat engine to compare with the steam engine, because the gas engine is the form of heat engine other than steam which is the most common, and of which we at present have the most experience.

One of the greatest difficulties with which I have had to contend in the preparation of these lectures has been to determine, for each particular branch of the theoretical portion of my subject, how far I ought to make that which I have to say absolutely elementary, and therefore, somewhat popular, or how much I should take for granted was already fully known to my audience.

To an extent I am governed in this decision by the short time at our disposal, but on consideration, it seem to me better I should err on the side of repeating to you many things which you already know. I am the more ready to do this, because I think it is well that I should at least put into words my ideas of even the elementary portion of our subject.

It will, perhaps, be as well for me to state exactly what I mean by a "heat engine." This title does not necessarily imply moving machinery, but such an engine may be defined as any apparatus or machine to which heat is applied, or in which heat is generated, and from which work in any form results ; or, to put it shortly, a heat engine is any apparatus in which heat is transposed into mechanical work. For instance, a smelting furnace is a heat engine, a steam boiler and a gun are both of them heat engines ; and although you may laugh, and think I am stating a paradox, yet a "cold-producing" apparatus is frequently a heat engine.

The philosophy of heat has been considered, and has, from the earliest days, been experimentally investigated by some of the ablest men who have ever lived. As a consequence, the literature in connection with it is large.

For the complete consideration of the more abstruse questions involved, I must refer those of you who are interested to the works of these men. I may, however, mention two or three of the more recent of those books which treat more particularly of the theory of the heat engine, and will well repay careful consideration and study.

In the year 1884, the late Professor Fleeming Jenkin, in the lecture which he delivered before the Institution of Civil Engineers, on "Gas on Caloric Engines," dealt fully with the theory involved in the working of many forms of heat engines. Professor Goodeve has recently published a work also dealing fully with the theory. Mr. Dugald Clerk (see his work published in 1886) has experimentally investigated the question of the gas engine.

Mr. W. Anderson (Member of the Council of the Society of Arts and of the Institution of Civil Engineers, delivered in this room a series of six lectures, in the Session 1884-85, under the Howard Trust, in which the theory, with some of its applications in practice, was also fully considered, and in Mr. Anderson's masterly manner. Further, there has been this Session published in the Journal of the Society, and read and discussed before one of the Wednesday evening meetings, the report of the judges on the trials of motors for electric lighting purposes, and the paper by Professor Kennedy on these trials. This paper and the report necessarily dealt largely with the subject of gas engines, some of the best of which were tried.

I hope, however, that there is yet room for me ; room for comparison of the theory and of the theoretical values with the practical possibilities, and for comparison of these with the results that have, in practice, been attained up to the present. There is room also for suggestions as to the direction in which further improvement must be sought, not only in those engines which are alone dealt with in the above books and papers, but in others new since their publication, or which have, in new forms, been recently proposed.

It is necessary, in order to consider with understanding the possibilities of heat engines, that we should investigate, to some extent at least, the science of heat and its laws. I do not, however, propose to do this to any greater degree than will enable us to comprehend the practical points in connection with our subject ; nor do I propose to recapitulate the various ideas which have from time to time been propounded as to what heat really is ; but I will ask you to accept that which is now universally agreed to be proved, namely, that heat and motion are convertible the one into the other, or in other words, that the title of that interesting book by Professor Tyndall is correct to its uttermost meaning, and that heat is—"A Mode of Motion."

Two of the earliest of those who investigated and propounded the true philosophy of heat were Count Rumford and Sir Humphrey Davy. The latter proved experimentally that, by rubbing one piece of ice upon another in *vacuo*, the temperature of the ice being 28 deg.. or four deg. below the freezing point on the Fahrenheit thermometer, heat was produced, the ice was melted, and the resultant water had a temperature some three or four deg. in excess of freezing point. He showed that the heat necessary for this increase of temperature could only have arisen from the friction of the one piece of ice upon the other. This experiment was even more conclusive than it at first sight appears, as we shall see when we come to deal with the questions of specific heat and of latent heat.

Count Rumford also had, in a paper read before the Royal Society, on January the 25th, 1798, shown that in the boring of a brass cannon heat was produced, which heat was sufficient to boil water in which the boring tool and the portion of the cannon being operated upon were contained.* He had also, as early as 1778, stated that he had proved experimentally that a gun which was fired without a bullet was hotter after the firing than when fired with a bullet. Count Rumford was not, at that time, cognisant of the dynamical theory of heat, but his suggestion, as I understand it, was that a portion of the heat developed by the explosion of the powder was dissipated or absorbed, in some way or another, in pushing the bullet out of the gun. We now know that this heat which disappears is transformed into the motion of the bullet.

Let us consides this discovery announced by Count Rumford in relation to a big gun (which is one of the simplest forms of heat engine, completing its work, as it does, in one stroke), let us see whether, when we have realised the reasons for that which Count Rumford observed, it will not carry us one step at least towards a complete understanding of our subject.

Here you have a sectional diagram of a big gun. At the left-hand end you see the breech closed by the breech screw, and here the space occupied by the cartridge is shaded and marked with the word "powder." In front of this you have the shot. Now, when the gun is fired the solid powder is converted, as combustion takes place, into gas and heat, and, therefore, heat and pressure are generated, and motion is rapidly imparted to the shot until it is expelled from the gun at a speed which in these days, reaches approximately a mile in two and a half seconds of time, or, if continued, of nearly 1,500 miles an hour. Further, you will see that as the shot is moved forward in the gun, the space behind it, *i.e.*, the space between it and the forward end of the breech screw, necessarily goes on increasing, and is at its maximum just as the shot leaves the muzzle. You will realise also that the gases which result from the burning of the powder would, if the burning were instantaneous, be at their maximum pressure at the moment of explosion, and that, as the space in which they are contained is increased by the forward movement of the shot, the gases having to occupy this larger space will become less in density, and, therefore, lower in pressure.

If you will look above the section of the gun, you will see a curved full line which, at the breech end is at its greatest distance from the dotted centre line through the gun, and is nearest to that centre line at the muzzle end. Now the vertical distance between this centre line and the curved line is intended to represent, at every portion of the travel of the shot, the pressure per square inch which the gases are exerting. At the breech end this vertical distance represents a pressure of about 18 tons on the square inch, and, at the muzzle end, the vertical distance represents about 5½ tons on the square inch, which will, in this case, exist at the moment when the shot is leaving the gun. The space enclosed between the full curved line and the dotted centre line through the gun, represents the "work" done by the combustion of the powder charge, a portion of which work must have been put into the shot in order to cause it to attain the velocity with which it leaves the muzzle.

Now, if that which I have told you is correct, and if heat and motion are convertible the one into the other, and if a portion of the heat due to the explosion of the powder charge, and represented by this space, has really been put into the shot in the form of motion, we should be able to reproduce from the moving shot the heat which in it has been transformed into motion. You, all of you, know we can do this. You, all of you, know that if we suddenly arrest the motion of the shot, heat is developed, and that, in fact, if the shot had sufficient velocity, and was composed of a metal having a low melting point, it might be fused.

A peculiar illustration of this transformation of work into heat by the stoppage of a rapidly moving projectile, is afforded by an incident which Sir Frederick Bramwell has related to me. He was present at the firing of one of the earlier Palliser projectiles. These are, as you know, made of cast iron, the points being chilled in the casting, so as to harden them, with the result that, although cast iron is very brittle, yet the shots will penetrate a thick armour plate, such as would stop a softer projectile.

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* See Tyndall's "Heat a Mode of Motion," 1887 edition, page 47.

When this Palliser shot was fired, it passed completely through the armour plate, the point of it, however, being broken up in doing so. Sir Frederick went to pick up one of the broken pieces. Someone present cautioned him that it would be hot; he, however, knowing it could not be hot on the inside—the motion (or heat) in it having been transformed into the work of penetrating the plate—took hold of it on the inside, and found that, as a fact, it was not hot; and it was not, because the "work" which had been put into it by the combustion of the powder charge in the gun had not been re-transformed into heat, but had been absorbed or dissipated by the shot passing through the armour plate. If the shot had been of a soft metal, say mild steel, it would have been "set up" or "burred over" when the plate was struck, and its motion would then have been transformed into heat, and Sir Frederick could not have touched the broken piece of shell without being burnt. Of course, on the outside of the shot, where it had been in contact with the plate, it was hot, due to the friction of that contact.

Let us now revert to the big gun diagram, and see what it has taught us. We have learnt that heat and pressure are developed by explosion or combustion of the powder charge; that as the shot moves forward the gases expand, or their density is lessened, and that, therefore, the pressure lowers; that a portion of the heat is transformed into motion, and is stored up in the shot, and that we can cause that heat to re-appear by arresting the motion of the shot; and this being so, it follows that when the gun is fired without a shot, as none of the total quantity of heat is abstracted for the purpose of giving velocity to the shot, it should be hotter than when fired with a shot in it, proving, therefore, the truth of Count Rumford's assertion.

Further, we can see that expansion or dilatation of the gases produced by explosion takes place as motion is created, or as work is done; we shall find that a similar expansion of the working agent almost invariably accompanies any transposition of heat into work. I shall have to refer to this very frequently later on.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

BALANCE OF LOCOMOTIVES.

To the Editor of "The Practical Engineer."

SIR,—"The Writer of the Paper," in his letter of July 5th, professes himself incompetent to understand how I can substantially endorse the remarks of "Dreadnought" with regard to a full balanced engine. This confession, if genuine, does not speak well for his logic. Surely, my endorsement cannot fairly be taken as contradicted by what I afterwards pointed out, that at certain speeds a wheel carrying a counter weight for horizontal moving parts would leave the rail.

The question is entirely one of degree, yet the "Writer" takes up my remarks in as captious a tone as though I had stated that a full balanced engine would jump the rail at 20 miles per hour.

There is a limit of speed for every engine so balanced, and that limit is soonest reached with small wheels, from which we may infer that American practice never can attain the speeds possible with English practice with equal safety. Anyone can determine the limit for himself.

If I had written that railway speeds might safely exceed 40 miles per hour, would the "Writer of the Paper" accuse me of being self-contradictory if I wrote also saying that 100 miles was too high a speed? It seems to me he would.

Further, your correspondent is entirely incomprehensible when he says that in arranging a correct balance you cannot disconnect the the locomotive from the permanent way. So long as the permanent way is constructed of sufficient strength for the maximum load or heaviest counter-weight pressure, it can matter nothing how fully an engine is balanced so long as the mechanical department is satisfied.

But, while a solid road bed may be had on earth, it is quite a different matter with the line on a bridge, the stresses in which are so much increased by full balancing, for the vertical action of the counter-weights very soon shows itself in a bridge as vibration, and, therefore, I stated that full balancing which might enable a locomotive to run so well over a nearly solid road, would be good for the locomotive, but might be very bad for the bridges. If the "Writer of the Paper" will turn to some of the earliest numbers of the *Practical Engineer*, he will find the subject of locomotive balance discussed on the principles he is now advocating, as laid down by Professor Reynolds, and showing how two balance weights are required for each piston, &c., for the reason that neither balance revolves in the same plane as the crank pin centre, and, therefore, to prevent swivelling in a horizontal plane, two disturbing elements are needed on each axle to counteract the disturbance introduced by the piston, &c. Of course the two weights in each wheel are shown to be combined, which combination is the cause for balance weight being slightly away from the diametrical line through the crank pin.

In inside cylinder engines only the reciprocating parts should be balanced in the wheels, for the crank cheeks offer the opportunity for directly balancing the purely rotative portions. Indeed, unless there is an objection to the bending stress introduced by the vertical excess of the balance, all parts might be balanced by continuing the crank webs on the other side of the axle.

The object of full balancing, expressed in a few words, is to confine all movement of the centre of gravity of the engine as closely as possible, not merely to the longitudinal central vertical plane of the whole locomotive, but to our vertical cross section of this plane, or simply to cause the centre of gravity to move up and down a plumb line passing through the centre of gravity of the engine when at rest, leaving all the effect of the vertical motion of the centre of gravity to be resisted by the rail and by the gravity of the engine. In ordinary practice this answers. At high speeds the wheel pressures vary very considerably, hence the division of the counterweights between two coupled wheels, the coupled wheel taking up much of the reciprocating action through the coupling rod. At best a locomotive is a compromise, and can never be practically balanced to perfection, for not only does the angularity of the main rod introduce a disturbance, but the guide block thrust, also arising from rod obliquity, tends to effect a transference of load between the leading and trailing or driving wheels, causing transverse surging and longitudinal plunging, whilst the steam action on the cylinder heads, and on the rails, variously influences the two sides of the whole machine, and causes the wriggling action which can only be balanced by having a pair of cylinders on each side of an engine, opposite side pistons moving simultaneously.

The ability to start from any position is, no doubt, a valuable feature in a locomotive, but it is most valuable in slow running engines, with frequent stops. As speeds increase, and the length of runs increase, the disadvantages of a locomotive with both pistons moving simultaneously diminish, and the advantages increase. We all know how Webb's compounds pull irregularly for a few seconds at starting, and how this action rapidly dies away. Abolish the cranks at 90 deg. of the ordinary engine, and the great source of unsteadiness is abolished—uneven steam action.

For a compound engine add two other cylinders on inside cranks, also with simultaneous pistons, but with cranks 180 deg. from the outside cranks, and produce an engine balanced throughout without any vertical action.

To this combination add a small "barring" engine for starting, and you have a high-speed engine which would be eminently suitable for long runs, and in which the fewness of the impulses would be quite unfelt. Surely when ring-spinning frames will sound a continuous uniform hum, though driven by a single cylinder engine at 60 to 80 revolutions, a 75-ton locomotive and tender may be trusted as flywheel to an engine at 300 revolutions.

The idea of cranks at 90 deg. has obtained a grip of locomotive engineering hard to shake off, but I cannot think it will continue in the face of bridge failures in America, which arise from unforeseen vibration, and in face of the demands for higher speeds among ourselves. If there is any objection to the idea of the barring engine attached to a locomotive more than will apply to the Westinghouse brake pump or the steam reversing gear, will some reader point it out. No doubt it will be laughed to scorn by those who have never seen outside a round house, or inside the engine room of an Oldham mill.—Yours, &c.,

W. H. BOOTH.

To the Editor of "The Practical Engineer."

SIR,—When I wrote the letter I sent you on the above subject, pointing out the mistakes made in a paper on the locomotive communicated to one of our societies, I made the statement that the balancing was a matter that had been well understood fifty years ago, and the letter in your issue of 5th inst., from the writer of the paper, does not lead me to believe we know anything more at the present time than was known then.

In the first place, the "precise and lucid explanation" of the statement that "revolving weights can only be balanced for one speed by weights in the wheel rim" will no doubt be read by most of your readers with great advantage to themselves and gratitude for the information it contained.

As for Professor O. Reynold's paper, on which your correspondent places so much reliance, I can't say I notice anything in it—or at least in the quotations given from it—that would lead me to alter my opinion as to the present knowledge of this subject. The only point noticeable is the language, which appears to me as leading all round the world to get to London, if I may use the simile.

Then, as to the "great unknown" quantity to be balanced. I am rather inclined to think that most of the derailments from unexplained causes are more to be attributed to the unbalanced proportion than to the action of the steam in the cylinders, as one of our M.I.C.E.'s suggests; and as for derailments from the vertical action, such a thing has never been heard of, at least by yours truly, DREADNOUGHT.

Glasgow.

PRESSURE IN DRILLING CAST IRON.

To the Editor of "The Practical Engineer."

Sir,—I am a profound believer in the uniformity of nature, and take every opportunity of reducing experiments of all kinds to graphic delineation. If experimenters would only be guided by these rules, the published results would be of much greater value than they often are at present. In your issue of 5th inst., p. 471, you quote the interesting experiments of Mr. L. B. Breckenridge, of the Lehigh University, upon the pressure exerted in drilling cast iron. Upon plotting the results of these experiments upon squared paper, I find that they do not form a straight line nor any regular curve, and they are therefore incorrect. Approximately the result arrived at may be expressed thus: Pressure exerted on head of twist drill in lbs. = diameter of drill in inches and decimals × 1,500; but as the material removed varies with the square of the diameter, it would be desirable to know the rate of progression in each size of hole. The pressure and rate of progression together should give the measure of the power exerted, power being a compound of pressure and movement in a given time.—Yours, &c.,

Henry Adams.

City of London College.

STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

Sir,—I am disappointed with Mr. W. J. Ellis's letter, and I should have been better pleased, along with many others of my acquaintance, if he had given us some evidence of the correctness of his formulæ: with its simplicity I am satisfied, and should be pleased if the rule merited my confidence. I want facts, not opinions: and as he omitted to give us any facts of its agreement with actual collapse as proved by test, I have had to look around and find some with which I could compare the formulæ.

In Mr. Nicholl's "Practical Boiler-maker," page 109, are given twelve experiments on the collapsing pressures of thick tubes. Of these, four have their length seven times or more the diameter, and hence the rule in question can be applied:—

No. 51 collapsed at 97lb.; rule gives 47lb. = 2·06 times stronger.
No. 52 ,, ,, 127lb.; ,, ,, 47lb. = 2·7 ,, ,,
No. 53 ,, ,, 99lb.; ,, ,, 53lb. = 1·9 ,, ,,
No. 54 ,, ,, 110lb.; ,, ,, 156lb.

Here we have three cases where the tubes stood from 1·9 times to 2·7 times the amount given by rule; while another collapsed at 70 per cent of what it should have done by the rule. I should be pleased if Mr. Ellis could explain this.

I am glad to see our old correspondent "Chalkline" has entered the lists on this subject. I have no doubt that the influences he names contribute very largely in causing flues to collapse at less pressure than we often expect. On this I may say something in a future letter.—Yours, &c.,

Practical Man.

QUERIES AND REPLIES.

61. Centrifugal Force.—I have been attempting to analyse the formula $\frac{W v^2}{g r}$, and have met with a doubt, which a brother subscriber will perhaps be kind enough to clear up.

A body moves in a circular path in a horizontal plane, and with a given angular velocity, and is maintained in that path by a string, whose length is equal to the radius of the circle. Required, the tension in that string, expressed in pounds.

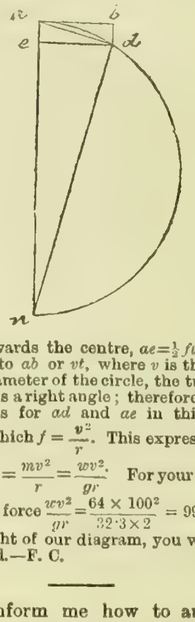
First, I learn that, taking a very small arc of the circular path, I may without sensible error consider the body to be moving along the chord of that arc, and in so doing being pulled centripetally along the smallest side of a right-angled triangle, whose hypotenuse is the chord aforesaid; whence I understand that the speed "set up," as it were, by the centripetal pull bears the same relation to the speed along the chord as the latter ("v") in turn bears to $2r$. Would it then be allowable to reason as follows: The force of gravity, acting for one second, produces in a unit mass a speed of 16·1ft. per second by exerting upon that unit a pull of one pound. Each unit mass in my circular-travelling body is travelling at $\frac{v}{2r}$ feet per second, a speed which is x times greater than 16·1ft. per second; hence the pull which produced that speed must be x times greater than one pound, and must equal y pounds for each unit of mass in the body. If my reasoning is thus far correct, I have eliminated $\frac{W v}{r \underbrace{2 \times 16{\cdot}1}_{``g"}}$, and I can easily see that the pull in my string in pounds, arrived at by those elements of the formula, will increase with the speed in the proportion $\frac{\text{new speed}^2}{\text{original speed}^2}$

I want to feel assured that to get the pull in my string in pounds for a body whose W = 64lb., for example, moving in a circle of 2ft. radius, at a velocity of 100ft. per second $= \frac{m v}{g r} = 3\frac{1}{8}$lb.; and under similar conditions, except that the velocity is 200ft. per second, the pull will be

$$3\tfrac{1}{8}\text{lb.} \times \frac{\text{new speed}^2}{\text{original speed}^2} = 12\tfrac{1}{2}\text{lb.};$$

whereas, if I use $\frac{W v^2}{g r}$ in both cases, I simply obtain comparative values, represented by 1 and 4 respectively, and these are no guide as to the actual pull in my string. The formula last quoted is used most recklessly at examinations, and the resulting values are pressed into service as pounds, tons, anythings, because one is not told that the results are merely numerical comparisons, and not actual values expressed in any one system of units. Shiny Boots.

Answer.—The analysis of the expression $\frac{w v^2}{g r}$ is as follows: Premising that the action may be in any plane, as it is with centrifugal forces alone we are dealing, let us suppose a body moving in a circle, with a given uniform velocity, to be at the point a in the diagram, the diameter of the circle being shown by the line acn, c being the centre of the circle. Now, if the body had not been acted on by a force in the direction ac, it would in a small succeeding interval of time t have continued to move in the direction of the tangent at a, and have passed through a distance which we will represent by ab. In consequence, however, of this force it has not followed this direction, but has arrived at the point d on the curve; hence the force has made it traverse the distance $bd = ae$ in this interval. If f be the accelerating force



which draws the body towards the centre, $ae = \frac{1}{2} f t^2$, and if ad be very small it may be taken as equal to ab or vt, where v is the velocity of the moving body. Now, if an is the diameter of the circle, the triangle adn is inscribed in a semicircle, and therefore is a right angle; therefore, $ad^2 = ae \times an = ae \times 2p$. Substituting their values for ad and ae in this equation, we find that $v^2 t^2 = \frac{1}{2} f t^2 \times 2 r^2$, from which $f = \frac{v^2}{r}$. This expressed in ordinary units gives for the centrifugal force $F = \frac{m v^2}{r} = \frac{w v^2}{g r}$. For your values $w = 64$ and $v = 100$, we have for the centrifugal force $\frac{w v^2}{g r} = \frac{64 \times 100^2}{32{\cdot}3 \times 2} = 9937{\cdot}7$lb. If you re-examine the question under the light of our diagram, you will no doubt see the rocks on which you have tripped.—F. C.

41. Hot-water Pipes.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse?—Water-heater.

50. Small Air Pump.—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

52. Details of Oliver.—Can any reader oblige me with details of an oliver, to work by foot, for making bolts from ⅜in. to 1in., with dimensions?—H. C., Egypt.

53. Dash Pots.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made and what is the approximate cost?—Crank Pin.

55. Testing Lubricating Oils.—I wish to know the methods of chemically testing the purity of lubricating oils. Is there any simple mode easily applied by an engineer?—Lubricator.

60. Set Pins.—Will you kindly permit me through the medium of your valuable paper to ask any of your correspondents if it is possible to get hexagonal-headed set pins $\frac{1}{16}$in. diameter, to buy, and where?—Model.

62. Boring Roll Cylinder.—I should feel much obliged for assistance from you, or any of your numerous readers, with the following: I have a cylinder for a roll; its length is 8ft., inside diameter 25in., and its thickness in rough metal about ¾in. I wish it bored out at the ends about 5in. or 6in., so as I can fit in arms and shaft, and to run pretty fair for outside turning. Can it be done in the lathe with any arrangement, or how would you advise me for cheapest and best, as my appliances are very limited?—Primrose.

63. Screwing Machine Dies.—Can any reader inform me of the best way of advancing and withdrawing dies in a screwing machine, with three die bits? The machine I have at present has four dies and cuts badly, besides making an unequal thread.—D. W.

64. Inside and Outside Tapers.—Will some reader kindly inform me the best way to "turn" outside and inside tapers, so that they may be the same? For example, the end of a piston rod and cross-head.—Anxious One.

65. Bursting Pressure of Copper Globe.—The tenacity of copper is 40,000 per square inch. What is the bursting pressure in lbs. per square inch of a hollow globe 2in. diameter and ¼in. thick?—J. C. W.

66. Roller Clutch.—Describe and sketch a method of employing friction rollers or spheres for causing a wheel to be locked to an axis when turning in one direction, but allowing it to run free when rotation is reversed.—J. C. W.

67. Travelling Crane.—In a travelling crane of 40ft. span, the load is supported on a carriage which runs on two similar girders, the axles of the carriage being 8ft. apart, and a load of 23 tons coming on each wheel. Obtain a diagram to show the maximum bending moment at every section of girder, and give numerical values at 10ft., 15ft., and 20ft. from one end.—J. C. W.

68. Change Wheels for Screw-cutting Lathe.—Could any of your readers kindly inform me, through your paper, the rule for finding the wheels for screw-cutting in the Buckton Lathe, leading screw two threads per inch—Roppet.

69.—Holden and Brooke's Exhaust Steam Injector.—Will some reader kindly explain the action of the above exhaust steam injector?—T. W.

TO CORRESPONDENTS.

J. C. W.—We thank you for your appreciative remarks, and we are obliged for your critical ones. The articles on gas engines will commence very soon. The others will follow in due course.

MISCELLANEA.

The volcanic eruption on the Island of Ipacano, one of the Lipari Isles, has attained considerable proportions, incandescent masses being hurled from two openings to the height of 600 metres, or more than 1,800 feet. The wind has carried a quantity of fine dust as far as Messina, a distance of about 40 miles.

The Swiss Watch Industry.—In spite of foreign competition watchmaking still progresses in Switzerland. The value of the output in 1887 was £3,450,000, or £16,000 more than in 1885, though prices were lower. The export quotations in 1886 were: For nickel watches 12f., silver 19f., gold 68f., works only 14f. In 1887 these prices fell 1f. for nickel and silver watches, 2f. for gold watches, and 1f. for works. Among the best customers for Swiss watches are the United States, although the industry is largely developed in America. Germany takes about 17,000,000f. worth of Swiss watches annually, Great Britain 13,000,000f., and France 6,500,000f.

Messrs. Coates' New Mill at Paisley.—Work has been commenced at an addition to the thread mills of Messrs. J. and P. Coates, Paisley, which will consist of a twisting mill to contain 80,000 spindles. The principal portion of the new erection will be a building of six storeys in height, measuring 236ft. by 100ft., and to drive the machinery two pairs of engines with an indicated horse power of 2,000 will be erected. A new scheme for cooling the water in the reservoirs for the use of the engines will be carried out on a scale unsurpassed anywhere for magnitude, the purpose being to reduce by forty degrees the temperature of 3,000 tons of water per hour.

The Cape Government Railways.—The Cape Government railways appear to have done much better last year than in the year preceding, and if business continues to progress as it is doing, we may look for even better results this year. The railways earned £4 17s. 10d. per cent on the total capital expended (£14,214,308). If the present indebtedness of the colony on account of railways be taken as the basis, the rate of interest earned has been £5 2s. 9d. per cent on the total amount, viz., £13,534,078, so that after paying all expenses and interest (£557,711) due on the present capital for 1888, the department contributes £137,645 towards the general revenue of the colony.

An Underground Railway for Paris.—It appears that an underground railway is to be erected in Paris, south of the river Seine. The projected line is to be seven miles long, with a short branch line. A central terminus will stand at the back of the Madeleine. The main line will run from that point to the Bastille, by the Opera House, and near the Boulevard. It will connect the termini of the Bastille-Vincennes, the Paris-Lyons, and the Paris-Orleans Railways. From the latter it will be brought round again by the Rue de Rivoli and the Place de la Concorde to the Madeleine. The underground part of the line will be four miles long, the rest will go through cuttings and by viaducts. M. Yves-Guyot is granting the concession of the Metropolitan to a syndicate of capitalists, who are to make it without a State subvention or guarantee of interest. They will issue shares of the value of 25 million francs, and bonds for 36 million francs.

New American Ideas.—Mr. Joseph A. Evans, of Philadelphia, Pa., has patented a lever for looms, which consists of a shuttle-box operating lever, designed to improve the box lever of a power loom adapted for weaving fancy fabrics, by making the lever in two parts, and joining it to work as free as a solid lever, yet yield at the centre to permit both ends to go up should the plunger be arrested in its upward movement from the anchor wings becoming locked. A pipe-testing machine has been patented by Mr. Michael Sexton, of New York. The invention provides for the use at each end of the pipe to be tested of a frame carrying a clamp screw with a packed head, one of the two clamp heads being provided with a testing fluid inlet, whereby water, steam, air, or other fluid may be forced into the pipe from a compressed apparatus at any desired pressure, to discover sand or blow holes, splits, &c.

A New Atlantic Steamer.—The second of the two large passenger steamers for the Liverpool and New York service of the White Star Line was launched from the yard of Messrs. Harland and Wolff, Queen's Island, Belfast, on Saturday, June 29th. She is named the Majestic, and her registered tonnage is about 10,000. She and her sister ship, the Teutonic, are the first mercantile steamers specially constructed and retained under agreement with the Admiralty for service as armed cruisers. The Teutonic is completed and ready to take her station in the company's fleet, and is advertised to make her first voyage with Her Majesty's mails on the 7th of August. The length of these ships is 582ft., constituting them, it is said, the longest vessels afloat; breadth, 57ft. 6in.; depth, 39ft. 4in.; with a gross tonnage of nearly 10,000 tons. They are built of Siemens-Martin steel, and will each be propelled by two independent sets of triple-expansion engines, constructed by Messrs. Harland and Wolff, driving twin propellers with manganese bronze blades. They are constructed with athwartship bulkheads, and also with a longitudinal bulkhead running fore and aft. The vessels are intended to carry 300 saloon passengers. There is also accommodation for 150 second cabin passengers and about 750 in the steerage.

Tinfoil.—In the manufacture of tinfoil, tin is melted and run into blocks weighing from 200lb. to 400lb. each, and in this form the metal is kept for ordinary use. The old method for reducing it to the necessary thinness for foil was by hammering it by hand as the gold beaters do gold leaf, and this process is still in vogue to a limited extent. This, however, is a very laborious process, as the sheet must be constantly beaten without intermission, to keep up the heat generated by the continuous strokes of the hammer, and the great drawback to it was that only one surface or face could be produced. The introduction of rolling machinery has completely revolutionised the trade, so that in place of importing we now export. In these mills the metal is given a beautiful polish on both sides; it is then cut into widths of from 12in. to 15in., rolled on reels, and cut to order by cutting machines. The great advantage of the machine-rolled foil over the hand-beaten foil is that while the latter is full of minute holes, so small as not to be visible to the naked eye, the former is, as a rule, perfectly intact, and thus being airtight, forms a wrapper that cannot be equalled by any other substance.

About Torpedo Boats.—An able paper was read not long ago before the United States Service Institution, by Mr. John Donaldson, on the recent improvement in Thornycroft torpedo boats. In the discussion, Admiral Barnaby, speaking of the torpedo boat, said: "It is undoubtedly true that she can be pierced by shot. I have heard that so often said concerning big ships, for which I was responsible, that I can sympathise with our friends the torpedo boat builders when it is said that the shots can get in. Of course they can, and I have no doubt the people in the torpedo boat will feel terribly nervous when they are going to make the attack. But he was perfectly sure the people will be very nervous on board the ironclad that is going to be attacked. That is an important thing. If you can succeed in making the other fellows nervous, never mind that you are running some risk yourselves. The real point lies, I think, there. It can be of no use to attempt to give protection against shot. I know that in France, where they have enormous ironclads of 11,000 and 12,000 tons, they are as nervous as can be over this fact, that the whole of their batteries can be searched out by machine gun fire. They know that, and they do not see how to remedy it. But if you cannot remedy it in a ship like that, what are you going to do with such vessels as these? The best thing you can do is to get a number of them, and make them as good as ever you can."

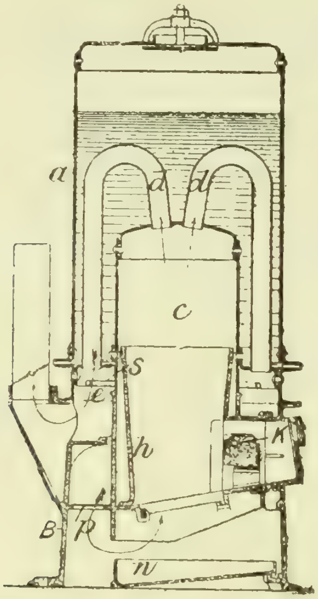
Research contains a paper on "The Aerial Propulsion of Ships," which will interest the curious and ingenious. The writer says: "A Dane—Mr. H. C. Vogt—has been engaged in perfecting his method of propelling ships by means of propellers revolving in the air instead of in the water. His invention is now patented, and will, if it fulfils the hopes of the inventor, revolutionise our present means of ship propulsion. On the deck of the ship a propeller is mounted, which is much larger and lighter than an ordinary water propeller. In a small vessel this air propeller would have to be some ten or twelve times larger than a screw revolving in the water, and capable of performing the same work. These 'air screws,' of which there may be two or more employed on the one vessel, have a wonderful resemblance to the windmill pumps used on board North American timber-ships. In addition to the propellant 'screws' a smaller one is mounted near the stern of the vessel, and can, along with its framing, be swivelled literally round a pivot for the purpose of increasing the manœuvring power of the ship, or for assisting the steering. The blade or wing may be made of one piece (thin sheet iron is generally employed) or of more than one piece united together and overlapping each other. An aerial propeller revolving at a uniform velocity creates a vacuum in front of it, and the difference of pressure thus created produces a forward motion similar to that due to an ordinary screw working in the water."

The Iron and Steel Industry in America.—We learn that the Illinois Steel Company, which was recently formed by the consolidation of three other companies, has now the largest facilities for steel production in the world. The works will employ 10,000 hands, and although the Krupp works at Essen, Germany, employ more men, their aggregate production is not so large. The new company can turn out annually 850,000 tons of pig iron, 975,000 tons of steel ingots, 900,000 tons of steel rails, 50,000 tons of structural shapes, 50,000 tons of wire rods, 60,000 tons of merchant bars, 40,000 tons of railway splices, and 15,000 tons of nails. The company will also take up the manufacture of tin-plate. This concern, in addition to its iron plants, controls some of the richest of the Bessemer ore mines of the Superior district, and large coke fields and ovens in Western Pennsylvania. The combined plants of the new company will consist of fourteen blast furnaces, an iron rolling mill, and four Bessemer steel plants, with machinery for producing in enormous quantities rails, beams, wire rods, merchant iron or steel, and nails. The consolidation of the three great western steel works is the most important event that has ever taken place in the history of the American iron trade. Nor has the world ever seen such an aggregation of capital in the hands of one manufacturing corporation as is now controlled by this new company. The influence of the consolidation upon the future of American iron and steel industries must be very great, although it may not be immediately manifested. One of the consequences which may follow the consolidation at Chicago is the adoption of a similar policy by some Eastern Bessemer steel companies.

ILLUSTRATED PATENTS.

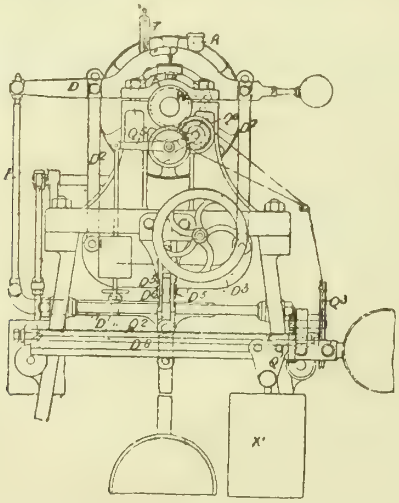
1824. **Vertical Steam Generator**, A. J. Boult, 323, High Holborn, London. (*A. Stehlik, Vienna.*)

The boiler itself is mainly constructed of two portions, viz., an outer cylindrical shell *a*, and an inner shell or firebox *c* with descending flues *d*. The furnace arrangement consists of a circular foundation B, forming the fire-chamber *h*, the annular smoke-flue *e*, and the air heating chamber *p*. The air supply enters the latter chamber through a lateral opening, passes round the foundation below the smoke-flue *e*, and enters the fire in a heated condition from the ashpit. An adjustable refractory block K is provided in the fire-hole to regulate the combustion. The ashpit is provided with a tray *n* filled with water. Jets of steam from the pipe S in the annular smoke-flue are provided for cleansing the flue tubes *d*.—February 7th, 1888. [6½d.]



1986. **Testing Lubricants.** A. J. Van Alstein, Antwerp.

The lubricant to be tested is placed in a grease cup R from which it is supplied to the bearing C attached to the lever D and resting on the roller A on the main shaft W. From the knife edges on the lever D hang rods D^2 carrying a frame D^3, which supports, by a linked framework D^5, D^6 the bar D^8 and weight X^1 on a runner Q^1. Thus as the weight X^1 is moved towards the left the pressure on the frame D^3, and therefore on the bearing C, is increased. A friction wheel Q^6 actuated from the main shaft drives a pulley Q^3, which by means of a screw causes the runner Q^1 to advance along the bar D^8; an index marks its position on a scale Q^2. Thus the pressure on the bearing C is gradually increased until the friction is so great that the lever D follows the motion of the shaft. It will then, by the rod *t*, raise the bar D^1, and through the lever Q^5 disconnect the friction wheel Q^6 from the shaft. The motion of the runner is thus stopped, and the position of the index shows the lubricating power of the substance tested. A thermometer T indicates the temperature of the bearing.—February 9, 1888. [8½d.]



1974. **Locomotive Fire-boxes, &c.** F. W. Webb, Crewe, Cheshire.

Arrangements are provided for allowing free expansion and contraction, whereby mild steel may be more readily employed in their construction. In the rectangular form of fire-box, illustrated in Fig 1, the plates forming the fire-box are corrugated with the exception of the water-bottom which is preferably left plain. The fire-hole *d* and the opening *e* are constructed by bending and securing together the inner and outer plates as shown, this arrangement having been described in specification No. 692, A.D. 1878. The front plate b^x of the boiler is also secured to the outer side and bottom plates by similar joints. The crown *c* is strengthened by bridge-stays *f* secured to the shell of the boiler through links f^2 and longitudinal rods f^1. In the modification shown in fig. 6, which represents a front elevation partly in section, the fire-box is constructed of two superposed, connected, cylindrical sections with correspondingly shaped steel plates. Each section of the cylindrical bodies may be secured to the adjacent by expansion joints, while the end plates may be annularly corrugated. Cross water-tubes may be also provided and suitable stays furnished.—February 9, 1888. [8½d.]

FIG. 1.

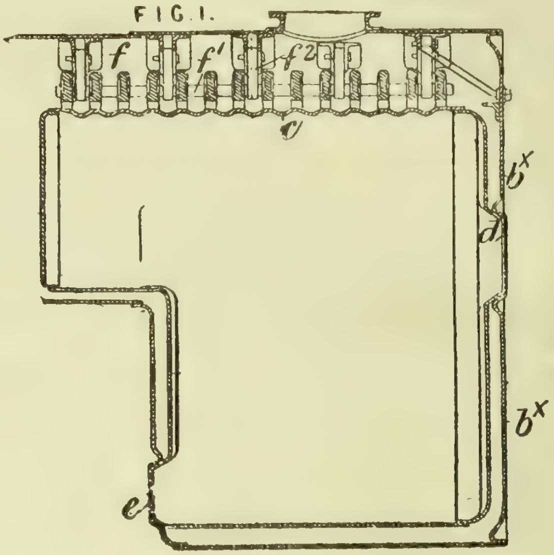
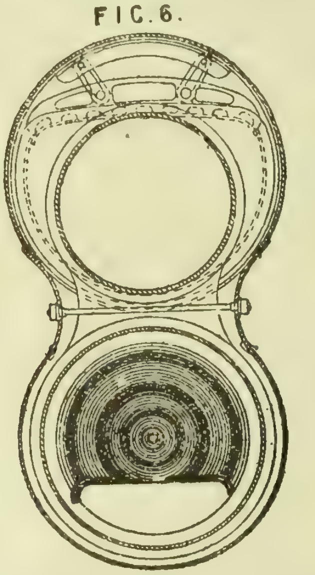


FIG. 6.



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

June 29th.

10536 Expansion Engines, H. Dunsmuir, Glasgow.
10540 Steam Boilers, G. Cawley, Manchester.
10544 Adjustable Spanner, J. T. Humphrey, London.
10548 Flexible Tubes, J. M. Sellers, Keighley, Yorkshire.
10556 Electric Cable, W. E. Gray, London.
10558 Flood Gate, J. M. Fletcher, Cheadle, Cheshire.
10560 Furnaces, W. A. Cox, London.
10563 Rotary Steam Engine, F. R. Martin, London.
10567 Gas Meters, P. Rouget, London.
10581 Gas Producer, J. C. Johnson, London.

July 1st.

10582 Motors, E. Butler and T. I. Cammell, London.
10586 Oven Heater, S. Green, Hooley Hill, Manchester.
10587 Lubricating Compound, J. Roots, London.
10592 Compounds, I. Oldershaw, Eastwood, Nottingham.
10593 Galvanometer, W. H. Grimsby and A. Dobrée, Stoke-on-Tren
10595 Steam Boilers, J. W. Macfarlane, Glasgow.
10597 Lighting Gas, H. J. Griswold, Leicester.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE

PRACTICAL ENGINEER,

JULY 26TH, 1889.

HEAT ENGINES OTHER THAN STEAM.

So long ago as 1854 the late Professor Rankine read a paper before the British Association "On the Means of Realising the Advantages of the Air Engine," in which he expressed his belief that such engines will be found to be the most economical means of developing power from heat. In this opinion he stood by no means alone. Engineers so able as Stirling, Ericsson, and Siemens, and Physicists so distinguished as Dr. Joule and Sir William Thomson, devoted much energy and study to their practice and theory. Mr. Bourne also, the well-known practical writer on the steam engine and steam matters, whose treatises we have all read, expressed a belief in the preface to one of his large works—"Steam, Air, and Gas Engines"—published in 1866, that the days of the steam engine were numbered, and that new forms of thermo-dynamic engines would be speedily produced, which would far excel the obsolete steam engine in utility and economy. Numerous inventors, too, of engines of the "binary vapour type"—a title suggested by Rankine—have experimented, indulged in like prophecies, and disappeared. Notwithstanding all this, the steam engine has as yet been quite able to hold its own against all competitors, and it still remains the leading form of motive power, beside which all other forms are relatively insignificant. A study of the patent abstracts classified under the above heading reveals, however, an astounding amount of effort which has been continuously and quietly exerted with the end of supplanting steam, and providing less wasteful modes of motive power. Great interest is now evinced in the various rivals to the steam engine, as may be seen from the lively discussions proceeding among engineers on spirit engines, ammonia engines, and the like; while the recent Society of Arts' trials and the interesting lectures by Mr. Graham Harris, lately delivered at the Society of Arts, point clearly to renewed excitement and restlessness among engineers interested in the question. Is there any greater hope of displacing steam now than there was over thirty years ago, when so many similar and equally confident predictions were common? We naturally wish to know why predictions so confidently made then, which have proved incorrect, should now be renewed. The question is an interesting one, and we propose to shortly consider the change in engineering practice and theory which has occurred since 1854, and which has led to the present attitude with respect to motive power.

In 1854 our readers will know that the engineering world was profoundly interested in the hot-air engines of Ericsson, in America, and Dr. Stirling, in England; and in the then state of steam-engine practice, when 4lb. of coal per indicated horse power per hour was a very usual consumption, even in large engines, the economy obtained by Stirling—a little over 2lb. per horse power per hour—was considered very extraordinary, and it was supposed that, when the practical difficulties were sufficiently understood and overcome, very much greater economy would be possible. At that time, too, the science of thermo-dynamics was comparatively in its infancy, and although its leading laws had been demonstrated by Joule, yet among the great mass of engineers their application to practice was not at all understood. From what we can gather of the opinions of both Ericsson and Stirling, it appears that in the heat regenerator they considered they had a means of recovering nearly all the heat which they imparted to the air in their engine cylinders, and they seemed to think that their whole losses would be those inherent to all practice, namely, loss to the cylinder sides and loss due to the imperfect action of the regenerator. In fact, they seemed unaware that heat disappeared by being converted into work in the engine, and therefore they imagined that in the regenerator they had a means of obtaining motive power in almost any quantity from an inconsiderable amount of heat. In this view of their opinions we are confirmed by the recollection of a conversation we had with the late Sir C. W. Siemens. He then described a regenerative steam engine with which he had experimented, and mentioned the fallacy into which he thought that both Stirling and Ericsson had fallen.

Notwithstanding the great economy of the hot-air engine, it was speedily found, both in Britain and America, that unsurmountable practical difficulties intervened to absolutely prevent the application of such engines for large powers and to any considerable extent. The leading difficulty was due to the fact that air heats very slowly by contact with metal walls, and that the temperature which iron can stand, in order to transmit heat to air, is very limited. The heating of the air was, therefore, very slight, and consequently the average pressure in the cylinders available for power was low. In the Ericsson engine only some four or five pounds per square inch was obtained, and in Stirling's thirty pounds; but in the latter engine the air was greatly compressed to begin with, so that the heater was continuously exposed to a pressure of close upon 200lb. per square inch. The difficulties of burning out of cylinder or heater bottoms, and the very low available pressures obtained, proved formidable enough to prevent the development of the hot-air engine, and to limit its use to very small powers.

Many attempts have been made to overcome these defects by burning the fuel within the engine cylinder, the most recent of which (the Benier hot-air engine) may be seen in action at the Paris Exhibition, but even with it very little power is given for the bulk and weight of the engine. The objections to the internal combustion of solid fuel are, we fear, a kind which are quite insuperable. It seems impossible to of avoid very considerable and rapid wear from the presence of dust and ash.

The principle of internal combustion, however, is undoubtedly the right one, and where gas is used the practical difficulties become reduced to controllable limits. Within the past ten years a most formidable rival to steam has appeared in the gas engine, and, although as yet only in its infancy, it is becoming better understood every day, and the way is being cleared for further and greater development. Without doubt the increasing use of the gas engine is mainly the cause of renewed anticipation on the part of engineers, and its history leads us to suppose that a very great development is still in store for it. In 1876 the gas engine was used to a very limited extent, and mainly in the form of the well-known Otto and Langen atmospheric engine. This engine consisted of an open-ended vertical cylinder containing a free piston: a mixture of gas and air was taken into the cylinder at atmospheric pressure and exploded; it drove up the piston against the atmospheric pressure, and caused a vacuum. The piston was free to move upwards without connection with the driving shaft; but on its return, under atmospheric pressure, it drove the main shaft round by means of a rack. The piston was a projectile, and the cylinder was a vertical open-ended cannon. Although exceedingly economical, this engine was not capable of great development, as, like the hot-air engine, it was very cumberous. The largest power made in this style was only three horse.

The production of the Otto "compression" engine in 1876 marked an epoch in the history of the gas engine. It resembled an ordinary horizontal steam engine, and gave a very fair average pressure, over 60lb. per square inch in many cases, and its action was smooth and efficient. In a very few years large engines of this kind were made in this country. We think the first gas engine indicating 40 horse power was exhibited at the Royal Agricultural Society's show in 1879, and since that time many gas engines have been constructed of over 100 horse power. We observed at the Paris Exhibition a four-cylinder gas engine, by the French makers of the Otto engine, which was capable of indicating 150 horse power. We did not see it running, as the engineers were much behind, and were still engaged in fitting it up. Mr. Powell, of Rouen, had there, among other gas engines, one of 100 horse power, which had a single cylinder. Such gas engines, we need hardly say, were considered impossibilities by engineers in 1876, only thirteen years ago. As the past thirteen years have seen so great and rapid progress in overcoming mechanical difficulties, and applying the internal combustion principle, we are of opinion that the next ten years will see still greater advance. The most hopeful feature in connection with this modification of the air engine lies in the fact, now proved beyond the possibility of doubt, that, considered as heat engines, they convert a far greater percentage of the heat given to them into useful work than has hitherto been done by any other type of heat engine. With the steam engine 12 per cent is the best result obtained as the combined efficiency of engine and boiler; with the gas engine 22 per cent has been obtained. That is, while the steam engine and boiler only convert 12 per cent of the heat given to it into indicated work, the gas engine converts 22 per cent into indicated work; and further, the consideration of gas-engine diagrams shows that with improved detail arrangements, an efficiency of 40 per cent is quite possible, and is indeed very probable, when large engines are constructed.

In view of all this, we think it very likely that, for many purposes, gas engines will largely supersede steam engines, and that in the immediate future gas engines of over 100 horse power will become quite as common as those of 10 horse at present. Before all the work of steam could be accomplished, however, very much yet remains to be done.

Mechanically, gas engines are clumsy and imperfect compared with steam engines. In governing, starting, and handling they have grave defects, but they are all defects which can and will be overcome.

With regard to the spirit engines and ammonia engines, to which attention is now called by recent experiments, they have doubtless important though limited future use; but they differ in this respect from the gas engine, not one of them have shown economy superior to the best steam engines; they have only been shown to be economical compared with the worst and most wasteful engines. Until they can be shown to consume heat equivalent to, say three-quarters of a pound of coal per horse power per hour, they cannot be considered as serious rivals to steam. It is forgotten entirely by those who advocate their extended use, that the best conditions for one liquid or motive power engine are by no means the best for all liquids. Each liquid has its own peculiar conditions which suit it best in practice, and however equal all are, and may truly be, in theoretical or ideally perfect engines, yet in practicable engines each has special conditions, which must be complied with if the best results are to be obtained.

In conclusion, we are of opinion that the present feeling of impending change in motive power engineering has a firm and sure basis in fact, and that the predictions of Professor Rankine in 1854 are, after all, likely to come true to a certain extent within the next ten years.

THE DIRECTOR-GENERAL OF ORDNANCE FACTORIES.

Mr. William Anderson, of the well-known engineering firm of Easton and Anderson, has been appointed by the Secretary of State for War to the position of Director-General of Ordnance Factories. In making this appointment, the Secretary for War has departed from the prevailing departmental ideas upon the subject, according to which only military men are suitable for such posts. The military portion of those in authority will be sure to disapprove of such a step, but in our opinion this appointment is distinctly a step in the right direction.

It has long been a grievance that military men are placed in positions for which they are utterly unfitted, and it is difficult to see how a military training can fit a man to conduct what is really an engineering manufacturing business. If we reasoned in the same style on other matters, we should consider it necessary that all our best shipbuilders should have qualified as sea captains. It is very necessary to have some knowledge of seafaring life to build efficient ships, and to this end it is most desirable that ship captains and seamen should be consulted on many points of detail. In the same way, it is most necessary that military men should be consulted on the practical points which occur on handling guns in the field and at sea, but it by no means follows that the military man is the best engineer and constructor of the weapons he must use.

Mr. Anderson, although a civilian, has had a most extended engineering experience in the construction of guns, and is well adapted for the position to which he has been chosen. We do not doubt but that his well-known engineering ability, as well as the commercial experience he has had, will be very valuable to the country, and help to bring the Government conduct of engineering construction more nearly level with that of our best firms. We may congratulate the country at large upon so reasonable and important a departure from red tape in such matters.

THE BRENNAN TORPEDO.

An interesting practical trial of this torpedo was made at the Isle of Wight recently, by the inventor, Mr. Brennan. The trial consisted in sending the torpedo after an old wooden hulk, which was rapidly towed past by a powerful steam tug, and guiding it in its course to avoid various obstacles, and then to strike the hulk. This was successfully accomplished, and the effect was really astounding. The torpedo struck fairly, and exploded with great violence, throwing the hulk heavily forward, after which it settled down and sank stern foremost. As the hulk was of about 300 tons burden and 160ft. long, the result must be considered a most satisfactory one. Of course, we could not expect an effect so great on striking a war vessel, as the strength is vastly greater; but still it is difficult to imagine even the strongest vessels escaping without severe damage. We do not envy the position of those in charge of the steam tug used to tow the hulk; they must have had considerable faith in Mr. Brennan's power of efficiently and safely guiding his terrible apparatus. However, the event proved the well-grounded nature of their faith.

The peculiarity of the Brennan torpedo consists in the fact that the motive power is supplied from a stationary engine on shore, so that it does not require to be aimed, and then left to the mercy of currents for its chance of striking its victim. It is like any other vessel, and can be steered with great accuracy, and its course changed when desired, with the great advantage of entire safety to the operator, who may be stationed on any secure position on shore. The torpedo contains two drums, upon which is coiled a large quantity of steel wire, and the motion is communicated by causing the wire to be wound off the drums very rapidly on to drums on shore. The screw propelling arrangements are driven from the drums, and by altering the rate of revolution of the shore drums relatively to each other, mechanism is acted on in the torpedo which controls the steering. The operator on shore, by increasing the speed of either shore drum, can cause the torpedo to take any desired course. A small flag, at the head of a light steel mast allows the operator to watch and guide the movements of the little vessel.

In the recent trial this mast and flag were distinctly seen, as well as the ripples in the water caused by the mast, and at first it seemed as if the torpedo were going to miss the vessel; but suddenly the operator changed the course, and it darted at once into the side of the vessel, with an immediate explosion. The hulk passed the torpedo station at a rate of 10 knots per hour, and the torpedo moved at nearly double that rate, so that there was no difficulty in overtaking and destroying it. Such a weapon is a most formidable one, and likely to do good service in coast defence work where a properly defended station can be erected; but there are several disadvantages. The fact that it must be seen by the operator implies that it can be just as clearly seen by the enemy, so that by bringing a heavy machine gun fire to bear they might easily destroy the whole apparatus before it reached them. However, the advantages are great, and it is protected to some extent by submergence. It is a great advance to be able to steer it from the shore.

BOILER LEGISLATION.

In a letter appearing in last week's issue of our esteemed contemporary *Engineering*, Mr. R. C. Longridge points out that after all the yearly loss of life due to boiler explosions has greatly diminished, and the preventable proportion is exceedingly small. For the ten years from 1869 to 1878 inclusive, there were on an average 69 explosions per annum, and 67 deaths per annum; from 1879 to 1888 the average fell to 36 explosions per annum, and 33 deaths per annum. These losses are of course sufficiently great; but if they keep on diminishing at the same rate, which is maintained notwithstanding the greatly increased number of boilers in use, it is very evident that the loss to be prevented by legislation will shortly be very small. Of course, if compulsory inspection would save only a few lives, it is most desirable; but there are undoubtedly grave difficulties in the way, and there must always be a certain proportion of accidents due to recklessness quite beyond prevention. Considering the enormous number of boilers of all kinds in daily use, some attended by very unskilled men, it is wonderful that we escape with so very few accidents. In our opinion, some standard of training among boiler and engine attendants is more likely to do good than compulsory inspection, as intelligent men in charge would almost annihilate danger from steam boilers.

THE PARIS EXHIBITION.

(*From our own Correspondent.*)

After the engineering visitor has spent a couple of days in the Palais de Machines, he will welcome as a pleasant relief to the heat, glare, and noise of the great hall a visit to the petroleum exhibit on the banks of the Seine. The exhibit consists of a panorama, the building for which is really a petroleum tank of a capacity of 2,500,000 litres, destined when the Exhibition closes to be sent to the refinery La Lucaline, at Rouen. It is erected close to the Pont de Jèna, on the Quai d'Orsay, and it answers its purpose most admirably, besides being pleasantly cool, and dark enough to be a desirable relief from the almost prevailing glare. We find it very interesting to ourselves, and still of a sufficient engineering nature to be properly within the scope of our visit. The circular petroleum tank is very tastefully got up and decorated. The lower circular walls are utilised to contain models and samples of tools used in the petroleum industry. On entering, we find ourselves in a circular gallery, lighted from above. In the entrance passage there is a fine model of a petroleum tank steamer, by Sir W. G. Armstrong, Mitchell, and Co., showing in section Swan's patent conical bottoms, which allow the use of water ballast under the conical floor to keep the water entirely separate from the petroleum, and also to permit of the petroleum being entirely drained off, when wanted, by pumping a channel forming the lowest point. The model is beautifully finished, and shows the peculiarities of the tank steamers very clearly. There is also a half model of the tank steamers Elbruz, Kasbek, and Dariel, each of 4,000 tons burden, by the same makers, as built for Messrs. Nobel, Baku.

Adjoining this, is a very complete collection of laboratory apparatus used in the fractional distillation of petroleum, and in testing the oils for density, flashing point, and in other respects. Specimens of refined paraffin and interesting photographs of wells in the act of spouting also find a place here. Looking at the photographs, we feel that in Britain our lines are indeed cast in pleasant places. The dreary sandy landscapes, with long rows of wooden huts and petroleum pools and tanks, so truly convey the nature of the country and industry, that we almost scent the peculiar and all-pervading hydrocarbon odour which is characteristic of such places. A complete model of the derrick and drilling machinery as used at Baku is well worth inspection, together with the samples of American and Russian drilling tools and tackle. The Worthington compound pumping engine, with high duty attachment, as built for the National Transit Company's oil pipe line, is represented by photograph. There are four pumps, and each is capable of pumping 25,000 barrels per day against a head of 1,500lb. per square inch.

Ascending the stairs leading from the lower gallery to the panorama platform, we find ourselves at once transported to the petroleum countries, and have a continuous view of what it looks like in Russia and the United States. Russia is represented by the village of the Societe Industrielle et Commerciale de Napthe Caspianne et Mer Noire, and a very dreary village it looks. A hugh oil tank in the foreground, open to the air and filled with a black-looking fluid, is connected by pipes to a pumping station in the vicinity, and the great derricks break the sky line all over the picture. The houses look very oily and disagreeable, while not a solitary tree or blade of grass relieves the desolate landscape. We turn with relief to the American scene, where at least country roads and some trees break the misery and squalor which seems indispensable to the oil wells. The long trains of tank wagons loading in front recall us, however, to the industry of the place. The panorama is most realistic, and gives us an admirable glimpse into the oil regions of the world. We feel deeply indebted to those who spend their lives among such surroundings to supply us with cheap and pleasant light for the dark nights of our winter months, but we feel thankful that our lot was not cast in a petroleum country.

Leaving the panorama, our attention is attracted by a small photograph of a duplex pump constructed by Messrs. Tangye, of Birmingham; it is the only sign which we are able to find in the whole Exhibition of that great Birmingham firm of engineers. Leading from the panorama, we enter a gallery devoted to other petroleum exhibits, where we find a Lenoir petroleum engine of two horse power, constructed by Messrs. Rouart Frères and Co., engineers, Paris, which is used at night for compressing air to supply the Lucigen light at the side of the building in the Quai d'Orsay. We are pleased to see the name Lenoir again to the front in connection with gas engines, as to him belongs the honour of being the inventor or designer of the first gas engine which was sold to the general public in any numbers. This he did about the year 1860. The old form of engine did not use any compression, and after a few hundreds were sold its manufacture was abandoned on account of its want of economy, and because of difficulties in detail of a practical kind. M. Lenoir was little heard of from that time till a few years ago, when he produced a gas engine using compression on the Beau de Rochas or Otto cycle. Some of the peculiarities of that engine are used in this petroleum engine. It is not intended to burn the heavy petroleums such as are used in lamps, but is only adapted for the light volatile oils such as gasoline or benzine. A cylindrical carburetter is mounted above the engine, and the entering air is saturated while passing through it. Sufficient surface is exposed by keeping the liquid in motion by means of a rotary agitator. In Lenoir's engine, also, the explosion chamber is not surrounded by water, as is usual in gas engines, and the heat from the explosion is sufficiently kept under by radiating ribs surrounding he exterior in contact with the cool atmosphere.

The higher temperature of the walls of the explosive space is said to effect a great economy, and within certain limits we should suppose that it would do so. The electric spark is used for ignition, and the admission and ignition valve is at the side of the cylinder, while the discharge valve is at the end. The engine worked with great smoothness and regularity during the considerable time we spent in watching it. Close by this engine there is a locomotive cab, driven by a horizontal petroleum engine, constructed by E. Roger, of Batignolles, Paris. It has three wheels, like a Bath chair; the front wheel is used for steering, and the other two wheels are keyed on an axle which is connected to the petroleum engine by a pitch chain and bevel wheels. The petroleum engine is of the usual Otto type, giving an impulse for every two revolutions, and the flywheel lies in a horizontal plane—that is, the crank shaft is vertical, while the engine lies horizontally. A battery under the seat supplies current to ignite the explosive mixture, and the petroleum reservoir is conveniently stowed away in the same place. Bevel wheels are driven by a belt from the engine, and a fast and loose pulley and a belt shifter allow the connection to be interrupted without stopping the engine. The whole contrivance looks crude and complex, and we feel sure would give the driver abundant occasion for discomfort and anxiety during any trip he might be daring enough to undertake with it. The same engineer (Roger) exhibits a gas motor, with electrical ignition, on the Otto cycle. We could not see any feature of particular novelty in this engine.

In a building devoted to hot-air engines, forming a continuation of the hydraulic exhibits, we find the Moteur Sécurité, of 3 H.P. nominal, also driven by petroleum, and constructed at the Ateliers de Construction Deiderichs, but designed to utilise heavy pretroleum, which is vaporised by means of the heat of the exhaust gases. The exhaust pipe passes through a chamber under the engine, and heats up metallic surfaces, upon which petroleum is allowed to flow, drop by drop, by means of a special sight-feed lubricator. The air also passes over these surfaces, and is heated so that a hot mixture of petroleum vapour and air is drawn into the engine at every second stroke. The cycle is of the usual Otto kind, and is, of course, well understood by our readers. The igniting arrangement is rather interesting, and is of the incandescent tube variety, but is different from those now in very general use throughout Britain. It consists of a thimble of metal pushed into the cylinder and raised to incandescence by means of a forced jet of petroleum vapour and air, which burns at a grating. The mixture burns with a slight roar, like a blowpipe, and keeps the interior of the tube at a bright red. The exterior projects into the cylinder, and is uncovered at the proper time by means of the valve arrangements. This engine is of somewhat complex character, but appeared to work very well, and without difficulty from premature firing.

THE UTILISATION OF TANK WASTE.

Last week the Jarrow Chemical Company commenced at their Friar's Goose works the second portion of the Chance process, viz., the manufacture of sulphur, which is obtained from the tank waste by means of carbonic acid. The sulphur is first liberated, by means of carbon dioxide, from the tank waste, in the form of sulphuretted hydrogen, and when of sufficient purity it is conducted from the gasholder to the Claus kiln, care being taken to allow a sufficient quantity of air to pass into the kiln to form water with the hydrogen liberated from the sulphuretted hydrogen. For this purpose the mixed gas and air first pass under the perforated bottom of a cellular kiln, lined with fire-brick; next, through a bed of broken fire-brick; and finally, through a layer of anhydrous oxide of iron, the heat of the reaction causing the oxide of iron to remain at a dull red heat, while undergoing no change itself. Free sulphur, and water in the form of steam, pass off. The sulphur and steam are then allowed to enter a tank, where part of the sulphur condenses in liquid form, and is run into blocks, and the rest of the sulphur, as vapour, goes into a large brick subliming chamber, and is there deposited as flowers of sulphur. As the tank waste contains from 12 to 14 per cent of sulphur, the company estimate that they will be able in a very short time to produce and place in the market for sale about 50 tons of absolutely pure sulphur by means of the process described above.

MESSRS. FOWLER AND CO.'S SPRING WHEEL FOR ROAD LOCOMOTIVES.

Messrs. J. Fowler and Co., Leeds, have recently introduced a new style of spring-mounted road locomotive, in which the gear and spring connections are of a novel kind. We illustrate the gear and general arrangement on page 511, from which it will be seen that the engine is free to rise and fall, while the driving gear retains the same position relatively to the driving axle. The gear consists of a train of gear wheels driven from the crank shaft, terminating in a large spur wheel, having a bevel wheel within it, which rotates on the driving axle. Attached to the internal face of the driving wheel is a similar bevel wheel, and the bevel pinions rotate on spindles carried round by a gimbal ring, seen in fig. 1. This gimbal ring has trunnions at right angles to the axis of the pinions, and it is free to slide on these trunnions. The pinions are also free to slide on their axis, so that, although the driving axle and wheels are driven by the gear, yet there is complete freedom for motion in any direction as between the axle and the engine. The arrangement is exceedingly neat and strong, and is capable of compensating for a very considerable amount of inequality. Fig. 2 is an end elevation, in which will be observed the details of the attachment of the large spur wheel, with its internal independent bevel wheel, and the opposing similar bevel wheel in the inward side of the driving wheel.

NEW SPRING-WHEEL GEAR FOR ROAD LOCOMOTIVES.

CONSTRUCTED BY MESSRS. JOHN FOWLER AND CO., LIMITED, ENGINEERS, LEEDS.

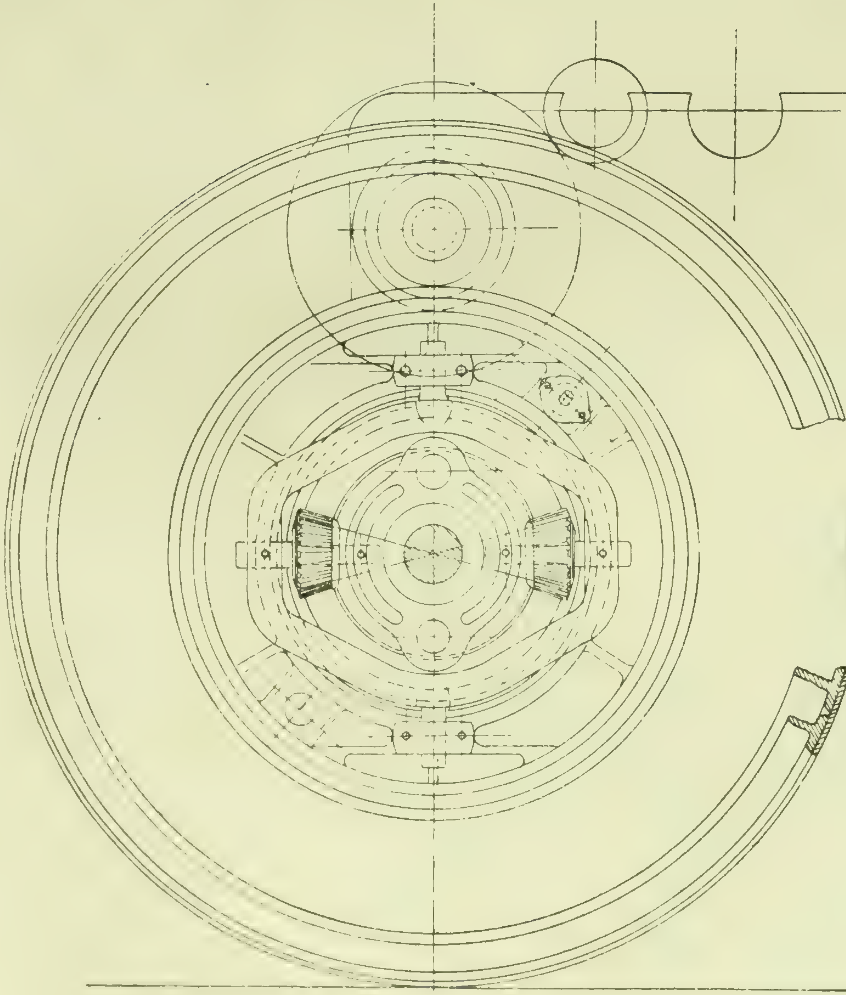


Fig. 1.

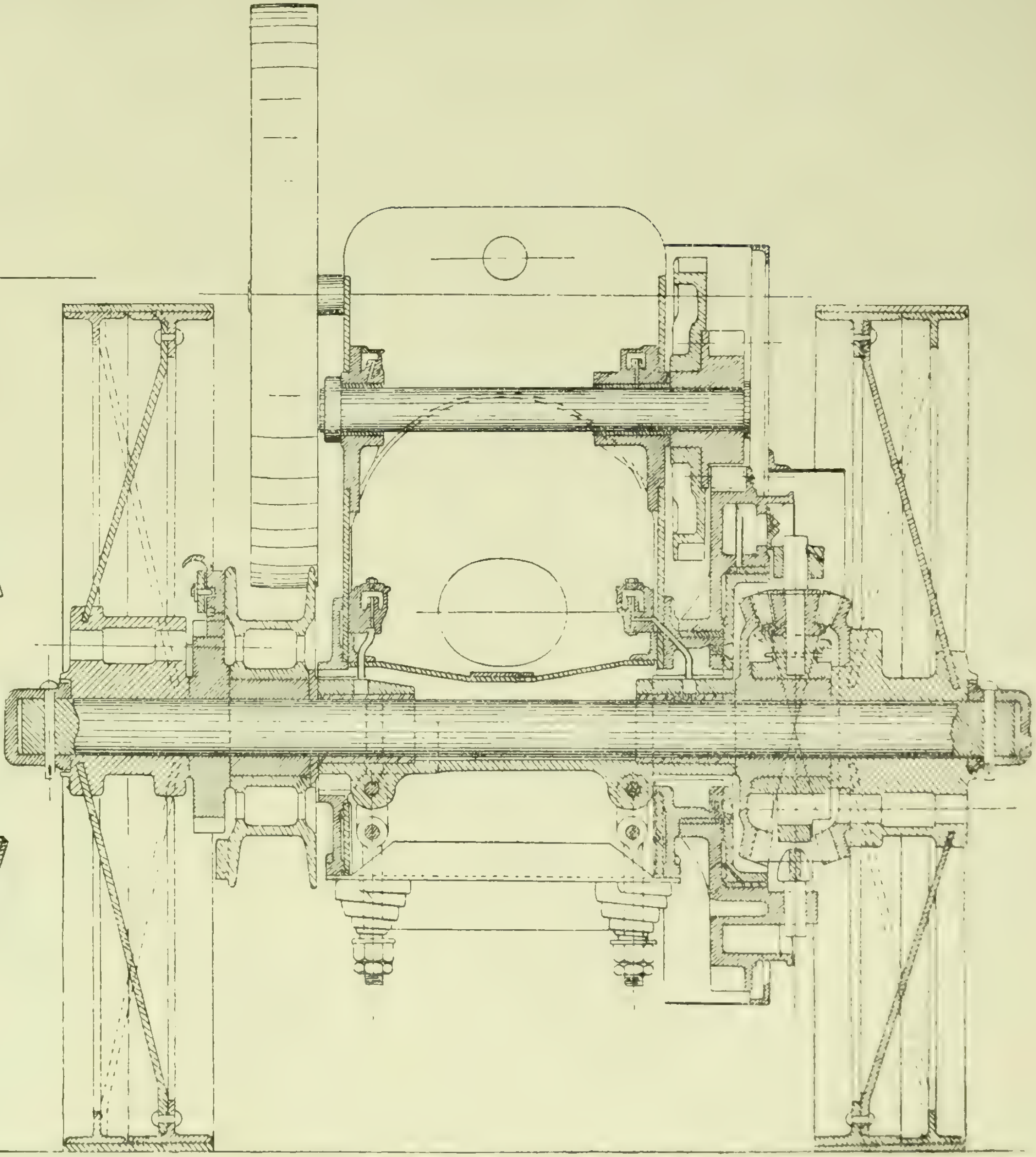


Fig. 2.

COMPOUNDING OF LOCOMOTIVES BURNING PETROLEUM REFUSE IN RUSSIA.

(*Concluded from page 495.*)

THE idea of making one engine by way of trial with the low-pressure crank leading in forward running originated in its being accidentally noticed that one of the other engines, compounded with the high-pressure crank leading in forward running, seemed to work better and to be more powerful, developing its full tractive force with an earlier cut-off, and making steam with greater freedom when running backwards with its train, in which case, of course, the low-pressure crank became the leading one. The line following generally the undulating contour of the plains, its profile has very long gradients of 1 in 125, thus demanding for long stretches at a time the full power of the engine, or say about the third notch out of four. The only objection the author now sees to the low-pressure crank leading is that it gives too much power in the large cylinder and too little in the small, thus putting the engine out of equilibrium ; but this irregularity will, in a great measure, be obviated by having a receiver about half as large again as those now used on all the present compounds.

TABLE 4.—POWER DEVELOPED BY SIX-WHEEL COUPLED 36-TON COMPOUND GOODS LOCOMOTIVE, NO. 53.

LOW-PRESSURE CRANK LEADING IN FORWARD RUNNING.

Grade of Expansion. No. of Notch.	Speed of Train. Miles per hour.	Driving Wheels. Revolutions per min.	Piston Speed. Feet per minute.	Indicated Horse Power.	Tractive Power.	Ratio of Tractive Power to Adhesion Weight.		
No.	Miles.	Revs.	Feet.	I H.P.	Tons.	Per cent.		Ratio.
1	20	131	524	167	1·449	4·2	=	1 to 24
2	18	117	468	366	3·395	10 0	=	1 to 10
3	15	100	400	482	5·116	14·7	=	1 to 6·8
4	13	87	348	478	6·112	17·5	=	1 to 5·7

The high-pressure cylinder in this engine was worn out and had a crack in its body, and a liner was therefore put in, whereby the clear working diameter was reduced to 460 mm. = 18·11in. ; whereas the first engine compounded, No. 35, with high-pressure crank leading, had its cylinder re bored to 470 mm. = 18·50in.

TABLE 5.—MEAN STEAM PRESSURES AND TEMPERATURES OF STEAM IN COMPOUND PASSENGER ENGINE WITH SIX WHEELS, FOUR COUPLED.—HIGH-PRESSURE CRANK LEADING IN FORWARD RUNNING.

See Indicator Diagrams, Fig. 11.

Cylinder.	Cut-off.		Steam Pressures, lbs. per square inch					Temperatures of Steam.			
	No. of Notch.	† Percentage of Stroke.	Valve Chest.	Mean Forward.	Mean Back.	Mean* Effective. D	D × 1·1	Beginning of Stroke.	End of Expansion.	Utilised in Expansion.	Utilised in both Cyls.
	No.	Per cent	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Fah.	Fah.	Fah.	Fah.
High-pressure, right hand.	1	30	132·4	88	57	31	34	356°	286°	70°	
	2	50	132·4	110	55	55	60	356°	306°	50°	
	3	70	132·4	125	54	71	78	356°	329	27°	
	4	80	132·4	132	53	79	87	356°	342°	14°	
Low-pressure, left hand.	1	42	55 88	34	7·1	26·9	30	302°	243°	59°	113°
	2	60	56 61	43	4·3	38·7	43	303°	257°	46°	99°
	3	78	57·35	48	2·0	46·0	51	304°	273°	31°	83°
	4	86	57·79	53	1·0	52·0	57	305°	286°	19°	70°

† The point of cut-off in percentage of stroke is given as marked from the valve setting.

* The mean effective pressure in column D is the difference between the mean forward and backward pressures ; in column D × 1·1 it is increased by 10 per cent to allow for the throttling effect of the indicator pipe and connections.

Air-inlet Valve.—When the first passenger compound was put into regular train service, it was noticed that, where an ordinary non-compound ran easily down hill with the regulator closed, the compound ran very stiff, and even required the regulator opening a little : thus proving that an increased internal resistance existed in the compound locomotive, which was traced to the large area of the low-pressure piston creating a strong vacuum in the receiver. This was overcome by placing on the receiver an air-inlet valve opening inwards, for enabling the large piston to draw in air when required, as is invariably the case when the steam is shut off. Since the addition of this valve the engine runs down hill with even greater ease than a non-compound locomotive. As for the objection that such a valve cools the low-pressure cylinder, the author had to choose one of two inconveniences : either to keep steam on when running down hill, or to cool the cylinder. The latter proves the more profitable method, and is accordingly adopted. Possibly in time it will be practicable to mix part of the hot smoke-box gases with the cold air, and to admit this mixture into the low-pressure cylinder at a temperature of from 120 deg. to 180 deg. Fah. ; this could easily be done without risk of injury to the valve faces and piston rings, because no solid particles from cinders or ashes exist in the smoke-box of these engines burning petroleum refuse.

In Tables 5 and 6 are given the particulars of the working of the passenger engine, and the corresponding indicator diagrams were taken in forward gear, and are very good ; the passenger engine indeed seems to work rather better than the goods.

TABLE 6.—POWER DEVELOPED BY COMPOUND PASSENGER ENGINE WITH SIX WHEELS, FOUR COUPLED.

HIGH-PRESSURE CRANK LEADING IN FORWARD RUNNING.

Cylinders 17¼in. and 25¼in. diameter, 22in. stroke. Driving wheels 5ft. 3in. dia. Adhesion weight 24 tons. Boiler pressure 130lb. per sq. in. above atmosphere.

Grade of Expansion. No. of Notch.	Speed of Train. Miles per hour.	Driving Wheels. Revolutions per minute.	Piston Speed. Feet per minute.	Indicat'd Horse Power.	Tractive Power.	Ratio of Tractive Power to Adhesion Weight.		
No.	Miles.	Revs.	Feet.	I.H.P.	Tons.	Per cent.		Ratio.
1	33	176	646	463	2·151	9·09	=	1 to 11
2	27	141	518	552	3·427	13·88	=	1 to 7·2
3	20	106	387	539	4·217	17·00	=	1 to 5·8
4	13	70	256	475	4·746	19·23	=	1 to 5·2

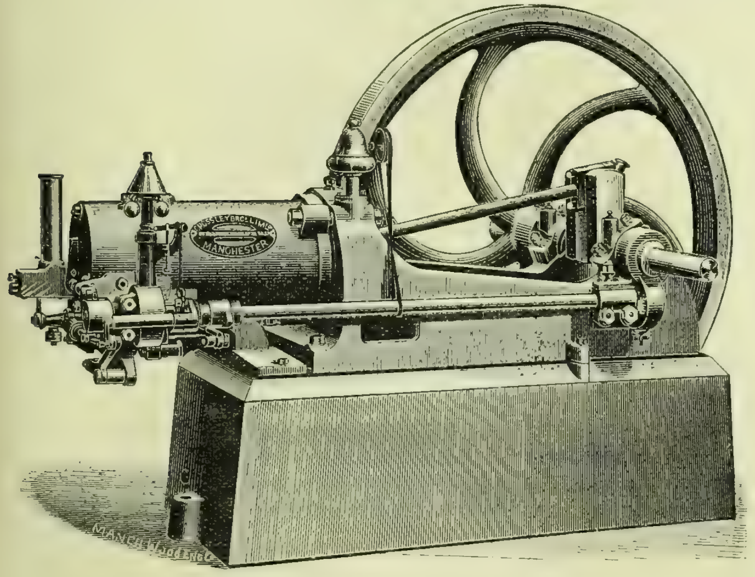
Starting Valve.—The starting valve on the receiver, for admitting boiler steam direct to the low-pressure cylinder for starting, is worked by hand by the driver, and is not automatic in closing, its only merit being that it is exceedingly simple. In fact, these valves were already in stock, having formerly been used for steam brakes on the locomotives. It cannot therefore be pretended that they present the same excellent features as the special automatic starting valves which have been introduced elsewhere and have proved so efficient in working. In the author's locomotives retaining their original boilers it must be borne in mind that his whole attention was directed simply to obtaining from old engines compounded with 8½ to 9 atmospheres pressure, the nearest and cheapest approach to modern compounds having 12 atmospheres pressure. As to any possibility of a wasteful expenditure of steam through abuse of the starting valve, this is sufficiently guarded against by the drivers being paid a premium for saving fuel; they are as a rule fully alive to their own interests, and never use the starting valve more than is absolutely necessary. The hand interchanging valve, together with the hand intercepting valve, enable the engine to continue working non-compound for any length of time, instead of for only the first stroke at starting; and the interchanging valve, when the intercepting valve is either open or closed, serves also as an air-inlet valve for both cylinders in running down hill with the steam shut off. These valves are indispensable for starting heavy trains without jerks.

Tractive Power.—The adhesion weight of the compound goods locomotive with six wheels coupled is 36,000 kilograms = 35·420 tons. In the engines having the high-pressure crank leading, the tractive power at the third notch is 5,632 kilograms = 5·543 tons, adding as before 10 per cent to the mean pressures shown in the indicator diagrams, so as to allow for loss of pressure in the connecting pipe from the cylinder to the indicator. At the fourth notch a tractive force of 6,295 kilograms = 6·195 tons is attained, which is equal to $\frac{1}{5 \cdot 6}$ or nearly 18 per cent of the adhesion weight, and is therefore quite sufficient on dry rails to utilise the total adhesion of the engine. In the calculation of the tractive power of the compound engines, the power of each cylinder is calculated separately by means of the formula: Tractive power = 0·57 × boiler pressure above atmosphere × (cylinder diameter)^2 × stroke ÷ (2 × diameter of driving wheels). The coefficient 57 per cent, which gives the mean effective pressure on the high-pressure piston in full gear, has to be replaced by a lower figure, deduced from indicator diagrams, when working more expansively; and for the low-pressure cylinder a still lower coefficient has of course to be taken.

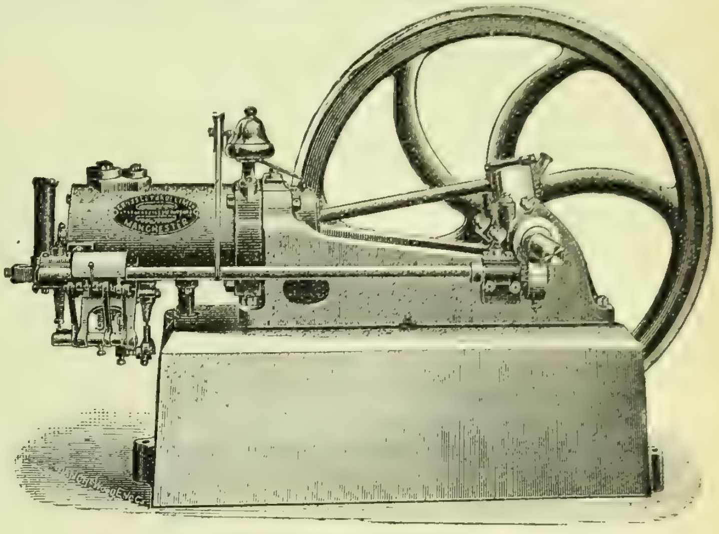
The results of the author's experience are such as to leave no doubt in his own mind that compound locomotives are the engines of the future in all countries. Plans are already in hand for compounding the eight-wheel coupled 48-ton goods locomotives; and advantage will be taken of the alteration of these and other engines to substitute also balanced slide valves, so as to save the extra 5 or 6 horse power at present absorbed by the friction of the slide valves. What is really wanted is to mature a thoroughly efficient two-cylinder compound, with moving parts as light as possible, and well balanced.

THE OTTO ENGINE AT PARIS.

Messrs. Crossley Bros., of Manchester, have a splendid show at their stand in the Machinery Hall, which consists of a vertical Crossley's Otto domestic engine, 5 man power engine, a half-horse power vertical gas engine, with pumps combined; 2 horse power and 3 horse power vertical gas engines, with hoist combined, and 4 horse power, 7 horse power, an d14 horse power engines—eight engines in all. The domestic, 5 man power motor and the 3 horse power engine are vertical single cylinder, and indicate respectively ¾, 1, 2, and 6 horse power. They are fitted with pendulum governors, and the domestic engine admits the gas and air, exhausts the burned gases, and ignites through a circular valve, while the 5 man power and the half-horse admit gas and air and ignite by a slide valve. The domestic and the 3 horse power vertical have the incandescent tube igniter attached.

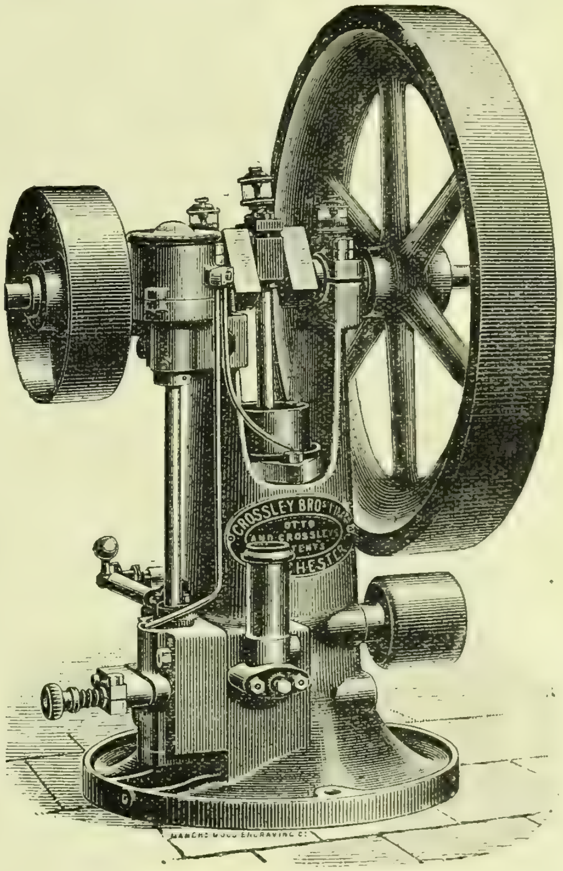


Four Horse Power Otto Engine.



Two Horse Power Otto Engine.

The half-horse power vertical has a set of 3in. by 5in. pumps attached, making 70 strokes per minute, and delivering 540 gallons per hour. The 2, 4, 7, and 14 H.P. engines are horizontal, with tube igniters, and they indicate respectively 4, 8, 14, and 33 H.P.



Crossley's Otto Domestic Engine.

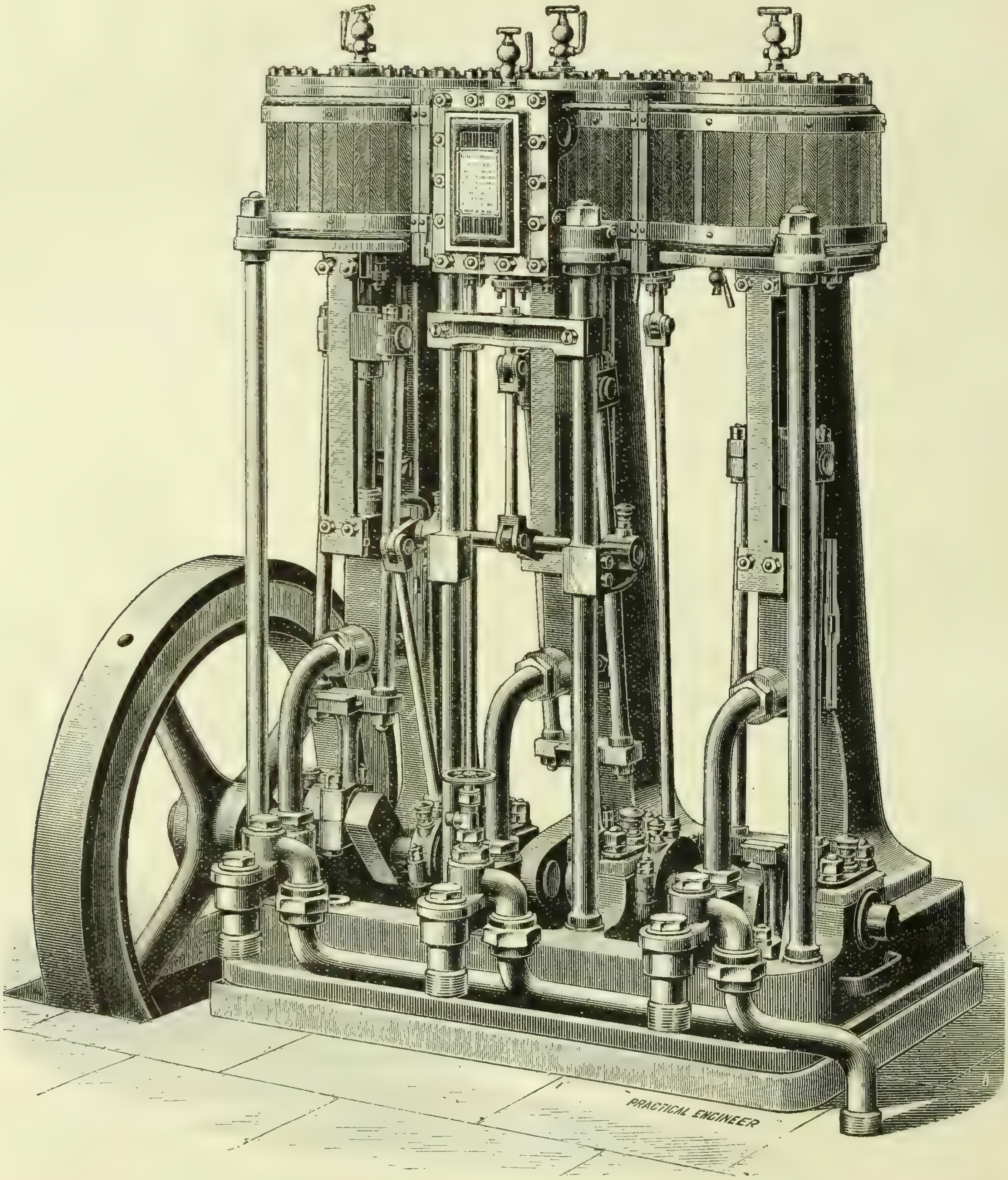
We illustrate here the domestic gas engine, the 4 H.P., and the 2 H.P. engines. All the engines are nicely got up, and in simplicity of design are, in our opinion, far superior to those of the Otto continental makers.

Naphtha is now much used as fuel in Middle Russia. Last year, 880,000 tons of it were sent up the Volga for fuel purposes; and it is expected that the export for the same purpose will this year reach no less than one million tons.

THE PARIS EXHIBITION.

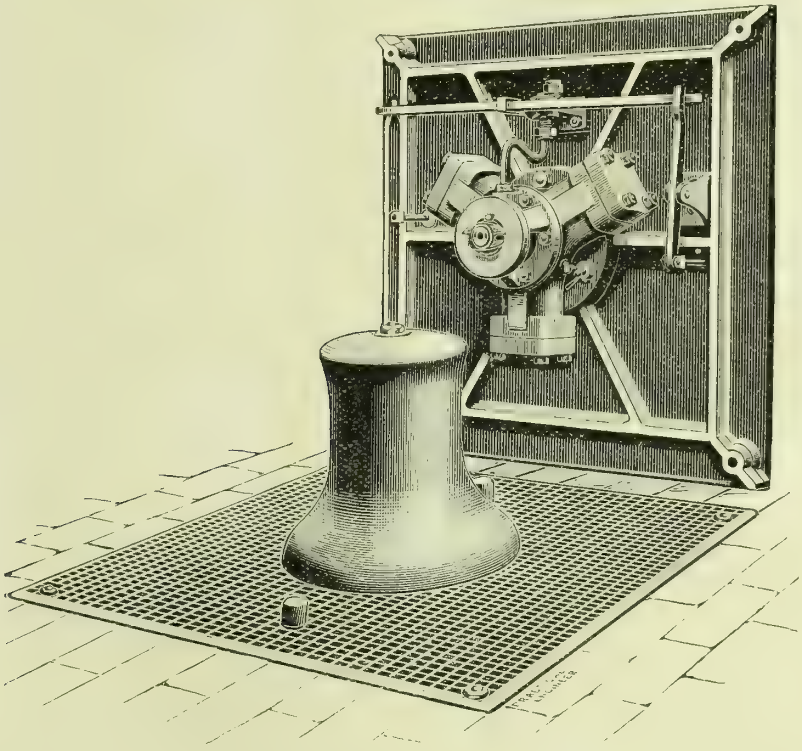
SET OF INVERTED COMPOUND STEAM PUMPING ENGINES.

CONSTRUCTED BY THE HYDRAULIC ENGINEERING CO., LIMITED, ENGINEERS, CHESTER AND LONDON.



THE Hydraulic Engineering Company have a very complete and interesting stand, and show examples of their leading specialties in pumping engines, lifts, and hydraulic tools. A set of inverted compound steam pumping engines are shown at work, and are illustrated above. As will be seen, the engines have three steam-jacketed cylinders—*i.e.*, one high pressure, 5in. diameter, and two low pressure, 6½in. diameter by 6in. stroke, working on cranks set at angles of 120 deg. one to the other, to insure a continuous and even flow of water from the pumps. Each cylinder drives one single-acting pump, which is fixed between the crank shaft and the crosshead guides. The rams, 1¼in. diameter, are secured directly to the crosshead, the connecting rods being forked to clear the pump bodies. These pumping engines receive steam from the main steam pipes in the building, and deliver about nine gallons of water per minute at 700lb. working pressure when running at their normal speed of 120 revolutions, and they supply all the water for the several machines the company show in motion. We may add that this pumping engine is a model of Ellington's patent inverted pumping engines, as in use by the London Hydraulic Power Company at their main pumping stations, at Falcon Wharf and Millbank Street, and the Liverpool Power Company's pumping station at Athol Street, all of which, however, are surface condensing, and were built and fixed in place by the Hydraulic Engineering Company Limited. The accumulator working in connection with the small engines we have just described has a ram 4½in. diameter by 8ft. stroke, with a moving cylinder arranged to carry the cast-iron loading weights, which are adjusted to produce the required pressure.

When the accumulator is fully charged, the steam to the pumping engines is automatically cut off by means of tappet gear acting on a throttle valve fixed in the steam supply pipe. On water being drawn for any purpose, the accumulator commences to descend, and causes steam to be again admitted to the engine to supply the necessary pressure of water. A hydraulic passenger lift, which is capable of raising four or five persons to a height of 20 feet, is shown in operation, fitted with one of Ellington's patent hydraulic balances of the latest and most improved type. The advantages of this balance are numerous. The consumption of water is reduced to a minimum, and all the dead weight of the moving parts (less an allowance to overcome friction) are balanced without the usual counterbalance weights, chains, and overhead sheaves and gear, which are often a source of danger and inconvenience, as well as being costly to maintain. The whole weight of the lift, including load, is borne directly on the solid foundations, and its movement is controlled by a hand rope passing through the cage, actuating a working valve fixed in the machinery pit. This valve, which is of the slide type, is constructed entirely of gun metal with specially hard face. A hydraulic punching machine is connected with the accumulator, so that this also may be seen at work. It is capable of punching ⅜in. diameter holes in ¼in. iron or steel plates, and of shearing ¼in. plates at 12in. from the edge of plate. This machine is on Tweddell's system, the Hydraulic Engineering Company being sole makers of these machines for Mr. Ralph Hart Tweddell, the inventor. The ram to which the upper tool is fixed is a prolongation of the main piston, on which it is arranged eccentrically, thus forming a guide, so that any twisting or side play in the tool is absolutely impossible. The cylinder is lined with gun metal. The working valve of the slide type is also of gun metal, and is controlled by a wrought-iron hand lever. To prevent waste of water, the stroke of the piston can be regulated by means of tappets to suit the thickness of the material to be punched or sheared.



PATENT THREE-CYLINDER HYDRAULIC CAPSTAN.

A hydraulic intensifier, which is exhibited, has been largely adopted for working in connection with hydraulic presses, where water power, such as supplied by the public supply companies, is available. The apparatus consists of a cylinder provided with a ram, which acts in turn as a cylinder to a smaller fixed ram, held in position by a crosshead and steel tension bars. On admitting the 700lb. water pressure through the working valve into the bottom cylinder, the moving ram is forced upwards, and the water displaced by the fixed ram is intensified in pressure in proportion to the areas of the moving and fixed rams. This machine is also adapted for testing hydraulic cylinders, pipes, and fittings, as, by a careful manipulation of the controlling levers, any desired pressure between the extreme limits for which the machine is designed can be maintained for any length of time, so that the same intensifier is available for tests of very considerable ranges, say from 1,000lb. to 5,000lb. or upwards per square inch. We are informed that Mr. Ellington designed this apparatus some years ago, with special reference to requirements of this nature. The Marc Berrier Fontaine drilling apparatus is represented by two machines constructed entirely of phosphor bronze, excepting the crank shaft and thrust bars, which are of steel. These machines are designed for a working pressure of 1,500lb. per square inch, at which pressure the smaller machine will drill holes up to 1¼in. diameter, and the larger machine (arranged to drive through a Stow flexible shaft) will, of course, drill relatively smaller holes. The hydraulic motor in these handy appliances is the well-known Brotherhood three-cylinder hydraulic engine. The whole machine, while substantially constructed, is readily portable, and can be carried to its work, being specially designed for drilling holes in place during construction.

About forty of these machines have been supplied by the Hydraulic Engineering Company to the French Government shipbuilding yards at Toulon and Cherbourg, and others to Messrs. Sir W. G. Armstrong, Mitchell, and Company, Messrs. Doxford and Sons, and Messrs. Tancred, Arroll, and Company, besides many shipping orders. These machines are also adapted for drilling holes in armour plates during the building of a ship, and can also be arranged for other special purposes, such as cutting out manholes in ships' decks, side lights, &c.

We were much interested in the Greathead and Martindale's patent injector hydrant, which, as its name implies, is on the steam injector principle, but is specially adapted for throwing a large volume of water in case of fire. The injector hydrant is connected to the 700lb. main, and also to a low-pressure supply pipe or other convenient source; a small jet of the high-pressure water draws with it, through the apparatus, four or five times its volume of the still water, and throws the whole over the top of the highest building. This apparatus has been kindly lent by Messrs. Sir W. G. Armstrong, Mitchell, and Company.

A patent three-cylinder capstan is exhibited by the Hydraulic Engineering Company, of the Brotherhood type, which has the qualifications of a perfect capstan. Its appearance when in position, and the engine underneath when the plate is lifted, is clearly shown in our illustration on page 515. It is exceedingly simple, strong, and durable, has only a few working parts, and is self-contained. There are no glands, stuffing boxes, or oscillating joints, and all the moving parts are subjected to strains in one direction only. The lubrication is all effected above the ground. These capstans work smoothly and well at 2 or 3 to over 100 revolutions per minute, and are started and stopped instantaneously by a treadle valve, which admits the pressure to the engine.

Among the great numbers now at work several instances are known of their running, more or less continuously, day and night for over eighteen months without examination or repair.

The engine works directly on the single crank of the shaft which carries the capstan head, the consumption of water is reduced to a minimum, and the absence of alternating strains renders a breakdown almost impossible. The working parts are all made to gauges, and new parts can be substituted when required, without any fitting, in a few minutes. Over 600 of these capstans are at work, many of which have been running for about ten years. Several of the leading railway companies, we are informed, use them exclusively. All these machines were inspected by us, and were of excellent finish and design; they worked with great smoothness. The hydraulic passenger lift was much appreciated, and many visitors ascended, and enjoyed the view of the Machinery Hall from its elevation.

OPENING OF THE BARRY DOCK.

A GENERAL holiday was observed on Thursday, the 19th inst., at Cardiff, on the occasion of the opening of the Barry Dock, which, situated about seven miles westward of that enterprising town, is expected to become a powerful rival port. The dock, with its contiguous railways running up into the rich coalfield of the Rhondda Valley, was promoted as early as 1883 by a body of freighters who were dissatisfied with the accommodation provided at the docks owned by Lord Bute at Cardiff, and who, by the construction of an independent railway from the coalfields to the sea coast, with a separate dock as an outlet, sought to improve their commercial position. The Parliamentary fight over the bill was very keen. The promoters, at the head of whom were Lord Windsor and Mr. David Davies, formerly M.P. for Cardigan, were opposed by various railway and dock companies of South Wales, prominent amongst whom was Lord Bute, the owner of the Cardiff Docks. The most eminent members of the Parliamentary bar were engaged for and against the bill, which was passed by the House of Commons in 1883, and thrown out by a committee of the House of Lords in the same session, but eventually received the sanction of both Houses in 1884. Since that period the Barry Dock Company have promoted no fewer than five bills, several of which have had for their object the securing of running powers over a rival line—that of the Taff Vale Company. From 1885 the Barry Dock Company, consisting mainly of shareholders in the Rhondda Valley, have been session by session before parliament for the purpose of adding to and improving the dock and railway. The result is that at the present time the company possess one of the largest docks in the world, it being no less than 73 acres in extent, whilst connected with it is a railway running up to Treforest and Safod, important centres in the Welsh coalfield. The main object to be served by the Barry Dock, the cost of which, by the way, has been upwards of two millions of money, is to afford increased facilities for the shipment of coal from South Wales, and also to provide for an import trade, which it is expected will be attracted to a dock that has an important amount of exports.

The great and increasing importance of the South Wales coal export trade during the past thirty years may be gathered from the fact that whilst the export of coal at Cardiff and Penarth (four miles away) was 2,977,152 tons in 1867, it was 11,048,053 tons in 1888. The import trade of Cardiff and Penarth is of much smaller volume than the coal trade, but it is of importance, amounting to 1,189,000 tons in 1887; and the opinion generally prevails that there is much scope for the further development of an import trade in this part of the Bristol Channel. The Barry Dock and Railway Company has a capital of about £2,000,000. All their railways appear to be first-class lines, with ruling gradients of 1 in 400 against the load of coal, and 1 in 120 against empty return trucks. These gradients, it may be interesting to explain, are so proportioned that an engine which can take a loaded train up the gradients of 1 in 400 can bring back the empty trucks by the gradient of 1 in 120. The branch to Penarth Dock, in addition to accommodating mineral traffic, forms the passenger connection with Cardiff and Penarth.

The site selected for the dock occupies the easternmost portion of a channel about a quarter of a mile wide between Barry Island and the mainland. The entrance at the eastern end lies well under the shelter of the land of Barry Island from all westerly winds. It is claimed for Barry Dock that it will possess the great advantage of having its entrance in a well-sheltered position, where there is but little tidal current, whilst at the same time it is close to deep water. A ship leaving the dock is in a few minutes in what sailors call "blue water," and is not exposed to the troublesome navigation of an artificial channel. From Barry to Sully Island, which is about three miles to the eastward, there is good anchorage ground. This is of importance, from the fact that Barry Dock, like all the other docks in the Bristol Channel, is a tidal dock, accessible only within a few hours of high water. The tidal range at Barry is 36ft. at ordinary spring tide, increased to 40ft. at equinoctial and extraordinary springs, and 19½ feet at ordinary neaps, diminished to 16ft. at extraordinary neaps. The entrance is protected by breakwaters, illuminated by a flashing white light of the fifth order, exhibited in a lighthouse 44ft. above high-water ordinary spring tides. The entrance of the dock is 80ft. wide, and gives access to a basin 500ft. wide and 600ft. long, having an area of seven acres, surrounded by vertical masonry walls.

The depth of water on the sill, which is curved, is as follows: High-water ordinary spring tides, 37·7ft.; low-water ordinary spring tides, 16ft.; high-water ordinary neap tides, 29·3ft.; low-water ordinary neap tides, 9·7ft. The entrance has a single pair of wrought-iron gates, with air chambers, so that they are nearly afloat at the times at which they will be used. The mode of working the dock is by using the basin as a large lock. Vessels intending to leave the dock will be brought into the basin some time before high water, and the passage gates will then be shut. The entrance gates will be kept open a short time after high water so as to admit inward bound vessels as late as possible on the tide. No lock is at present provided, but one is contemplated, having a length of 600ft. and a width of 65ft. If this be carried out, the Barry Dock will be in the important position of being the only dock in the Bristol Channel available at practically all states of the tide. There is also at Barry a large graving dock, and space for a second is reserved. The machinery for opening and closing the gates is somewhat novel in character. They are worked by direct hydraulic rams of sufficient strength to resist the shock of waves in rough weather, and so to hold the gates rigidly during their movement. The gates are 48ft. high and 48ft. long from heel post to mitre post. The caisson, which is made of wrought iron and steel, has a beam of 24ft. The dock is 3,100ft. in length, and it is approached by both a high and low level system of railway. The dock and sidings are lighted by electric light, and the tipping and all other arrangements are of the most approved type.

At an early hour on the opening day large numbers of people flocked to the vicinity of Barry, which, with American-like rapidity, has grown in a few years from a straggling agricultural village into a thriving township of about 10,000 or 11,000 people. The dock sides and the embankment at the basin were crowded by eager sightseers, whilst a fleet of vessels in the offing were gay with bunting and streamers and flags, which connected mast with mast. The Barry Company had been generous with their invitations, and the company included many leading representative men of our various shipping centres. The entrance to the dock was barred by a festoon of many coloured ribbons, the cutting of which was to constitute the opening ceremony. About 10 o'clock the steamship Arno, of Sunderland, separated herself from the flotilla at sea, and steamed gently towards the entrance, being steered by Mr. T. K. Thompson, one of the Barry Dock directors. As the vessel approached, Mrs. Lewis Davies, the widow of a late director, handling a silver sword, severed the cord of ribbons at the basin entrance, and the ship passed in, amidst the plaudits of the people on shore and aboard. A salvo of artillery was fired, and a band struck up an enlivening tune, whilst the utmost enthusiasm prevailed. The Arno was followed by a stream of gaily bedecked craft, including steamers, tugboats, and private yachts.

At a luncheon which followed, Mr. David Davies presided, and was supported by most of the other directors. Proposing success to the Barry Dock and Railways, the Chairman said that the coal exports of Cardiff showed an increase of over 50 per cent for the past seven years, whilst there had been a corresponding and in some instances even a greater increase in the import trade. Provision had been made for a lock, which would form a second entrance to the dock, and it was intended to place sills of the lock 15ft. deeper than the present sills, so that ships could go in and out at all states of the tide. There was a depth of 26ft. at low water of spring tides within 700 yards of the entrance to the dock, whereas at the neighbouring ports of Cardiff and Penarth a similar depth of water was not reached within 3 miles and 2⅓ miles respectively. It was not the object of the Barry Company to create undue competition, however, but to provide an accommodation for the rapid and unfettered expansion of the various trades in the district, and so to facilitate their full development for the general benefit of the community. There would not be excessive competition between Cardiff and Barry, but only healthy rivalry. Several other toasts followed. Amongst the speakers were Mr. J. Wolfe Barry, the engineer of the works; Mr. Downing, the solicitor of the company; and Mr. Cripps, the Parliamentary agent. Mr. Walker, the well-known contractor, entertained nearly 2,000 of the workmen to dinner, and later on in the evening there was a display of fireworks.

THE SKILLED LABOUR MARKET.

The following memorandum has been prepared for the *Board of Trade Journal* by the labour correspondent to the Board of Trade: The returns sent in this month from the principal organisations of skilled trades show the labour market to be in a remarkably prosperous condition. With but a few exceptions, the societies reporting state that improvement in demand and increased remuneration is the order of the day. This advance is most clearly indicated in the shipbuilding trade, in the allied engineering industries, and in those branches of production and manufacture which supply them with material. The activity of the shipbuilding trade is almost unprecedented. There is, indeed, still a proportion of unemployed reported at 3 per cent, but this is almost entirely due to the still-pending strike of riveters on the Clyde, which affects at least 700 men, and but for which the proportion of unemployed in this industry would not be more than ·63 per cent, which is somewhat less than the average of that golden year of iron shipbuilding, 1882. In seven societies of the engineering trade, representing engine and machine building, ironfounders, smiths, and pattern-makers, with an aggregate membership of 85,000, the percentage of men out of work is only 1·75, as against an average for the same societies in July of last year of 5·2. The building trades also are in a vastly improved state, and the proportion of those out of work is at least one per cent less than in the corresponding month of last year. Cabinet-makers are well employed; but the cotton and woollen industries are only spoken of as moderate. The demand for printers, both in London and the provinces, has somewhat fallen off; but the clothing and boot and shoe trades are fairly brisk. In the departments of iron and steel manufacture, work is plentiful, and, as a natural result, the coal trade continues prosperous, and the mining population is better employed than for some years back. Altogether, eighteen societies have sent in reports. These show an aggregate membership of 188,774, of whom 3,461 were out of work at the end of June. The general percentage of unemployed in these trades is, therefore, but 1·8 per cent, and it is extremely probable that even this small figure represents chiefly a floating quantity of labour unemployed for short periods only. The percentage a year ago was 4·6. A general summary of the reports shows that while only five return the state of their trades as "moderate," thirteen describe it as "very good."

A HYDRAULIC RAILWAY.

A Paris correspondent says: A press view took place on Saturday June 20th of the so-called "chemin de fer glissant," or "slide railway," on the Esplanade des Invalides, within the Exhibition. The new invention is a singularly original contrivance for enabling trains to run by means of water power at a speed hitherto undreamt of. Arriving there without any intimation as to what a "sliding railway" might be, I at first mistook it for an overgrown switchback with the humps smoothed away. The train consisted of about four carriages, affording room for about 100 passengers. In a hydraulic train travelling at full speed—that is to say at the rate of 140 to 200 kilometres, or 87 to 124 miles an hour—there would be almost no consciousness of motion. The journey down the length of the esplanade only occupied a few seconds.

HEAT ENGINES OTHER THAN STEAM.—I.

(Continued from page 503.)

We can also realise, from our big gun diagram, that, while the addition of heat produces expansion, the converse is true, and the abstraction of heat will lessen the density of a gas; or, what is the same thing stated in another way, will lessen its pressure if the volume remains constant.

It is true of almost every body, and in all the various "perfect and complete states" of each body—*i.e.*, the solid, the fluid, or the gaseous—that the addition of heat causes expansion; but it is also true that with almost every body, at the critical periods of change of state from the solid to the fluid, or from the fluid to the gaseous, there is an absorption or disappearance of the heat which may be put into it, which heat can only be caused to re-appear when the body is allowed or compelled to re-assume the more solid state, or its lower state of being, if such an expression may be permitted. To this I will refer again almost directly after dealing with the question of specific heat.

Solids expand by the addition of heat, though in less proportion than gases. An instance, familiar to those of us who are engineers, is afforded when we have to deal with a cast-iron steam pipe of great length, subjected as they are to considerable variations of temperature. We know that in a pipe of 800 feet we have to allow for a variation of, roughly, one foot for each difference of 200 degrees of temperature to which the pipe will be exposed; that is to say, a pipe which is 800 feet long at a temperature of 32 degrees, or at freezing point, will expand to nearly 801 feet if it is filled with boiling water.

Mr. Benjamin Baker tells me that at the Forth Bridge he has made an allowance of three-fourths of an inch for every 100 feet of length, and this to provide for the difference of summer and winter temperatures, which may be as much as 100 degrees.

A still more familiar instance of the effects of variations of temperatures is afforded by the ordinary mercurial thermometer. Heat causes the liquid mercury to expand or dilate, cold causes it to contract. The expansions of the steam-pipe and of the mercury, however, are small in comparison with the expansion of gases; "steam," "air," or whatever they may be, for an equal increase of temperature.

We know if we have a bladder partly filled with air, and we heat it, it expands, filling that bladder—or appearing to fill the bladder entirely; we heat it still more, the expansion is greater; and we can heat it till the pressure increases so much that it exceeds that which the bladder is capable of bearing, and the bladder bursts. This is a simple illustration of the fact of increase of temperature causing expansion, and also causing increase of pressure.

Let us now consider the question of specific heat, and let me here caution you as to the difference between the words "heat" and "temperature." This caution is necessary, for, as I am about to show you, heat may be added to, or taken from a body without corresponding change of temperature.

Experiment has proved that different solids and fluids require varying quantities of heat to be put into them, or to be taken from them, in order to increase or to lower their temperature through any given range.

The amount of heat absorbed or given off, as the case may be, by any substance to vary its temperature through any given number of degrees, is termed "specific heat."

A "quantity" or an "amount" of heat is always spoken of as so many "heat units" or "thermal units." By an English "heat unit" is meant that amount of heat necessary to raise 1lb. of water from 39·1 deg. to 40·1 deg. Fah., *i.e.*, the amount of heat necessary to raise 1lb. of water at the temperature of its greatest diversity 1 deg. Fah.

Of all bodies water is the one which opposes the greatest resistance to a change of temperature; that is to say, it requires a greater amount of heat imparted to it, or extracted from it, to cause a given change of temperature in it, than does any other solid or liquid we know. Water, therefore, is used as the standard of comparison, and its specific heat is taken as unity. From this it follows that the specific heat of all other bodies, whether solid, fluid, or gaseous, must be expressed in fractions, or in parts of unity.

The specific heat of water itself is not absolutely constant at all temperatures, it becoming slightly increased at 212 deg. Fah., or at its boiling point; but it is sufficiently constant, at all events, for us to ignore the variation.

You will now comprehend the definition of specific heat. It is the ratio of the quantity of heat necessary to raise or to lower a given weight of any given body through a given variation of temperature—say one degree—to the quantity of heat required to raise or lower the temperature of an equal weight of water through the same variation of temperature.

We have talked of the expansion of cast iron and of mercury, and have noted how small are such expansions for equal changes of temperature compared with that of a gas. Let us consider what their relative specific heats are, and see what quantity of heat will have to be added to 1lb. of each to raise its temperature by the 200 deg. with which we have dealt before.

Regnault's experiments have told us that the specific heat of cast iron is ·12983, therefore ·12983 × 200° × 1lb. = 25·966 heat units.

The same experimenter gives the specific heat of mercury as ·03332, therefore ·03332 × 200 deg. × 1lb. = 6·664 heat units, or in other words, about ⅓th the heat needed to raise 1lb. of water 200 deg. would raise the same weight of mercury through the same temperature; and, as between the two metals, nearly four times as much heat would be required to raise a given weight of cast iron through a given range of temperature as would be required to raise the same weight of mercury through the same range.

One of the best common-place illustrations of specific heat is, I think, afforded to us if we look upon it as equivalent to "appetite."

Two persons are equally hungry, that is to say, that if there were any accurate instrument by which we could test them, we should find that they were in an equal state of wanting their dinner. They sit down to eat it, and when they have finished, if we could again apply the "hunger-meter," we should find that they were equally satisfied. When, however, we come to examine as to the quantity of food consumed by each, we find that one has made away with some 5lb., while the other has only needed ½lb. to satisfy him to an equal degree. So with bodies and heat. Here experiment has shown one body requires five portions of heat to raise it through a certain range of temperature, while another body only requires one portion of heat to raise it through an equal range.

One of the distinguishing characteristics of all gases is, as we shall now find, that their specific heat does not vary, under similar conditions, to any appreciable extent.

Let us try to understand this question of the specific heat of gases (one of the most difficult points which it is necessary for us to fully comprehend in connection with the theory of our subject), and let us refer again to the diagram of the big gun. You will remember that when the gun did the work of driving out the shot, a portion of the heat of explosion was transformed into the motion of the shot, and we were able to reproduce the heat by suddenly arresting that motion. In this case, therefore, we prove that we had a lessening of the total quantity of heat developed by the combustion of the powder charge, due to its transformation into mechanical work. As we shall see, it is necessary to bear the possibilty of such a transformation in mind when dealing with the question of the specific heat of gases.

If we had maintained the volume of the gases in the gun constant, that is to say, if we had not allowed the shot to move at all—thus preserving the space in which they were contained at all times constant—then the amount of heat necessary to be imparted to the gas, or to be abstracted from it, in order to cause a given change of temperature: that is to say, a gas when the volume is maintained constant follows the same law, or principle, in respect to specific heat, as governs the case of a solid or of a fluid; but, allowing the gases to expand or increase their volume as we did; that is to say, allowing the space in which they were contained to increase by the forward motion of the shot, we should find, if we tried the experiment, that the amount of heat necessary to be imparted, in order to maintain the same temperature, would be as much greater as would be represented by the difference in volume of, or space occupied by the gases.

Let us put this difference of the specific heat of gases, under different conditions, into figures: The specific heat of a gas—say air—when the air—when the volume is constant, but the pressure is allowed to vary as the heat is imparted or abstracted, is ·169, or practically 1-6th of that of water, but the specific heat of the same gas (air), when the volume is allowed to vary as the heat is imparted or abstracted, but the pressure is kept constant, is ·238, or a little less than 1-4th of that of water. You will see that the ratio between the two is as 1 to 1·408.

This is the way in which this question of the difference of the specific heat of gases, under varying conditions, is usually stated in the text-books; but it has been pointed out by Sir Frederick Bramwell and others that the bare statement thus made is hardly intelligible and is incomplete. They show that the increase of the specific heat of a gas, when its volume is allowed to vary, arises from the amount of heat necessary to be turned into work, in order that the gas, in increasing its volume, shall be capable of displacing that portion of the atmosphere which it does displace; that is to say, if while maintaining the temperature constant we had allowed the shot to move forward in our gun, and assuming that no work was required for moving that shot, and that no heat was lost in any way whatever, then the extra amount of specific heat which the gas would require as its volume increased would be exactly that necessary to overcome the pressure of the atmosphere, and to do the work of displacing that portion of it which would be occupied by the increased volume of the gas.

I wish time would allow me to go into this matter more fully, but we shall have again to refer to it when dealing with the expansions arising in the cylinders of heat engines, when I will endeavour to put the explanation in other ways, so as to enable you to completely grasp this rather complicated question.

We have one more question of heat to consider, which almost logically follows from that which we just discussed, and that is "latent heat."

Let me refer again to our appetite illustration, in order to enable you to realise this question of "latent heat." Imagine that the two persons who have already assisted us have been for a long period without any food, and imagine that although they eat a hearty meal, yet, when they get up, they do not feel their hunger satisfied, and that our hunger-meter registers no more satisfaction after the meal is over than it did when our friends sat down; that is to say, all the food which they had consumed would, as far as the hunger-meter was concerned, be "latent," and this instrument would fail to indicate to us that they had eaten any food at all. A similar thing happens when we put heat into a body which is, say, a fluid, but is at the critical state of change in its condition from fluid to gaseous; the heat which then disappears is termed the "latent heat of vaporisation." The thermometer will not register the heat which is at that time put in, that heat being necessary to make the change of state of the body. A similar apparent disappearance of heat takes place when the change is from solid to fluid; this is termed the "latent heat of liquefaction."

Let us take water again for our illustration. A certain definite addition of heat is necessary to raise any given weight of water each degree of temperature up to the boiling point; but then, in order to change the water—which is at boiling point—to steam, which is not, however, at any higher temperature, a large quantity of heat has to be added, which seems to totally disappear, and can only be caused to reappear by re-changing the gas—steam—into the fluid—water.

As a fact, we may look upon steam as a mixture of heat and water, the heat really being absorbed by the particles of water at the time of its change into steam, and not making itself sensible in the instrument with which we measure the heat; and we may also look upon water as a mixture of heat and ice.

You know we can tell by the sense of touch the difference of temperature of a body. Now, if it were possible for us, without burning ourselves, to put our hands into boiling water and realise its temperature, we should suffer no more from the heat than we should by putting our hands into steam at atmospheric pressure; and yet we find by experiment that, in order to change the fluid (water) into the gas (steam), we must add a quantity of heat which would be sufficient to raise the temperature of the water, if it remained as water, 966·6 deg.

James Watt was one of the earliest to discover and publish this fact of latent heat in reference to water and steam, and in 1781 he estimated the number of heat units necessary to make the change in 1lb. of water as 950, but he subsequently put the numerical value at 960. Corrections were made by Regnault, based on experiments which he had made, and his formula gives the true value, namely, that which I have stated—966·6 units—as the quantity of heat which disappears or becomes latent when each 1lb. of water, at the temperature of boiling point, is transformed into steam, which will only be at the same temperature. Further, I must remind you that in order to change 1lb. of ice at 32 deg. into water which is only at the same temperature, 142·4 units become latent or disappear. You will now fully realise the necessity for my caution to you not to confuse the terms "heat" and "temperature."

The theory of working of heat engines is indissolubly connected with the name of a Frenchman, an ancestor of the present President of the French Republic (M. Carnot).

(*To be continued.*)

EXTENSION IN THE STEEL TUBE TRADE.

The Credenda Seamless Steel Tube Company Limited, of Birmingham, we understand, have just arranged for the purchase of the extensive freehold property at Smethwick formerly occupied by the Birmingham Plate-glass Company. These works occupy an area of seventeen acres, and are admirably placed and laid out for a great factory, being practically surrounded by canals, and in direct railway communication with all parts of the kingdom. Some idea of the magnitude of the works may be formed from the fact that one great hall in the building measures 528ft. by 156ft., and around this central workshop are grouped numerous others, all admirably fitted up, and of scarcely inferior dimensions. The works are now being rapidly prepared for the reception of machinery of a most costly and powerful description, constructed in accordance with the latest improvements made by this company, from the designs and under the supervision of the managing director, Mr. W. C. Stiff, to whose special knowledge, experience, and administrative skill it may be fairly said the company's success is largely due. When the fitting up of these branch works is completed they will furnish employment for a large number of additional hands, and the company will be speedily in a position to cope with all demands, and obviate the delays which have unavoidably arisen of late in satisfying the requirements of their numerous customers at home and abroad.

Testimonial to Professor Kennedy.—In consequence of the announcement by Professor Kennedy that he resigns the chair of Mechanical Engineering at University College, London, W.C., at the end of the present session, his past and present students, in appreciation of his valuable services as head of the engineering department of the college, desire to present him with some token of regard in expression of their deep sense of admiration for the zealous and courteous manner in which he has so ably filled the chair held by him during the last fifteen years. Any old students who have not been directly communicated with can receive full particulars from the hon. treasurer, Mr. R. H. Willis, 17, Bear Alley, Farringdon Street, London, E.C., who will also be very pleased to receive any contributions they may think proper to send.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

THE STRENGTH OF FURNACE TUBES.

To the Editor of "The Practical Engineer."

SIR,—I think the best evidence of the correctness of my formula is found in the reports of explosions in which the flues have collapsed. The formula applies to boilers in actual use, and not to experiments with cold water on new tubes. When applied as intended, I have generally found it correct within a small margin, except when there has been overheating through shortness of water, excessive thickness of scale, &c.

I do not know the book mentioned by "Practical Engineer," but, judging from the meagre information he supplies, I do not attach any great importance to the experiments referred to. They are not consistent with each other, nor with any formula that has been proposed, unless with Fairbairn's original one, which is now generally considered to give pressures at least twice as great as it should do.

I find the report nearest at hand is Mr. D. K. Clark's letter in *Engineering* of 21st September last, in which is a list of flues and the pressures at which they failed, to which I have added, in column 5, the pressures that would be given by my formula.

Length in feet.	Diameter in inches.	Thickness in inches.	Pressure in lbs.	Pressure by formula.
18	32	$\frac{3}{8}$	60	81
24	34	—	68	72
25	35	—	64	68
26	35	—	60	68
43	36	—	50	64
28	36	—	45	64
33	39	—	45	55
25	41	—	40	52
28	42	—	45	47
30	42	—	45	47
32	44	—	40	43
34	48	—	40	36
17	34	$\frac{5}{16}$	55	97
32	43	—	57	66
40	45	—	45	56
32	47	—	50	51
30	48	—	43	49
33	—	—	42	—
32	—	—	50	—
28	—	—	50	—

This table was, I believe, compiled from the reports of the boiler insurance companies, and "Practical Engineer" can no doubt find others. He will see that he has been misled by his book into supposing that my formula gives pressures that are rather too low, and that the facts are rather the other way. It appears to me that what we want is a formula that is applicable to boilers as they are—one that gives the actual collapsing pressures, so that flues will no longer "collapse at less pressure than we often expect."

In my letter in *Engineering* of 4th January, 1889, before alluded to, I explained that my formula, applied to flues less than seven diameters long, with the same units of measurement as used by Fairbairn, would be $p = \frac{344064\ t^2}{D\ L}$. If I remember rightly, this is almost exactly the same constant as is used by the Board of Trade; and I further explained that if Fairbairn's experiments had been accurately investigated, his constant would have been 443483, the difference being almost entirely accounted for by the variation in the conditions between a heated boiler flue that has been used many times and a new cold experimental tube.

I think I may, therefore, fairly claim that experience and experiment on an extensive scale confirm the accuracy of the formula. I perhaps ought to repeat that the formula $p = \frac{16\ t^2}{D^2}$ for the collapsing pressure of flues seven or more diameters long is applicable to short ones, by considering that they are stronger in proportion as they are shorter than seven diameters long—that is, the strength is inversely as the length when compared with the strength of a flue seven diameters long.

Yours, &c. W. J. ELLIS.

BALANCE OF LOCOMOTIVES.

To the Editor of "The Practical Engineer."

SIR,—Since my last communication on this subject, further thoughts and ideas have occurred to me with regard to the practical elimination of the evils of non-balance, without the introduction of the disadvantage of an inability to start from any position of rest.

It is, we may take for granted, pretty well understood that the use of counterweights for the rectilinearly moving parts, as well as for the revolving parts, is for the purpose of abolishing the twisting movement about a vertical axis which would be introduced by the unbalanced movement of such working parts—such movement not being simultaneous on both sides of the engine.

If for a moment we assume that the pistons in each cylinder moved simultaneously in the same direction, instead of, as now, being controlled by cranks at 90 deg, then we readily perceive that the centre of gravity of the whole locomotive would never depart from the longitudinal centre-line of the engine, but would move to and fro along such a centre line through a short distance, proportionate to the mass of the unbalanced moving parts.

All revolving masses being balanced, the centre of gravity would preserve its horizontal position. The effect of the longitudinal motion of the centre of gravity would be twofold. In the first place, there would be an alternating exchange of load between the leading and trailing ends of the engine corresponding with the movement to and fro—a distance of about two feet—of the piston and its connections. This would have a very slight influence indeed on the fore and aft steadiness of any engine, and of course none whatever on its transverse stability.

Secondly, the whole locomotive would be caused to advance not uniformly, but with a motion alternately quicker and slower as its centre of gravity was moved back and forward, the natural tendency of the centre of gravity being, as expressed by the first law of motion, to preserve the same speed relative to the earth. If the unbalanced rectilinear moving parts for two cylinders weigh 500 pounds, and the whole engine and tender 75 tons, the ratio of disturbing mass to whole load in front of draw bar is 1 : 336. Now, $\frac{1}{336}$th part of 2ft. is equal to $\frac{1}{14}$th of an inch, and this $\frac{1}{14}$th inch is the whole extent of the longitudinal movement of the centre of gravity, a quantity quite inappreciable at the draw bar.

If, therefore, on application of these principles, a locomotive be constructed with two inside cylinders on one axle, and two outside cylinders on the same axle, with cranks at 90 deg. from the inside cranks, we should have an engine perfectly free from the objectionable vertical action of counter balances; equally free from all tendency to twist in a horizontal plane; capable of starting anywhere, and suitable for compound working if desired, and especially suitable for a single engine for express service. The inside cylinders could equally well be replaced by one high-pressure cylinder for compound working, placed centrally, but connected to the same crank on the outside low-pressure cylinder. All this is, of course, based on the supposition, now fast becoming recognised as a fact, that the great cause of unsteady running is due to the non-simultaneity of the two pistons. That such is the cause of unsteadiness is plainly shown by the greater steadiness of inside cylinder engines, the twisting couple being of so much less moment.

With simultaneous moving pistons the transverse rocking of an engine would disappear, which arises from the pressure on the guide bars, due to the vertical component of the thrust and fall on the connecting rod. Necessarily, where the adhesion of four wheels is desired, these principles of transverse balancing can only be applied at a sacrifice of starting ability, which would be met by the use of a starter or "barring" engine.

It is sometimes argued that the fixing of the wheels on the two sides of the locomotive rigidly upon one axle secures that each side of the engine shall advance equally. In a sense this is true so far as regards absolute advance, but it is impossible to get over the fact that the steam action on the forward cylinder cover which propels an engine when the crank pin is down is identical with the action of a rope attached to and pulling at, say one end of the buffer beam. A rope so pulling would certainly, with rigid axle, bring about a square advance of the whole machine, but it would also bind the opposite side leading tire against the rail; and similarly the steam action on the forward axle bar guide, which advances the locomotive when the crank pin is above the cylinder centre line, will push the same tire against the rail, though to a less degree at the front, still to a greater degree the (diagonal) trailing tire.

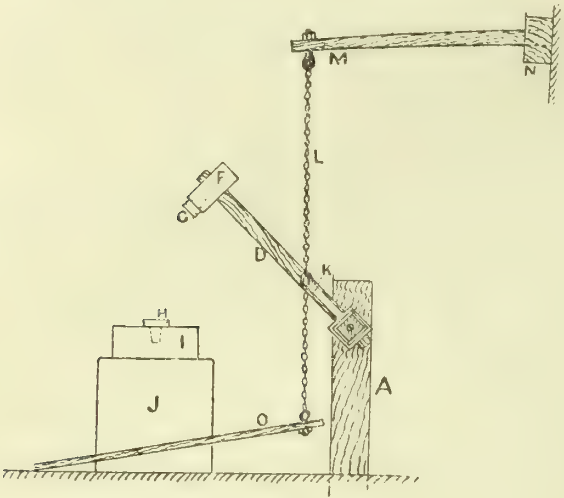
Let anyone try the effect of opening and closing a two-handled drawer by one knob only, especially if the drawer is wide and short. The uneasy motion of locomotives, their sinuosities especially, simply arise from this old-fashioned clinging to cranks at 90 deg., good enough no doubt for goods engines, but quite unsuitable for safe high speeds, and a great cause of the inability of engines attaining the speeds now desired.—Yours, &c., W. H. BOOTH.

QUERIES AND REPLIES.

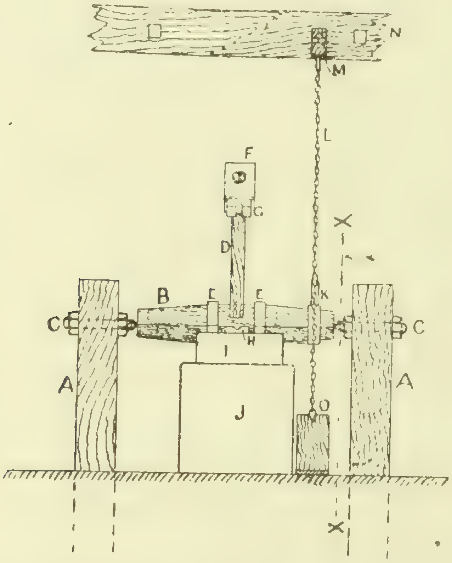
52. **DETAILS OF OLIVER.**—Can any reader oblige me with details of an oliver, to work by foot, for making bolts from $\frac{5}{8}$in. to 1in., with dimensions?—H. C., Egypt.

Answer.—The bolt-forging machines have almost entirely driven out the bolt olivers, so that these are seldom to be seen now. I have, however, seen them in regular use more than twenty years ago. The accompanying sketch will perhaps assist you to make one. A A are two stiff posts driven into the ground, between which is pivoted the rocker B; this is supported similarly to a lathe crank, that is with stud bolts C adjustable endways, and locked between the inner and outer nuts. The bolts are either steel pointed or case hardened, and centres are driven into the ends of the rocker bar to take the conical pivots. Into the rocker is wedged the hammer shaft D. To prevent the constant concussion from splitting the rocker, it is bonded at E E on each side of the hammer shaft. The head F is formed of a block of iron, which is recessed to take top swages G of different sizes. The similar bottom swages H are let into an anvil I, resting upon a massive anvil block J. To pull down the hammer a short lever K, with an eye at one end for the chain L and looped at the other end to embrace the rocker, is provided. The chain L is attached at the top to an eye bolt fastened near the end of a spring pole M, morticed into a stout timber beam N, bolted to the wall or other convienent support. The lower end of the chain is fastened to a bolt in a treadle board O. The thrusting downwards of the treadle board with the right foot pulls down the hammer shaft and spring bar, and so brings the top and bottom swages together. On the release of the foot the spring bar M pulls the hammer head up again into the normal position shown in the figure. There are no hard and fast dimensions about this so long as ample strength is given. Say you make A A from

6in. to 8in. square, B 6in. square in the centre, the bolts C 1¼in. diameter, the hammer shaft D 2in. square and 2ft. 3in long, the hammer head F 3in. square and 8in. or 10in. long, the pole M overhead 2¼in. square at the outer end, tapering to 3in. or 3½in. at the end next the wall, and about 4ft. or 4ft. 6in. long. The anvil I may be 10in. or 12in. square, and 5in. or 6in. thick, and stand 2ft. high. The measurment between the timbers A A may be 2ft. 6in.—J. H.



SECTION X-X



60. **Set Pins.**—Will you kindly permit me through the medium of your valuable paper to ask any of your correspondents if it is possible to get hexagonal-headed set pins $\frac{1}{16}$in. diameter, to buy, and where?—Model.

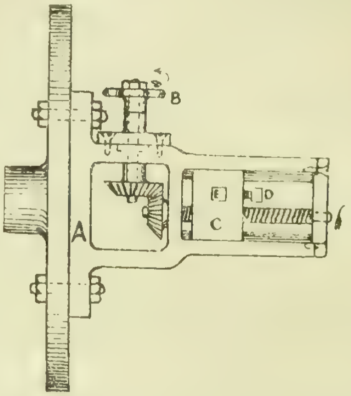
Answer.—Set pins of any minute dimensions can be obtained of Bateman, "The Model Dockyard," High Holborn, W.C.—J. H.

68. **Change Wheels for Screw-cutting Lathe.**—Could any of your readers kindly inform me, through your paper, the rule for finding the wheels for screw-cutting in the Buckton Lathe, leading screw two threads per inch?—Roppet.

Answer.—For any lathe the principles of screw cutting are the same. Thus, for a simple train, the pitch of the guide screw bears the same ratio to that of the screw to be cut as the number of teeth in the driving wheel bears to the number of teeth in the driven wheel. For a compound train the pitch of the guide screw bears the same ratio to that of the screw to be cut as the product of the number of teeth of the driving wheels bears to the product of the number of teeth in the driven wheels. Thus, guide screw : the screw to be cut : : drivers : driven. When cutting threads finer than the pitch of the guide screw, the smaller wheel or wheels will drive, and the larger be the driven. When cutting threads coarser than the pitch of the guide screw, the larger wheel or wheels will drive and the smaller be the driven.—J. H.

62. **Boring Roll Cylinder.**—I should feel much obliged for assistance from you, or any of your numerous readers, with the following: I have a cylinder for a roll; its length is 8ft., inside diameter 25in., and its thickness in rough metal about ½in. I wish it bored out at the ends about 5in. or 6in., so as I can fit in arms and shaft, and to run pretty fair for outside turning. Can it be done in the lathe with any arrangement, or how would you advise me for cheapest and best, as my appliances are very limited?—Primrose.

Answer.—The proper and best tool for boring your cylinder ends would be a self-acting boring bar, which would, however, be expensive to make. For a cheap rig up I should advise a modified star feed arrangement, as in the figure, which only differs from a common star feed in having a mitre wheel arrangement to cause the cutter to travel longitudinally instead of radially. In this A is a rigid casting made to convenient dimensions to suit your piece of work, and bolted to a slotted face plate at the radial distance required; B is the star turned through one tooth in each revolution, a rod being clamped either to the slide rest or lathe bed or to the cylinder for the purpose. This wheel actuates the mitre wheels and screw, and so traverses the block C, which carries the tool, pinched fast, with the set screw D in the hole E in the block C. The details of the construction are clear without further explanation. With a left-hand screw, as shown, the tool will haul away from the plate, cutting inwards as it should do.—J. H.



64. **Inside and Outside Tapers.**—Will some reader kindly inform me the best way to "turn" outside and inside tapers, so that they may be the same? For example, the end of a piston rod and cross-head.—Anxious One.

Answer.—If you set the top slide of the rest to the angle of taper, clamp the swivelling portion to suit, and do not move it while turning the inside and outside tapers, there should be no want of proper fitting in the rod and its hole. If hand-turning is intended, then you must make a couple of templets, one female to slip over the end of the rod, and one male to fit within the hole. If the templets fit each other, and also the work, inaccuracy is impossible.—J. H.

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41. **Hot-water Pipes.**—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse?—Water-heater.

50. **Small Air Pump.**—I wish to make a small air pump, double-acting, of 3in. diameter and 8in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—Apprentice.

53. **Dash Pots.**—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made and what is the approximate cost?—Crank Pin.

55. **Testing Lubricating Oils.**—I wish to know the methods of chemically testing the purity of lubricating oils. Is there any simple mode easily applied by an engineer?—Lubricator.

63. **Screwing Machine Dies.**—Can any reader inform me of the best way of advancing and withdrawing dies in a screwing machine, with three die bits? The machine I have at present has four dies and cuts badly, besides making an unequal thread.—D. W.

67. **Travelling Crane.**—In a travelling crane of 40ft. span, the load is supported on a carriage which runs on two similar girders, the axles of the carriage being 8ft. apart, and a load of 23 tons coming on each wheel. Obtain a diagram to show the maximum bending moment at every section of girder, and give numerical values at 10ft., 15ft., and 20ft. from one end.—J. C. W.

70. **Twin Screws.**—Will some reader kindly inform me of the advantages of twin screws? What are the advantages over one screw in speed and economy, and when were they first used?—Marine.

71. **Hardening Steel Springs.**—Will any of your readers kindly inform me, through your paper, the best way to harden steel wire springs?—Spiral.

72. **Book on Boilers and Templates.**—Can any of your readers inform me where I can get the best book on boiler-making and templates?—Boiler.

73. **Process for Cooling Water at Coates' Mill.**—I shall be obliged for any particulars of the process for cooling water to be employed at Messrs. Coates' new mill, at Paisley.—Lever.

74. **Flattening Saws and Plates.**—Will some reader kindly inform me how to hammer buckles out of saws 4ft. 6in. diameter? Also if the same method does for square plates?—Blacksmith.

TO CORRESPONDENTS.

S. O., Hook Langam.—There is no book of the title you mention. You probably refer to Clerk's paper on "The Theory of the Gas Engine," which is published by the Institution of Civil Engineers, but it is not for sale. A paper by Mr. W. J. Crossley, of Manchester, "On the Use of Various Gases in Engines," will probably suit your purpose. It costs one penny, and you can get it through any bookseller, or by writing to Mr. John Heywood, the publisher, Manchester. We are commencing a series of articles on the gas engine very soon.

W. W. S., Bury.—The principal ingredients of common match heads are common red or amorphous phosphorus and chlorate of potash. They are exceedingly dangerous in handling, when mixed, unless thoroughly understood.

T. H., Bolton.—We are preparing an article on automatic vacuum brakes, in which full information will be given. There is no book of which we are aware specially dealing with the subject.

MISCELLANEA.

A firm in Germany is now manufacturing steel flywheels capable of double and even treble the speed of flywheels made of cast iron. The naves or spokes are constructed of iron or steel, and a rim is made entirely of steel wire wound round itself a great many times.

Illinois Miners.—The death-rate by accident of the miners in Illinois was very heavy last year, there being 55 men killed. This was more than in any year since 1883; and it was not only more numerically, but more in proportion to the men employed and the coal produced. The largest part of the loss of life was due to the falls of coal and rock in the mines.

New Railway in Brazil.—A communication has been received at the Board of Trade from Messrs. Burchell and Co. to the effect that the Condé d'Eu Railway Company have recently opened a railway from Parahyba, the chief city of the province of that name in the north of Brazil to the port of Cabedello. They add that they are informed that there is an excellent harbour and anchorage for vessels at that port.

It is stated that the Pennsylvania Railroad Company has decided to make another innovation in its service by placing on engines a connection with the steam pump, by which a hose can be attached, and in case of fire be of great service. Whenever a smash-up or wreck of passenger cars take place, especially in the winter, when the car stove is doing its best, a great many lives are lost by fire. The new arrangement, it is hoped, will prevent a great many casualties.

Illinois Coal.—The official reports of the State Inspectors of Mines for Illinois have been sent to us. They show that the output in that State was last year the largest in its history, and the coal realised a slightly better price; the number of mines in Illinois was increased by 21, but the increase was chiefly in the mines having only a comparatively small output. The average value of coal at the mines was a little over 4s. 3d. per "ton," but the ton was the American net ton of 2,000 pounds. The average price paid per ton to the miner for his work showed a slight reduction last year.

On Wednesday, July 17th, at the Darlington Forge Company's Works, the largest steel ingot ever cast in the town, weighing 35 tons, was manipulated. The charge took 12 hours to prepare, and was run from a ladle. It will take a fortnight to cool, and will then be forged, forming part of the connecting rods for the Vulcan Shipbuilding Company, Stettin, for a new American Liner, the largest in the world, building to the order of the North German Lloyd's. The connecting rods, six in number, will be 14ft. long and 4ft. 6in. by 4ft. at the largest end.

New Railway in the Argentine Republic.—The *Moniteur des Intérêts Matériels* for the 30th May last, with reference to the construction of a proposed new railway in the Argentine Republic, says: "A new railway with a broad gauge is about to be constructed; it will start from Constitution, a port on the Parana, to the south of Rosario, will proceed to Melincué and to Venado-Tuerto, and finish at the colony of Carlota. The total length will be 187 miles. The region traversed by the projected line is an essentially agricultural country, already occupied by a large number of Italians. Immigration towards the same district is encouraged by a colonisation company, the Santa Fé and Cordoba Great Southern Company."

Colliery Accident.—An alarming accident occurred on Wednesday, the 17th inst., at Bodringalt Colliery, Ystrad, North Wales. The usual process of letting men down the pit proceeded with, when, after about 300 men had descended, a cage containing eight men started, and had scarcely gone ten yards when the piston of the engine broke, rendering the machine powerless to stop. The cage, with its living freight, descended 600 feet with great velocity, reaching the bottom with considerable force. Fortunately the occupants escaped with only a severe shaking. The empty ascending cage got entangled amongst the framework, causing serious damage. In order that the 300 men should reach the bank, they had to climb a considerable distance up the shaft, where a temporary cage conveyed them to the top. Work has been suspended, and will not be resumed for some days.

Air Tramcars.—Consul Launcefote sends home a report on the Nantes tramways, which are worked by compressed air, and which have now been established ten years. The working continues to be satisfactory, and the roads are a great boon to all classes. The cars are comfortable, they run smoothly, and make little noise. They do not interfere with the ordinary street traffic, and there has been remarkable immunity from accidents. The average speed run is as high as eight miles an hour; it can be easily moderated or increased, and stoppage can be effected almost instantaneously. The machinery, moreover, is simple, and does not require a skilled mechanic for its management. Mr. Mekarski, who is the managing director, is the inventor of the system, which he asserts is cheaper than horse power, steam, or electricity. The cost of coal is only five francs a day, equal to eight or ten horse power. Mr. Mekarski's system has been introduced at Nogent and Berne, and this year is to be applied to the Lyons tramways, which are at present worked by horse power.

The Linotype.—An ingenious machine for performing the combined functions of type founding and setting, and which is the invention of Mr. Mergenthaler, has been brought over to this country from the United States. This apparatus has as its basis a serious of small type-matrices, each having an indented letter or character on its edge forming a mould. These matrices are placed in magazine tubes, arranged vertically side by side, each tube being connected with a finger key. The action of any one key causes the delivery of a single matrix from the tube with which the key is connected. Each matrix falls into the top of an open inclined trough or conduit, through which the matrices follow each other to a point on the left of the operator, where they assemble side by side in a line of the desired width of the column to be printed. By means of a special key space bars are delivered into the line at the proper points during its formation. Upon pressing another key the assembled line of composed type is automatically carried against the open side of a mould. From a mass of molten type metal, in a pot carried by the apparatus, a portion is forced into the mould and against the sunken letters into the matrices. A bar is at once formed, having on its edge in relief all the characters represented by the assembled matrices. The bars as they are formed are automatically ejected from the mould and assembled in a galley in position for immediate use. The matrices from which each line of type is cast are at once automatically carried up to the distributor, which sorts them and returns each to the tube whence it started.

Submarine Signalling.—At a recent meeting of Danish naval officers, Herr A. Köhl gave an account of an apparatus invented by him for signalling under water between ships. The speaker had noticed that a sound is heard clearer through water than air, and that it travels in a straight line in all directions around the point of issue. If a bell, for instance, be struck sharply with a hammer under water, the sound would be heard for some five miles. The saline contents of the water has no effect upon this phenomenon. The apparatus constructed by Herr Köhl consists of a bell with an automatic hammer, and an acoustic receiver, both fixed upon the ship beneath the surface of the sea. The receiver is pail-shaped, 3ft. in diameter and 1ft. in depth, and is connected by electric wires with a receiving table on board. By an ingenious arrangement of dipping needles, the direction of an approaching vessel is indicated on by the sounding of a gong, and on the signals being repeated as that vessel proceeds its steering course may be ascertained. Practical trials are shortly to be made with the apparatus.

A Tide-wheel.—There are numerous water-wheels operated by salt water on shores where the rising of the tide is very considerable. They are of the type known as tide-wheels, where the rising tide rushes in through gates to a confined space, and is impounded until low tide, when the out-going water operates water-wheels of any type capable of working under a low head. Yet such apparatus is feasible for use only in peculiar localities, and for purposes where the work is not disturbed by irregular hours; these conditions practically limit the applications of these devices to grain mills. But there is at Bowdoinham, Maine, U.S.A., a peculiar tide-wheel which is designed and suited directly for the purpose of being operated by the tide. It is 27ft. in diameter, and contains a number of blades like a propeller, and is placed in a deep channel of an estuary where the tide runs very rapidly, the direction of the axis of the wheel being parallel with the current. This wheel will give over 50 horse power, and is in motion eighteen hours out of the twenty-four, running one hour during ebb, and all the other hours during the flood tide.

The Earnings of Locomotives.—The average earnings in six months upon our English railways is about equal to the original cost of a locomotive. But the earnings of these machines vary in a very considerable extent on the different railways, a fact which introduces a difficulty in the way of establishing what are called uniform mileage rates. Apart from the Metropolitan and District Railway Companies, the engines of which systems earned £4,585 and £3,427 respectively, the highest amounts earned per locomotive are shown by the southern lines. Thus the Chatham Co.'s engines earned on the average £3,512 each, the South-Eastern £3,191, the Brighton £2,906, and the South-Western £2,854, the large suburban traffic of these companies materially increasing the figures. On the North London, where the mileage is short and the traffic heavy, the average for each engine is £2,894. The Great Western Company, which has the longest mileage in the country, earned its revenue at the rate of £2,579 per engine, the Great Eastern following with £2,505, the North-Western £2,384, the North Stafford £2,326, Great Northern £2,274, Midland £2,192, North-Eastern £2,166, and the Lancashire and Yorkshire £2,130. On nineteen English lines the average earnings per engine was £9,425. In Scotland, the *Railway News* says, the North British Company's engines do the most profitable work, earning £2,385 each, against £2,120 on the Caledonian, and £2,010 on the Glasgow and South-Western. In Ireland the highest return per engine is £2,580, on the Great Northern; the Dublin Wicklow system, with a large suburban traffic, following with £2,478, and the Midland Great Western £2,335, Great Southern and Western £2,205, and the Northern Counties £1,969 per engine. Taking the twenty-nine companies, the traffic receipts give an average of £2,393 per engine for the first six months.

ILLUSTRATED PATENTS.

2742. Brake Gear for Hoists, &c., R. Gay, 59, Corbett Street, Smethwick, E. A. Whitehead, Snow Hill, and D. T. and H. W. Young, Ryland Street, both in Birmingham.

Relates to self-sustaining mechanism for hoists, crabs, pulley blocks, &c., and consists of brake blocks which are brought against a friction or serrated wheel, itself braked by pincer-like jaws tightened together by the weight of the body being lifted. The drawing shows the application to a pulley block in which the weight is hung only at one side. The spindle C carries a cam disc fitting loosely within corresponding surfaces in blocks *d* (fig. 3). If the spindle is rotated in the direction of the arrows, these blocks rotate free of the ring F, but if, as happens when the power is released, it turns in the opposite direction, the blocks are separated and jam against the ring. The latter is clasped by claws G, which are pivotted on a distance bolt *b* of the frame A, and connected at their upper end to the suspension hook, so that the pressure of the claws is proportional to the weight of block and body being lifted. T is a releasing lever for lowering rapidly, when the pulley block is arranged to lift a weight at either end of the chain, the spindle is slotted for a sliding steel plate, which presses outwards either the upper or lower block *d*, according to the direction of the back pull. When applied to a wall hoist the frame A is hinged so as to have slight vertical play. The claws G are horizontal, and the weight acts to close them by bringing their opposite ends against fixed curved surfaces. When used with the crab of a travelling crane the pressure upon the claws is obtained by attaching one end of the hoisting chain to them. February 24, 1888. [1s. 2d.]

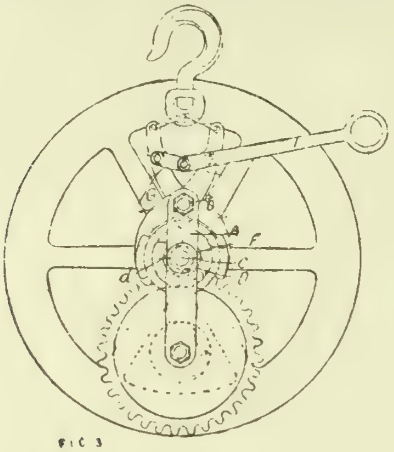
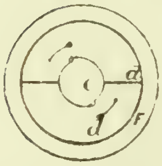
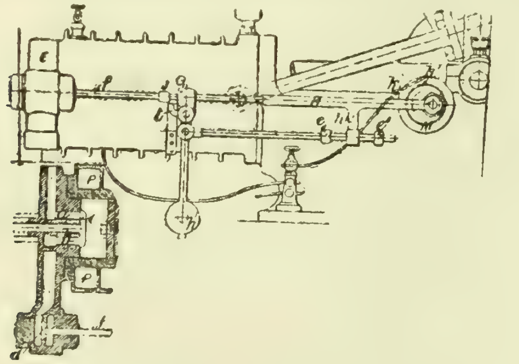


FIG 3



2804. Gas Engines, J. Y. Johnson, 47, Lincoln's Inn Fields, London.—(*La Société Salomon frères et Tenting, Paris.*)

The improvements are in the admission and exhaust apparatus and the cylinder; arrangements for igniting and governing are also described. Valves and gear: The gas and air are drawn into the cylinder through the ports *a* and *b* respectively, the area of which are proportioned to the relative volumes of the constitutents of the charge, and through the heat valve *c*; this valve and the exhaust valve *d* are carried in the cylinder cover. The exhaust valve is opened by a rod H coming in contact with its spindle *f*; the rod H is actuated by a crank pin on a wheel M, which revolves at half the speed of the crank shaft, the engine being of the two revolution cycle type. The cylinder is connected to its casing by radiating strengthening ribs, which form between them spaces P for the circulation of air for cooling the cylinder. The igniter acts by breaking a continuous electric current by means of an insulated projection k^1 on the wheel M, which raises the wire *k* from contact with the wheel, this rupture causes a spark to pass between two terminals in the cylinder as the readiest means of completing the current. For governing, a projection *h* on the rod H, by coming in contact with the washers e, e^1, oscillates the pendulum h^1; when the speed is excessive the projection *t* on the pendulum, by rising between the bearing G and the collar J on the exhaust valve spindle, prevents the valve from closing. February 24, 1888. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

July 1st.

10598	Gas Meters, W. A. McIntosh Valon, London.*
10599	Stamping Die, W. Chrimes, Tipton.
10603	Motors, W. Clarke, London.
10606	Sifter and Mixer, W. Gardner, London.
10607	Lathe Drivers, C. W. Shartle, London.
10609	Electric Signalling, H. S. Schultess-Young, London.
10611	Lubricating Bearings, J. Smith, London.
10615	Body Cushions, F. J. Brougham, London. (H. E. Spencer, Germany.)
10617	Amalgamating Machinery, H. J. Haddan, London. (A. Dalma, France.)
10623	Printing Presses, N. Billstein and J. F. Snediker, London.*
10626	Ball Cock, C. Smith, London. (E. G. B. M. Parker, Syria.
10634	Gas Engines, J. C. Bull, London.
10639	Aluminium, H. Ritter von Dahmen and A. S. Collin, London.
10640	Arc Lamps, T. P. C. Crampton and A. Essinger, London.

July 2nd.

10648	Water Tube Boilers, J. Taylor and T. H. Taylor, London.*
10652	Carding Engines, R. Tatham, Manchester.
10653	Dust Collecting Apparatus, H. Bensted, Maidstone.
10658	Pulverised Coal, W. P. Thompson, Liverpool. (A. Mason, United States.)
10660	Burning Hydrocarbons, W. P. Thompson, Liverpool. (J. Wilson and A. Mason, United States.)
10665	Multiple-expansion Engines, H. Dunsmuir, Glasgow.
10669	Gas Motor, W. T. Rowden, Glasgow.
10672	Liquid Meter, C. Christiansen, London.
10673	Fire-escapes, W. M. Taylor, London.
10674	Slide Valves, T. W. Barber, jun., Hastings.
10684	Reversing Gear, C. L. Reade, Manchester.
10686	Crushing Substances, H. J. Haddan, London. (Jaime Planas y Rodoreda and Eraimo Puig y Rodriguez, Spain.)*
10689	Steam Pumps, E. C. Johnson, London.*
10690	Fire-extinguishers, S. Babcock and H. A. Mansfield, London.*
10692	Box-nailing Machines, J. Casey, London.*
10694	Ventilator, A. H. Curtis and A. M. Yeates, Dublin.
10697	Hydrogen Gas, G. Bower, London.
10700	Gas-making Apparatus, J. W. Rock, C. G. Moore, J. H. Wood, and J. B Nicholson, London.*
10706	Purifying Water, W. Anderson, London.
10707	Surface Gauges, W. H. H. Norcross, London.*
10708	Electric Cut-out, S. C. C. Currie, London.*
10710	Steam Generators, G. B. Shepherd, London.
10715	Hydrocarbon Engines, J. Virtue, London.

July 3rd.

10717	Gas Generator, J. Blum, London.
10720	Pumps, J. Brindley, Wolverhampton.
10721	Pulleys or Drums, R. R. Gubbins, Paddington.*
10725	Packing, G. Platt, Manchester.
10736	Vapour Lamps, J. F. Schnell, Higher Openshaw, Manchester.

July 4th.

10778	Sawing Railway Rails, H. H. Lake, London. (J. Robison, United States.)
10787	Coupling Pipes, T. Littler, Sheffield.
10788	Magnetic Compass, J. Milne, Manchester.
10791	Propelling Boats, A. Hunnable, London.
10792	Purifying Water, G. W. Allen and H. J. A. Bowers, Manchester.
10801	Electric Lamps, H. Pieper, London.
10815	Looms, M. Taylor, London.
10817	Propellers, C. Simkin, Holborn.
10827	Coupling Brake, R. Gagné, London.
10829	Gas, B. Van Steenbergh, London.

July 5th.

10831	Gas Engines, H. H. Leigh, London. (P. F. Forest and G. Gallice, France)*
10842	Injectors, C. E. Church, London.*
10844	Bending Metal Plates, J. Waterhouse, Dukinfield, Cheshire.
10849	Water Gauges, G. Sumner and S. Sumner, Oldham.
10850	Hydro-carbon Engines, E. G. Wastfield, Stoke-on-Trent.
10856	Marine Propulsion, R. Bell, Glasgow.
10860	Motor, C. J. Eyre, London.
10872	Shut-off Valves, G. Dixon, Liverpool.

July 6th.

10894	Pumps, D. Guelbaum, London.
10905	Governing Mechanism, W. Pickup and W. Knowles, Manchester.
10910	Annealing Furnaces, W. P. Thompson, Liverpool. (W. Schleicher, Germany.)
10929	Type-writing Machine, C. S. Snell and A. Thompson, London.

July 8th.

10940	Couplings, F. T. Hollins, Derby.
10945	Feeding Furnaces, J. Vicars, T. Vicars, and J. Vicars, jun., Liverpool.
10948	Steam Engines, C. Lewis, Smethwick.
10949	Doubling Frames, G. Ormondroyd and W. Webster, Bradford, Yorkshire.
10950	Rotary Engines, J. Melvin, Glasgow.
10952	Tubes, T. R. Voce, Birmingham.
10955	Heating Apparatus, J. Johnston, Manchester.*
10961	Belt Fastener, P. Loison-Prost, London.*
10965	Railways, C. Fayel and H. Magron, London.
10970	Motive-power Engines, E. Burgin, London.
10972	Electric Gas Lighters, A. E. Clements, London.
10973	Winches, H. Spuhl, London.*
10974	Knitting Machines, J. Seyfert and H. Donner, Berlin.*
10975	Crushing Mills, C. W. Guy, London.
10980	Locomotives, A. Klose, London.
10983	Axles, C. Lock, London.
10984	Steam Engines, R. Edwards, London.
10985	Rolling Mills, J. Thomas, London.
10986	Grip Hinge, C. Brown, London.
10994	Furnaces, T. Plant, London.

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

AUGUST 2ND, 1889.

THE PREVENTION OF SMOKE AND THE ALKALI ACT.

Mr. Fletcher, the Chief Inspector of the Alkali Works for Great Britain and Ireland, has just published his annual report, as presented to the Local Government Board, and in it he has discussed the smoke question at some length, and arrived at some interesting if not entirely novel conclusions. The Alkali Act of 1866 has, in its working, conferred almost incalculable benefits upon the community, and manufacturers, in whose business gases such as hydrochloric acid were at one time freely evolved, to pollute cubic miles of our atmosphere, now find it to their interest to condense those substances, and apply them to some useful purpose. For the present comparatively pure atmosphere which we enjoy, even in the vicinity of chemical works, we, as a nation, are greatly indebted to the late Dr. Angus Smith, of Manchester, the first inspector under the Act, and a scientific man to whom we owe much of our exact knowledge of the variations in the composition of air and rain under the artificial conditions of our modern life. Mr. Fletcher has had the advantage of many years' experience in conjunction with the late Dr. Smith, and we are pleased to see that he is an energetic successor, likely to still further improve our atmospheric condition. Coal smoke, although sufficiently disagreeable, is not nearly so deadly to animal and vegetable life as the invisible but pungent hydrochloric acid, and accordingly public opinion is not so easily aroused upon the smoke as upon the acid question. We naturally object strenuously to the irritation of our lungs by acid, and the injury to our eyes caused by its copious emission; but smoke is more bearable, and not so irritating. Doubtless, if smoke were an absolute necessity to our commercial and manufacturing existence, we could and would put up with it at the sacrifice of health and life; and accordingly we find many who take advantage of that fact, and assert that smoke is the lesser of two evils. We have never doubted the possibility of greatly lessening the smoke nuisance by a little attention to detail in firing, even without the use of mechanical stokers; and with any good mechanical stoker, smoke, in steam-raising, should be practically absent.

Mr. Fletcher mentions the very prevalent illusion—for illusion we consider it—that the presence of smoke from a furnace guarantees the absence of the deadly but inodorous and invisible gas, carbonic oxide. Many experiments by Bunsen and other well-known authorities on the question of the combustion of the gases have clearly proved that where the conditions of combustion are such that air supply is limited, the oxygen invariably prefers to combine with the hydrogen first, and thereby leaves the carbon free in the form of smoke and carbonic oxide. Other gases quite as objectionable as carbonic oxide exist in smoke in minute quantities, but still in sufficient amount to be extremely prejudicial to health. We refer to acetylene and cyanogen, which invariably accompany soot, although not in sufficient quantity, under ordinary circumstances, to be evident in an ordinary gas analysis. In taking samples they are apt to be condensed by the carbon and glass, and so escape recognition in the analysis; nevertheless, they are exceedingly important, as their action upon animals is most pronounced and dangerous. Mr. Fletcher has made over fifty analyses of the gases leaving the chimneys from various kinds of furnaces, and he found that carbonic oxide was not often present in any of them, but when present it was always accompanied by black smoke, and in no case where smoke was absent did he find any appreciable amount of carbonic oxide. Apart altogether from the previous stock of knowledge on this subject, these experiments prove, in the most emphatic manner, that black smoke is no guarantee of immunity from the deadly gas, but is rather an indication of its probable presence. The experiments made in the Newcastle and Lancashire districts were not limited to one class of coal, but the fuel was in all cases of the bituminous or flaming kind, which is liable to produce smoke. In Mr. Fletcher's numerous experiments there was no exception to the rule that where smoke was absent so was carbonic oxide.

From this, however, we must not rush to the opposite extreme, and suppose that in all possible cases, with every kind of fuel, the absence of smoke means complete combustion and freedom from carbonic oxide. The popular impression that the opposite is the case no doubt arises in great measure from the fact that the best known means of producing this gas are unaccompanied with smoke. Its production from charcoal in an open fire basket or chauffer, and from coke, anthracite, and flameless coals generally, is well and widely known, but it is forgotten that in all cases of this kind air must be present in limited quantity. That is, the incandescent coke or carbon must be so arranged that part of it is glowing, and in such a position that there is an insufficient access of air. An improperly arranged furnace may therefore readily produce carbonic oxide without producing smoke, and Mr. Fletcher's results prove, not that the absence of smoke means the absence of carbonic oxide, but only that in the furnaces examined by him the arrangements were of a proper kind to ensure both conditions. It is a very valuable result of the experiments to prove that furnaces in such number are properly arranged, and it is an encouragement to those whose fires at present offend to have them forthwith altered to the better conditions.

Some engineers uphold that in steam boilers greater economy of fuel is obtained with considerable smoke, and the argument is often put forward that a flaming coal, with a long, bright flame, gives off much more heat by radiation than when the flame is clear and has but little radiating power. There is no doubt a certain amount of truth in this argument, as it is beyond doubt that a clear Bunsen flame does not radiate a fraction of the heat radiated by the same flame when the air holes are stopped, and it is caused to burn bright and smoky without previous admixture of air. This is evident to all from a very simple experiment. If we watch a clear Bunsen burner flame, with the face say about 9in. off, we feel but little heat; but if we close the air holes with the fingers, the heat is instantly felt upon one's face, without in any way varying the position relatively to the flame. The increased radiation is at once felt, and no doubt the interior of a boiler flue will perceive this change much as does the human skin. More heat will be absorbed by the metal without requiring direct contact of the flame with it, and this to some extent is an advantage. With sufficient heating surface in the boiler and the economisers, this is entirely unnecessary, and it is only where the boiler is too small for its work, or misproportioned in some way, that the radiation need be depended on to any great extent. It is also a question whether the greater radiation from a mass of incandescent fuel in a furnace does not more than compensate for the brighter flame when the fire itself is necessarily far blacker and less radiant. It is forgotten, however, by those who press the argument upon us, that a comparatively bright flame is quite consistent with the absence of smoke. It by no means follows that when smoke is consumed we must have only a clear blue flame, without light and radiating power.

Mr. Fletcher rightly calls attention to the mass of law on the smoke question, and the lack of vigorous administration in carrying the law into effect. We are distinctly of opinion that if all engineers and manufacturers were compelled to avoid smoke, they would speedily find it profitable to adopt the many well-known contrivances which now exist, and the matter would end, as it has done in the case of alkali works, in additional profit instead of great loss. When the Alkali Act first came into force it was contended for the manufacturers that it was practically impossible to condense hydrochloric acid except at very serious loss; but now the collection of this acid, and the utilisation of the chlorine which it contains to produce bleaching powder, is a paying branch of the alkali industry. Indeed, in a few years, judging from the rapidly increasing quantities of soda manufactured by the ammonia soda process, it may be that the old Leblanc process may only remain alive to produce bleaching powder. Necessity is certainly the mother of invention, and if our manufacturers were forced to conduct their operations without smoke, they possess energy and knowledge enough, with the aid of engineers, to do so, and to do it in a commercial and paying manner.

With one part of Mr. Fletcher's remarks we cannot entirely agree. We do not think it at all likely that steam boilers will be fired with gas to any considerable extent. On this point we have had some special experience, and, without doubt, gas-firing is far less economical in fuel than coal-firing. We have already pointed out the reasons for this fact in a previous issue, but we may again say that when coal is first converted into gas, and then the gas burned under a boiler by the very best processes at present known, there is a loss of at least thirty per cent of the total heat of the fuel to begin with, and this loss is not compensated for by any increased economy in the combustion in the boiler flues. We do not know of any existing gas producer which will give more than two-thirds of the economy of the best coal-fired boilers. As we have previously stated, gaseous fuel is properly applicable for producing intense temperatures, as in metallurgical operations, and is not at all suitable for steam-raising. When gas is a waste product as in blast furnaces and other processes, it is, of course, economical to use it for steam-raising, but it will not pay to put down gas-producing plant for firing steam boilers, except in cases where rubbish can be burned to gas, which could not be used at all in ordinary fires. We do not, therefore, share Mr. Fletcher's belief in the millenium to come when steam boilers will be fired by gas producers.

Mr. Fletcher's suggestion of a competitive trial of boilers and smoke-reducing appliances is good, and we hope that it may be carried out; the results would be most valuable and interesting. The London Smoke Abatement Exhibition of 1881 had this idea as its foundation, and we hope that, if experiments are made, the committee in charge may escape the somewhat ludicrous fate of the South Kensington show, where, on a complaint from the adjoining inhabitants, the Smoke Abatement Exhibition authorities were fined for the excessive production of smoke.

THE NEW HYDRAULIC RAILWAY AT PARIS.

The well-known French hydraulic engineer, Girard, who was killed during the Franco-German war, proposed a novel form of railway, intended for high speeds, and M. Barré, formerly his assistant, has now succeeded in reducing it to practice on a small scale at the Paris Exhibition. A length of line of about 200 yards is laid down the Esplanade des Invalides, where the Algerian, Tunisian, Annam, Tonkin, as well as the French Colonial sections are located, together with the Pavilion of the Minister of War and other exhibits, and trains on the new system are now running.

The trains have no locomotives and the carriages no wheels. The carriages are supported on broad rails, raised some distance from the ground on metal blocks. The rails and carriage supports correspond to the planed slides and guides in steam engines, and before starting water under high pressure is forced between the sliding supporting pieces, the rails thus bearing up the carriages on a water film and preventing the supports from resting directly upon the rails. The whole weight of the train is thus supported on water films, and the friction is not that due to two solids but to liquid surfaces. The motive power is supplied in a manner quite as novel.

Along the centre of the track is laid a water-supply pipe, into which water is pumped at great pressure, and all along the track a series of discharge nozzles point in the required direction of movement. When the train is started, one or more of these nozzles discharge water, which strikes against projections under the carriages, and forces them on. As the train moves taps are opened, so that at regular intervals new impulses are received from the issuing jets. As the carriages pass, the valves or taps close again, so that at any particular time only those under the train are in action for propelling. The train thus receives its motive power from the force of the water jets striking the projecting surfaces under the carriages.

The system is extremely interesting, but we fail to see any advance over the present railways with locomotives. Apart altogether from the wasteful mode of applying water power by impact, the hydraulic system of transmitting power through pipes is incapable of economical transmission for long distances, such as those on our railways, and enormous powers would require to be generated at the pumping stations to give even a small power at the carriages say 100 miles off. The expense, too, would be very great even for short distances.

The line at Paris works well, it is said, and the trains move at a considerable velocity.

A SUBSTITUTE FOR SILK.

A NEW process has been invented in France by M. Chardonnet, whereby he produces a fibre closely resembling silk. Cellulose is used as the chemical basis of the material, and it is nitrated by a mixture of nitric and sulphuric acid to form nitro-cellulose "gun cotton." This dissolved in alcohol and ether forms a collodion closely resembling that used by photographers, but instead of making a film, as is done on the photographic plate, the collodion is utilised to make a fine thread in a very ingenious manner. The collodion is placed in a vessel capable of sustaining considerable pressure, and it is then forced by air pressure through a capillary tube into water; the thread at once sets, and the water dissolves most of the alcohol and ether. It will be familiar to many of our readers that common collodion, when poured into water, at once precipitates and becomes milky. In this process the water precipitates the nitro-cellulose as a continuous thread, instead of in powder or flakes, because it is rapidly forced into the water from a capillary tube, and consequently the water acts upon the surface and solidifies it in continuous form.

We need hardly state that silk which really consisted of nitro-cellulose woven gun cotton would be a highly dangerous substance for ordinary wear, on account of its great inflammability. This anyone can easily test by lighting some kinds of celluloid collars or cheap jewellery resembling ivory. Many such collars burn more quickly than a piece of sealing wax when lit. What rate the combustion of a thin dress would attain it is difficult to imagine, but it would be far more imflammable than any ordinary fibre. Accordingly the inventor is said to de-nitrate the fibre in some way, or rather to de-oxygenate it, so as to leave it comparatively uninflammable. This, we should imagine, would be a most difficult process without destroying the fibre; however, it is said to be done. Fabrics prepared from this artificial fibre are said to resemble silk most closely, and the fibre is said to be extremely strong. It is well known that silk fibre is almost as strong as steel wire of equal area. Its breaking strain is said to be about thirty tons per square inch, and many kinds of iron and steel wire break at less than that. The new fibre is said to be nearly as strong as silk. The process is a most original one, and the inventor deserves success; but we fear there must still be many difficulties to encounter before the manufacturing stage is reached.

A PERMANENT SET IN METALS EXPANDED BY HEAT.

THE properties of metals are in some cases of a much more complex kind than the text books of science inform us. Some time ago we had occasion to heat a number of cast-iron cylinders to a red heat, and to keep them at that temperature for a few days. We carefully measured the lengths before heating, and preserved those lengths by gauges made to fit over fitted portions of the extreme ends. On allowing the cylinders to cool again to the original temperature, we found that in every case a permanent lengthening had occurred. In one case, a cylinder 6in. diameter, $\frac{1}{2}$in. metal, and 18in. long, had taken a permanent set out of $\frac{1}{16}$ of an inch. We experimented with different metals, and found that with close-grained cast iron there was less permanent set, and with cast steel least of all. With common porous cast iron the permanent set was greatest. The temperature of the cylinders in the furnace was carefully measured by calorimeters, and found to be close on 800 deg. C. as nearly as possible. If any of our readers have had a similar experience, we shall be pleased to hear of it. We have formed a theory or explanation, but shall not describe it meantime. This action, if it exists at moderate temperatures, may readily cause serious deterioration and straining in parts of furnaces which are not at all expected in ordinary work.

RUSSIAN PETROLEUM.

INTELLIGENCE of a serious kind has recently been received from Baku, according to which the petroleum wells of that region are showing a permanent decrease in production which may shortly cause a crisis in the Baku industry. The naphtha basins of the Apsheron peninsula and Bibicibut are still very productive, but the continued yield, it is stated, can no longer be relied upon, and consequently all the Baku oil refineries, including those of M. Nobel, are suffering from want of the raw product. Many new borings have been made, but without encouraging results.

If this news be true, it severely shakes the reasoning of those who look to petroleum as the fuel of the future which is likely to displace coal, and save our country from a fuel famine when our coal supplies are exhausted. The experience of the American oil fields make this failure extremely probable, and it is likely that we shall shortly see a rise in the price of petroleum, which will put it entirely out of consideration as a fuel for steam-raising, at least in our country. It has never reached a price here at which it could compete with coal; and accordingly engineers had better give their attention to further economy of coal consumption in steam or heat engines, and abandon any vague reliance on possible new fuels after our supplies have been exhausted.

It is some consolation to feel, however, that in the event of lessening competition from petroleum, our paraffin and shale industry will once again attain a flourishing condition which it has not known for years past.

THE PARIS EXHIBITION.

(*From Our Own Correspondent.*)

IN our last article we omitted to state that the building devoted to hot-air engines is close by the Petroleum Panorama, on the Quai d'Orsay, and next the river, and also that it is somewhat remarkable to find only one sample of a hot-air engine in a building supposed to be devoted to that type of motor. In fact, throughout the whole Exhibition we only observed one type of hot-air engine, that of Messrs. Benier Frères, using internal combustion. This fact is somewhat interesting, as showing the direction of effort and thought among engineers, and it is somewhat significant that a field once so popular with inventors, and well represented in previous great exhibitions, should, to all appearance, be almost deserted now. We well know that there are many excellent hot-air engines in the market, filling a limited but still important field in an efficient manner, and we regret to find them so generally absent.

In Britain the Rider hot-air engine is used in considerable numbers up to one horse power, mostly for pumping in country houses, where only unskilled labour or attendance is available, and in America the Ericsson engine, in its smaller sizes, is very well known. The fact seems to be that inventors who formerly were attracted to hot-air engines now devote their energies to gas and petroleum engines, and the decisions in the French law courts liberating the Otto cycle to public use have undoubtedly caused a great amount of experiment in France. As yet we cannot say that any substantial advance has been made upon the original Otto form of engine, but it is hardly possible that so much attention can fail to result in substantial progress.

The present result, however, is to fill the hot-air section with gas and petroleum engines mostly using the Otto cycle. First comes the Otto petroleum motor constructed by the Cie. Francaise des Moteur a Gaz. It is an ordinary Otto gas engine of the French style, with a vaporiser for benzine and light oils, but without other noticeable novelty. The Noel petroleum motor is also here, and it is one of the few explosion engines exhibited in which compression previous to ignition is not used; it has also an electrical ignition. The Moteur Forrest, by Camille Dupont, engineer, Paris, is also of the non-compression type, but is adapted for either gas or petroleum, and uses the flame ignition.

Messrs. Salamon Frères and Tenting, engineers, Paris, show a gas or petroleum motor, also on the Otto cycle, but without water jacket, and arranged to radiate its heat to the air by means of ribs; it is evidently intended for the smaller sizes only. In some manner the Friedrich steam motor, fired with petroleum, has found its way among the gas and petroleum engines. They, it is true, have some claim to be considered hot-air engines, but we should hardly have dared ourselves to classify a steam engine under this head. The Friedrich motor is a very compact engine and water-tube boiler combined in one. It is fired by petroleum, and has automatically adjustable contrivances for preserving constant steam pressure and water supply; it is constructed by Panhard and Levassor, of Paris. A very compact little double piston compression gas engine next claims our attention, also on the two to one cycle. It is fitted with two pistons attached to the crank by connecting rods and beams, as in the engine known in Britain for some time as the Linford. Messrs. Rouart Frères have here an agricultural petroleum engine of the Lenoir type, mounted on wheels for ready transport. Lastly, there is a good example of the Benier hot-air engine of six horse power, and the same design as the larger one we have already described in the Machinery Hall.

On leaving the hot-air section (so called), we continue our walk along the Quai d'Orsay by a long open shed containing the hydraulic exhibits, and are attracted by the animation imparted to the scene by a great number of windmills of the most modern forms, all revolving in a rapid manner, at the end of the hydraulic department. Perhaps the most attractive exhibit in this section is that of the Pulsometer Company, who show a very varied assortment of their well-known pulsometer in various sizes, both large and small. This extremely handy and useful form of pump seems now to be extensively adopted on the Continent.

The French workmanship and design, as shown in this section, seem to us very indifferent. Some of the pumps are fairly good, but many are both roughly finished and badly designed. One pump, for example, of the three-throw kind, was actually designed to drive the three plungers by eccentrics, which must cause a very serious loss of power, and that without any adequate reason. We observed one modification of the toothed-wheel rotary pump, in which helical wheels replaced the spur gearing common in this country with such pumps.

Resisting the attractions of the windmills, we turned back and walked towards the petroleum exhibit again, but passed through a series of buildings on the opposite side of the road to the hydraulic section, containing boilers which supply the pumping station engines and the electrical generating station of the Société Anonyme L'Eclairage Electrique of Paris. These boilers are, without exception, of the water-tube type, and include examples by Messrs. Babcock and Wilcox, Collet et Cie., Terne and Déharbe, and Roser et Cie. We stood by these boilers for some considerable time, but were unable to observe the fluctuations in steam pressure and water level to which some of our correspondents referred in a recent discussion on "Water-tube Boilers" in our columns. Both steam pressure and water level seemed quite as constant as with the Lancashire type; the boilers, in fact, seemed to answer admirably.

Most of these boilers have already been described in our columns; but we purpose shortly to again point out the more novel details, for after all water-tube boilers of to-day do not radically differ from those of a few years ago. Difficulties have been gradually overcome, but we fear there are still troubles inherent to the type which may place it at a disadvantage under some circumstances. However, we may leave these matters at present for discussion in detail at another time, and enter the main pumping station of the Exhibition, where we examine a splendid example of the Worthington large high-duty pumping engine. The engine is of the standard Worthington or duplex type, direct acting, without flywheels, but fitted with the ingenious high-duty attachment, which compensates for any inequality in effect of the expanding steam. The pump piston rods are prolonged through their covers, and carry, by means of a crosshead and slide, two rocking trunk cylinders opposing each other, and so arranged that at middle stroke they stand in line with each other, which line is at right angles to the axis of the cylinder. Any pressure upon the trunk pistons from behind in this position has no effect in tending to move the pump piston, but only causes thrust upon the crosshead from two equal and opposite pistons, which entirely neutralise each other. Air pressure is kept up behind these pistons from a receiver, the leakage of which is supplied by a Westinghouse air pump, the same as is used with the Westinghouse automatic brake; and when the pump is commencing its stroke, and steam pressure is high, the pistons resist the movement, but less and less as the mid-stroke is reached. After mid-stroke the air pressure assists the falling steam pressure, so that, although great expansion is used, the driving effort upon the pump piston remains very nearly constant throughout the whole stroke. The pumping engine is beautifully finished, and the Corliss type of valve is used on the high-pressure cylinders. The engines work with beautiful smoothness, and fully sustain the high reputation of the Worthington Pumping Engine Co.

Leaving the pumping station, we arrive at the central electric lighting station, from which a considerable portion of the Exhibition is illuminated, and here we find four very well-made horizontal steam engines of the Corliss type, constructed by Messrs. Lecouteux and Garnier, engineers, of Paris, hard at work driving dynamos of the Ferranti, Rechniewski, and Gramme types. The engines are not polished up with the elaborate care of some of those in the Machinery Hall, but they answer their purpose well notwithstanding this, and are most favourable samples of French design and construction. We could find nothing really novel in their arrangements, but in that point they do not differ from the other engines of the French Section.

Continuing our walk up the Quai d'Orsay and past the petroleum tank, we enter a building devoted in most part to life-saving and marine purposes, and find confronting us a very beautiful model of Baron Rothschild's magnificent yacht Eros, and a well-finished fire engine, by the Fives Lille Company; then a steam launch, completely constructed of Delta metal, and copper riveted. The Stevens rudder controller is designed to firmly hold the rudder of a vessel in any desired position without undue rigidity, so as to prevent the disturbing effect of heavy seas, and allow the rudder to be held firmly when the vessel is at anchor.

Those of us who have passed nights on a vessel at anchor in a sea, well know the disturbing effect of the movement of the rudder upon our rest, and will gladly welcome any contrivance which keeps it quiet under these circumstances. This, however, is one of the least important uses of the controller. We shall not further describe it here, as we propose to illustrate it fully hereafter.

The Compagnie des Messageries Maritimes show a full-sized cabin of their steamer, Le Polynésian, which is exceedingly well and handsomely got up, but, in our opinion, is not equal to the best examples with which we are familiar of Clyde practice. They also show a model of the La Plata, and a fine selection of photographs.

The exhibit of Henri Satre, of Lyon and Arles, is well worth examination; it consists mainly of photographs and models of his specialties. He is a river ship builder, and it is interesting to observe the strange forms of vessel he has found it necessary to produce to meet varying river requirements. The Société Anonyme des Forges et Chantiers de la Mediterranée are represented by models of vessels they have built, among which there are models of the steamers Parana, Dordogne, the Unebi, an armour-plated cruiser, and the Bresil; the Japanese side-armoured cruiser Itsakushina, and the French cruiser Admiral Cecille, as also the Spanish armoured cruiser Palayo.

Mining Machines.—In the collieries in the State of Illinois there are now over 230 coal-cutting machines at work. These are of three kinds, and the large numbers that are at work seem to give satisfaction to those concerned in the working of the mines—both employers and employed. The largest number of the machines are of the "Harrison" type, and their use has grown very rapidly of late.

INDICATOR DIAGRAM PRACTICE.

Although most of our readers who are interested in engine indication may be assumed to have a sufficient acquaintance with the subject to enable them to understand the manipulation of the indicator, and to ascertain from the diagrams the average pressure on the piston and the indicated horse power of the engine, and also to know the meaning of the several lines forming the diagram, a description of various details and processes which present themselves in working out diagrams from different kinds of engines may prove of service. The subject of indication of engines is, of course, a very wide one, and admits of considerable diversity of opinion as to the best mode of distributing steam to meet the circumstances of each case.

Economical working may be said to be the general object of engine indication, and to attain this it is necessary to know that the engine is in good condition and properly proportioned to its load, and that the steam is utilised to the best advantage. The various matters to be considered may be divided under four heads, as follow:—

1. The general condition of the engine, under which would be included the adjustment of valves and the steam tightness of valves and piston.
2. The load on the engine as affected by average pressure on piston and speed.
3. Loss from mal-proportion, insufficiency of ports, and throttling.
4. The distribution of steam. Water consumption per I.H.P. per hour. Compounding.

The first operation to be performed on the diagrams is to ascertain the average pressure, and to calculate therefrom the I.H.P. The quickest way of arriving at the average pressure is by the use of the planimeter, but where, as most frequently happens, only occasional diagrams require to be dealt with, the ordinary method of drawing ordinates, measuring each separately and dividing the sum of the pressures by the number of ordinates, is sufficiently convenient and accurate.

A small ivory or boxwood scale, say 5in. long, or of such length as will cover the longest diagram, is very useful. Such a scale, divided along one edge into 100 parts, may be used to divide the length of the diagram into any number of decimal parts by placing the scale diagonally, at such an angle that the first and last marks on it rest on ordinates drawn at the extreme ends of the diagram, and marking off the required divisions along the edge of the scale. The exact positions of ordinates drawn through the points of cut-off, release, and compression may also be measured in the same way. These processes may of course be effected in other ways—by a strip of paper, for instance, similarly marked, or by one of the parallel steel frames supplied with some indicators. The other edges of the ivory scale may be graduated for measuring the pressures from diagrams taken with different springs, say 12ths and 24ths on one edge, 16ths and 32nds on another, and so on.

For calculating the load on an engine that is always run at one regular speed, a constant number or multiplier for that engine may be found by multiplying the area of piston in inches by the speed of piston in feet per minute, and dividing by 33,000. This constant represents the I.H.P. from each pound of average pressure, and, multiplied by the average pressure from any set of diagrams, at once gives the I.H.P. For example, the constant for a cylinder 20in. diameter, with a piston speed of 400ft., would be $\frac{314{\cdot}16 \times 400}{33{,}000} = 3{\cdot}8$.

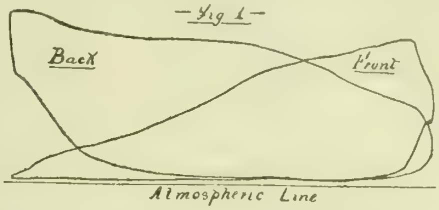
General Condition of Engine.

After calculating the power shown by the diagrams, the adjustment of the valve is next to be considered, to see if it is set so that the "lead" and the average pressure on the two sides of the piston are as nearly equal as may be, and if the eccentric has the proper amount of advance. With the ordinary arrangement of slide valve and eccentric, the "lead" and cut-off cannot both be quite equalised at the two sides of piston, owing to the effect of the angularity of the connecting rod, which, with equal "lead" of valve at both ends, causes an earlier cut-off at the crosshead end of cylinder. The length of valve rod requires to be such that when the valve is in its central position it gives an equal amount of cover over each steam port, or—which is the same thing—so that the "lead" is equal at both ends when the crank is on the dead centres. But this may be varied a little where the effect from angularity of the connecting rod is considerable, by drawing the valve slightly nearer to the back end (or bottom end as the case may be) of cylinder. A little more steam is, however, sometimes allowed at the bottom end of a vertical unbalanced engine to counteract the weight of the moving parts.

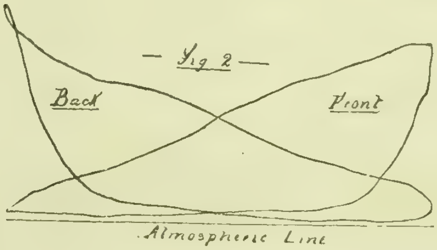
Effect on Diagram if Valve Rod is too Long or too Short.

The valve will be drawn nearer to one end of cylinder, and the processes resulting from traverse in one direction will be later, while those in the other direction will be earlier.

The admission and compression at that end of cylinder towards which the valve is drawn will be later, and the cut-off and release will be earlier, or, in other words, the steam line or top side of diagram will be shortened and the exhaust line lengthened; while at the other end of cylinder the reverse will be the result. The average pressure will also be reduced at the end towards which the valve is drawn.



The tightening up of the joints of eccentric and valve rods, rendered necessary by wear, will, of course, affect the position of the valve, and necessitate occasional adjustment. Fig. 1 shows a pair of diagrams where the length of rod required adjustment. In these, the valve is evidently drawn towards the front end, the admission and compression being later, while the cut-off and exhaust are earlier than at the back end. The average pressure at back end is considerably greater than at the front, as is also the terminal pressure, which may be taken as representing the proportional weight of steam admitted.



The diagrams in fig. 2 were taken from an engine of the same construction and dimensions, and working under similar conditions, as the engine from which the diagrams in fig. 1 were taken. The diagrams in fig. 2 are fairly equal, and the terminal pressures at front and back side of piston are much alike. The weight of steam per I.H.P. per hour, shown by the diagrams in fig. 1, is 39lb., while in fig. 2 it is 32·8lb.

ENGINE PATTERNS.—V.

The accompanying figures illustrate the construction of a double cylinder casting used for a steam hoist. The cylinders A A, figs. 28—32, are cast together and bolted to the boiler, which is of the vertical type, the axis of the cylinder being vertical also. The foot B is curved to the radius of the boiler, and fitted with chipping strips. The steam is brought in at the flange C, and

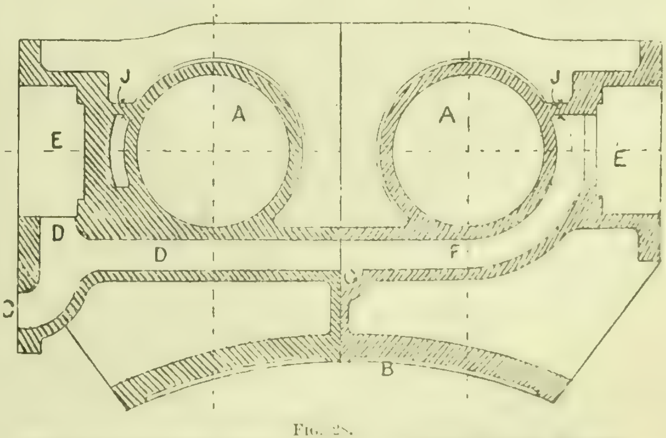


Fig. 28.

Section Through Steam Pipe. Section Through Exhaust passes along the pipe D into both steam chests E. The exhaust passes into the curved pipe F, parallel with the steam pipe, and has a common exit G through the straight pipe into the atmosphere. The steam chests E are not divided, but are made entire with the cylinder, and receive plain covers only. H are the stuffing boxes for the valve rods. As the cylinder, steam and exhaust pipes, and chests are made in a single casting, this affords an excellent example of intricate coring out, the pattern being extremely unlike the casting which is made from it.

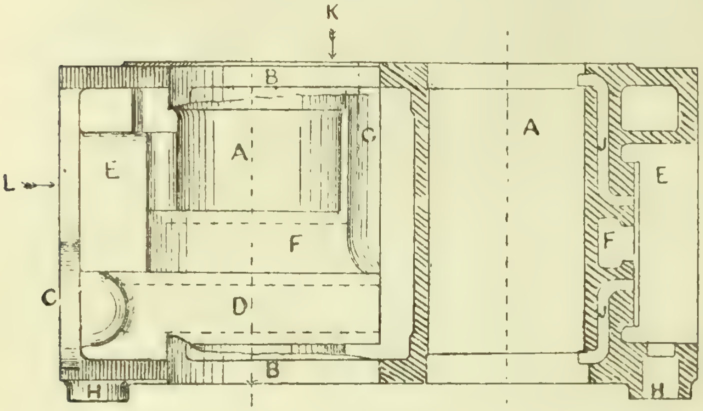


Fig. 29.

Elevation at J, Part of Foot Removed. Longitudinal Section.

Figs. 33, 34 represent respectively the pattern in plan, and in sections and end view. From this it is seen that while one half of the pattern is composed of the cylinder bodies, flanges, &c., the other half consists only of a large print, and of a portion of curved flange for bolting to the boiler. The whole of this portion is therefore made in cores.

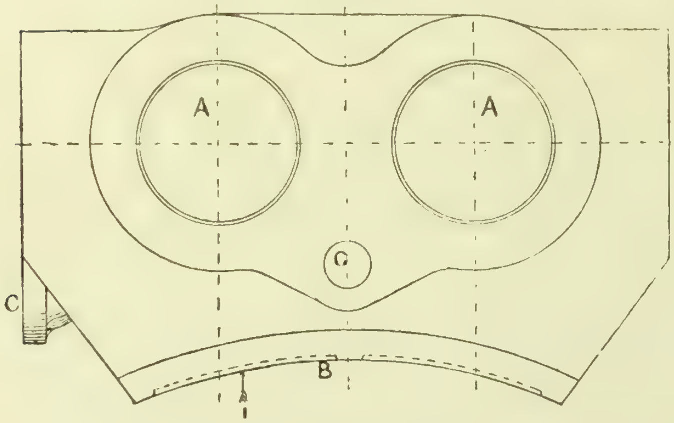


Fig. 30.—Plan at K.

Going through the details of the pattern in succession, in figs. 33 and 34, A A are the cylinder half bodies, with their head metal B and prints C. The diameter being small—6½in. bore—they are turned of solid stuff. Into their suitable grooves are fitted the flanges D, and between these the steam-chest flanges E, and against these the prints F. Within the flanges E are fitted the blocks G, which form the outside of the steam chest and the metal J around the passages, seen in section, fig. 28. There are also the half stuffing boxes H.

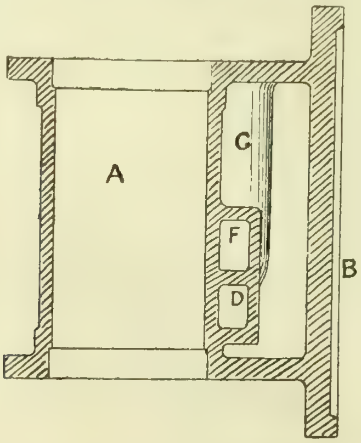


Fig. 31.—Vertical Section.

The other half of the pattern is boxed up, as seen in end view and in section, fig. 34, and partly in plan, fig. 33. There are two sides J J, and two ends K K, which are rebated to a little distance inwards to receive the top L and bottom M. This is a better method of boxing up than making the top and bottom pieces to the extreme dimensions, and placing the sides between them. With the sides continuous from top to bottom any subsequent shrinkage of portions of the pattern will not produce lapping joints to drag up the sand of the mould, but the lift will be smooth and continuous. And as the top and bottom are made to rest upon rebates, they cannot be knocked down out of position in rapping, as they would be in the absence of a rebate. The middle rib N supports the central part of the boxed up portion. The curvature of the foot is cut partly out of piece M, which is thickened behind at A, and is partly made in the blocking up pieces R. The only pattern parts which are put upon this half are the other portion S of the stuffing box, two sweeped pieces T skewered on, which complete the breadth of the curved foot, and the facings U for the cylinder covers, and on one side the facing and boss V around the exhaust exit, together with the print W for the core.

The main core box for the blocked-up print in figs. 33, 34 is shown in plan, and in section in fig. 35. In this A A are the sides, B the ends, and C the bottom board. Upon the latter are fastened the two half bodies D, the steam-chest flanges E, and their bodies F, and prints G. At H is seen the steam inlet flange and its print I. I I is the steam pipe, and J the exhaust; one half the exhaust pipe leading from the passages is seen at K, and the stiffening rib between it and the curved flange at L. Since it is evident that the lower half of the outlet pipe cannot deliver from the box if made as in the casting without giving some trouble which it is desirable to avoid, we place a core underneath it, whose print is shown at M, and whose core box is seen in fig. 39. The pieces N in the box form the solid plated portions of the casting.

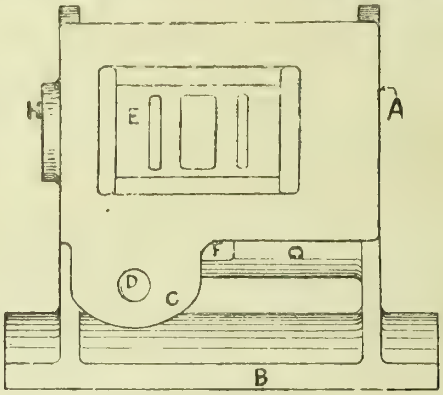


Fig. 32.—Steam Chest.

Fig. 36 shows the core box for the steam chest, one half of the core fitting into the prints F, in fig. 33, and the other half into the print G formed in the core, fig. 35. The prints in fig. 36 for the passage cores are of the pocket form, because it is necessary to put the steam chest covers in place before the passage cores are inserted. Into the print B the exhaust core is put. This core is made from the box, one half of which is shown in fig. 37. The recessed portion A in this box is flat on the bottom in one half and semicircular in the opposite half. Against the flat portion a circular core is abutted, coring out the pipe made in boxes, fig. 35 K and fig. 39, entering at the opposite end into the print W, fig. 34. In fig. 37, B B correspond with the centres of the cylinder, whence the radii of the passages are struck. The widths C C represent the allowances for the print thicknesses of B, in fig. 36. Into the other prints C, in fig. 36, the steam passage cores enter. These passages are seen in fig. 29 J J, and as the core boxes are like the box shown at fig. 24 in the previous article, the proportions alone being different, I need not illustrate them.

One half the box for the steam inlet core is shown in fig. 38. The end A enters into the print I made in the core, fig. 35, and the portions B and C enter into the impressions made by the circular prints D in the core, made in the box, fig. 36. In this fig. 36 only one round print is rammed at one time, the two prints there shown being for the purpose of reversal of the core, one for right, the other for left hand.

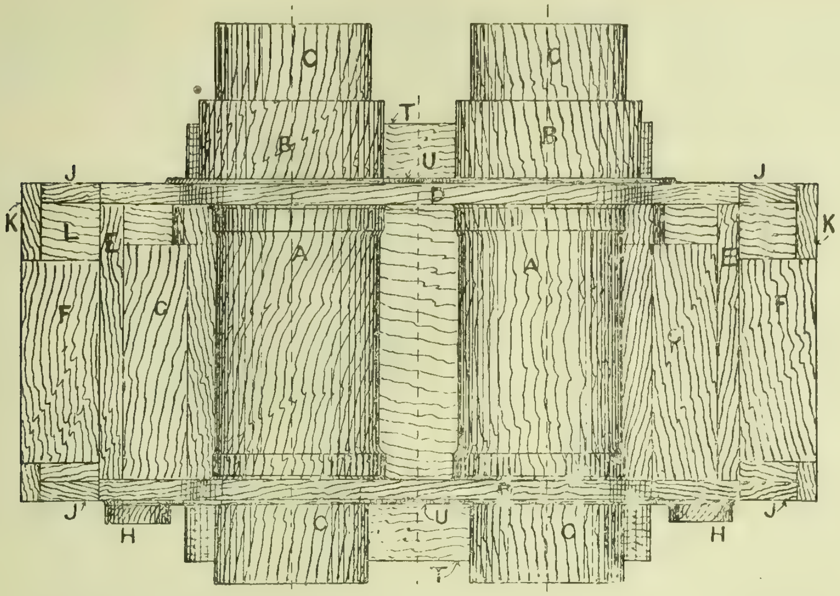


Fig. 3.

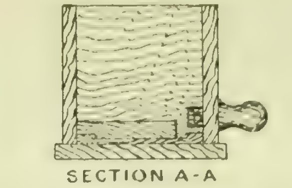
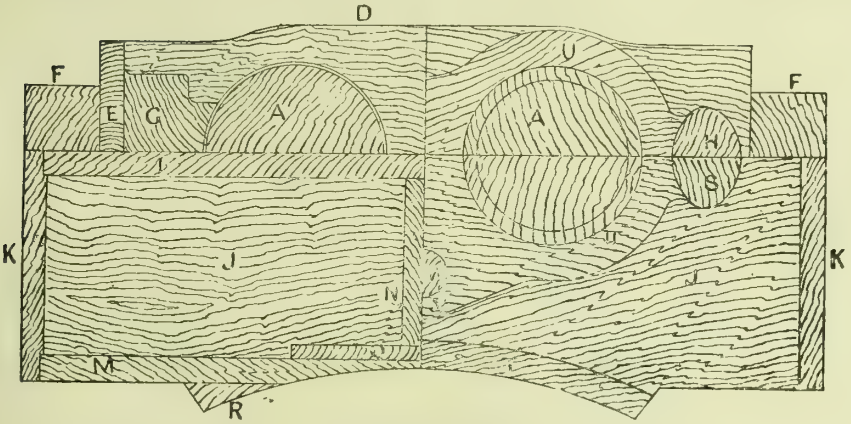
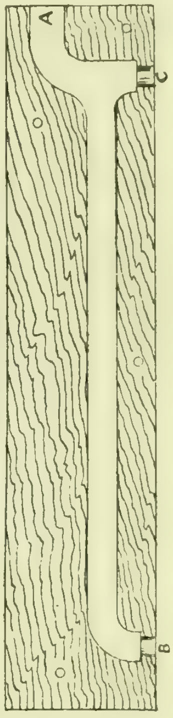


Fig. 36.



Section. Fig. 34. End View.



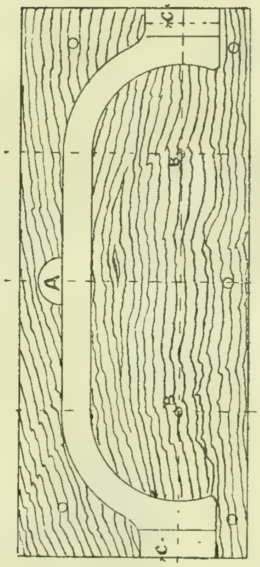
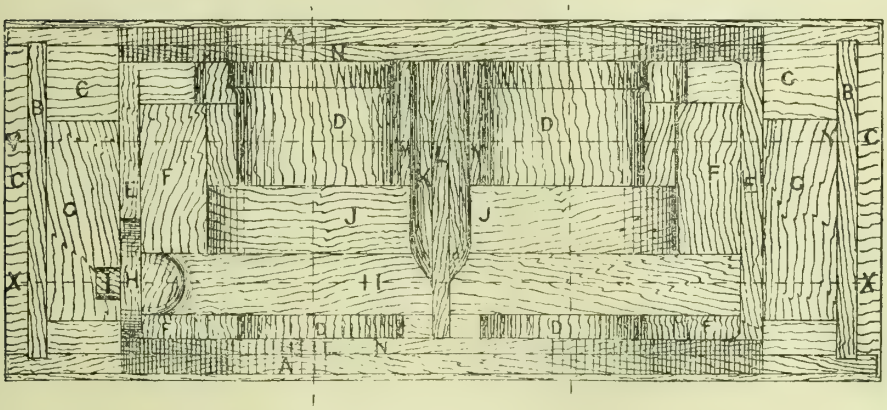
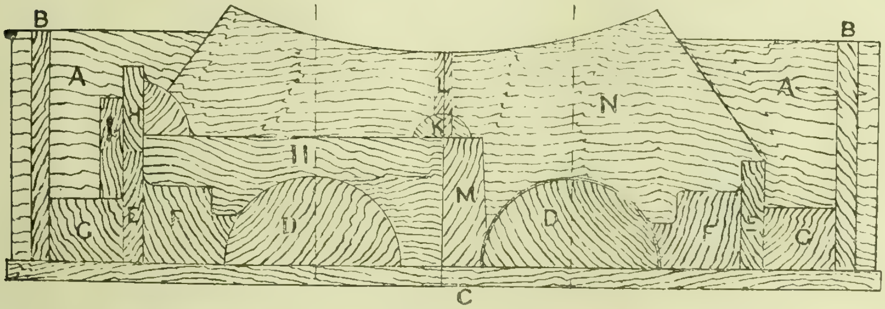


Fig. 37. Fig. 38.



Plan.



Section on X X. Fig. 35. Section Y Y.

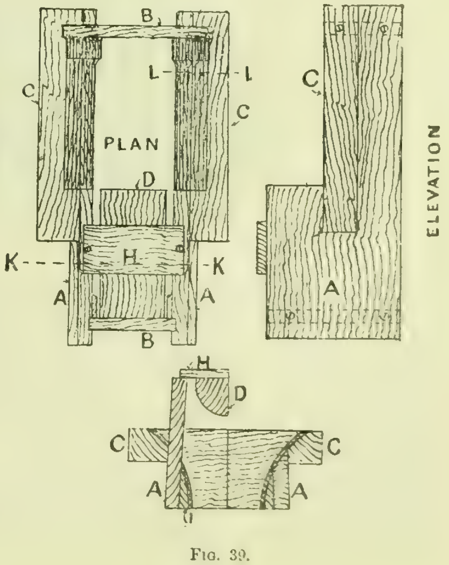


Fig. 39.

As the mould is made, the core from box, fig. 38, is first set in place, partly resting upon chaplets, the studs C C therefore standing upwards. The cores made in box 36 are then laid down in their prints, and the round stud-holes formed by D D fit over the studs B B, in fig. 38. Then the curved steam passage cores J J, in fig. 29, are fitted into their prints C C, in fig. 36, and the core made from box 37 is dropped into its print B, and all are then secured and stopped over. This is a good example of cores fitting into cores, a method which receives large application in intricate work.

Fig. 39 is the box whose core forms the under side of the pipe G in figs. 28, 29, 31, and 32, and whose print is shown at M, fig. 35. It also cores out the portion H, in fig. 28. Here A are the box sides, B the ends, C blocking pieces, which are cut to the curve of the cylinder body, so forming H, in fig. 28. D is the block which forms half the pipe G in the figures just now alluded to. H is a batten by which it is retained in place. The portions I complete those parts of the curvature of the cylinder body which are covered by the print M, in fig. 35.

The use of a bottom board in several of these core boxes will be noticed. This is a common practice when a portion of the work has to be laid in the bottom, being better than laying those portions upon a core bench, having probably an untrue surface. Moreover, by means of the bottom board those portions are all kept together in their relative positions. The board is either dowelled on the bottom edges of the box sides, as in figs. 35 and 36, or is held in position by means of blocks screwed upon it, and fitting within the sides and ends, or often the internal work fitting within the box keeps the box frame in position.

J. H.

ELECTRICAL MEASURING INSTRUMENTS AND FITTINGS AT PARIS.

The Acme Electric Works Exhibit.

This firm has a considerable exhibit of their electric instruments and fittings, among which we observe several examples of Cockburn and Thomas's patent switches, for which are claimed perfect locking, combined with a very rapid break of contact when breaking circuit in order to escape destruction of parts by the arc. The contact bar or brush is free to move independently of the rate at which the handle is turned, and the bar is quite separate from the handle.

Round the spindle is fitted a strong spiral spring, one end of which is securely fixed to the brass base plate, the other end being fastened round a pin fixed on a movable contact bar. This spring tends to keep the contact bar in the "off" position; but the main feature or improvement in this switch is the device for firmly holding or locking the bar in the "on" position. This is accomplished by means of a special spring fitted to the base plate, and so arranged that when the contact bar has been moved to the "on" position the spring rises and catches against a projecting steel-faced flange fixed to the contact bar, and so holds the bar firmly locked in the "on" position against the force of the spiral spring before mentioned.

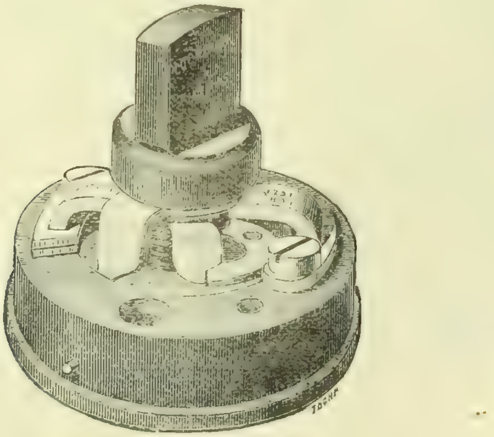


Fig. 1.

In breaking circuit the first action is to unlock the catch spring, to do which a special projection or flange is attached to the handle, so arranged as to depress the holding spring, thus setting free the locking catch. Directly this is done the contact bar is free to move, and, having the full force of the coiled spring acting upon it, flies quickly off the fixed contact pieces, and allows no time for a destructive arc to form. By this arrangement the bar is not first pushed off the contact piece and then drawn quickly away, as in many miscalled quick break switches, but the bar is actually moving rapidly before the contact bar has left the contact piece or even circuit broken; it is also impossible for the bar to remain partly "on," but must either be locked in the "on" or held firmly in the "off" position.

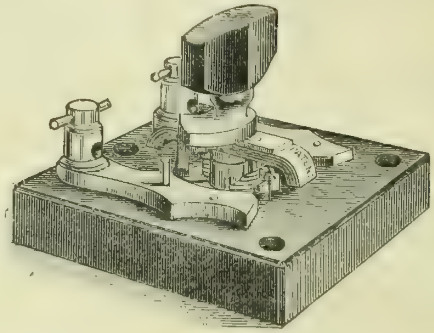


Fig. 2.

Fig. 1 shows the switch full size, as applied for currents of 3 amperes, and fig. 2 is the main switch of quarter full size.

The "cut-out" or safety fuse exhibited by this firm is also interesting. Our illustrations show it at figs. 3 and 4. These "cut-outs" are especially designed to obviate the danger and unreliability attendant upon the use of fusible wire or strip fuses. In fusible wire, as usually employed, unless a large excess of current above the normal were sent suddenly through it, the fuse would not go off at a definite current, and frequently became *red hot* and itself a source of danger. In the Cockburn cut-out, by the addition of a small lead weight, the fusible wire is caused to break when in a crystalline or plastic condition, before the temperature becomes excessive; in fact, under no conditions can it be made red hot. Practice shows that it can be relied upon to break at a definite current, and, if used as directed, is guaranteed to break within five per cent of the current for which it is issued. This arrangement is very ingenious, and is now widely used, among other places, at the General Post Office, H.M. War Department, Baron Rothschild's, and Sir David Saloman's.

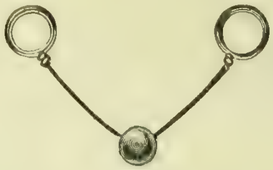


Fig. 3.

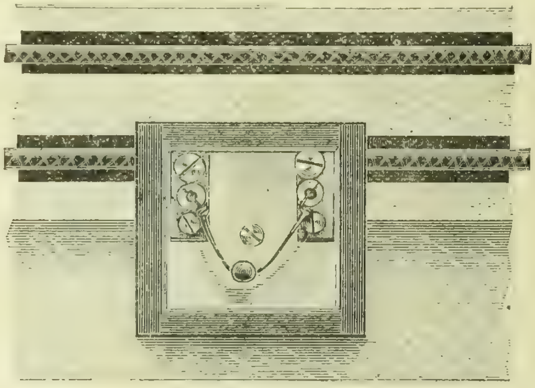


Fig. 4.

Messrs. Paterson and Cooper's Exhibits.

Messrs. Paterson and Cooper exhibit a variety of electrical measuring instruments and appliances, amongst which are included the well-known permanent magnet ammeters and voltmeters of Ayrton and Perry, which this firm has manufactured since their first appearance. But another class of instrument, possessing several advantages over these, has come into favour in recent years. We refer to that in which the permanent steel magnets are replaced by soft iron electro-magnets. These instruments require no recalibration, as the magnet has an invariable strength for the current being measured, whereas in steel magnets, though nominally permanent, the strength alters with time. Messrs. Paterson and Cooper's ammeters and voltmeters, constructed on the electro-magnet principle, are here shown (see fig. 1), and differ in several important particulars from the ordinary instruments of this class. For the weak controlling force of an electro-magnet has been substituted the powerful force of a spiral spring. The deflecting soft iron needle is attached to the spring, and forms part of a magnetic circuit, which when no current is flowing lies at nearly right angles across a gap in the soft iron frame which comprises the other part of the magnetic circuit. On this frame the wire through which the current is to flow is wound, the needle tending, when the frame is magnetised by the current, to set itself parallel to the frame and so close the magnetic circuit. As its movement to effect this is against the spiral spring, the deflection actually observed is a measure of the force exerted on the spring, and, the dial being properly graduated, of the current flowing. The instrument described is made both for the measurement of current and difference of potentials, being wound in the former case with coarse and in the latter case with fine wire. Two instruments constructed on the above principle, for the measurement of large currents, are shown. A front view of one of these is shown in fig. 2. Here the wire carrying the current, described in the last instrument as being wound on the iron frame, has been replaced by a single bar of copper 1½in. diameter, the iron frame being in the form of a ring, which nearly embraces the bar, leaving only a sufficient space between its open ends for the soft iron deflecting needle to lie in. One of these instruments indicates only the current flowing, but the other not only indicates but records on a card the variations of the current from minute to minute. The cards are fastened on a cylindrical barrel driven by clockwork, and the records of each separate day's running can be preserved for future reference. Several Cardew voltmeters of the latest design (fig. 3) are shown, as well as a pocket voltmeter (fig. 4), which, being about the size of an old-fashioned watch, can be conveniently carried in the pocket. The Thompson and Starling universal photometer (fig. 5) for measuring candle powers, from half a candle to 10,000 candles, is shown. This consists of a graduated bar, at the centre of which are fixed, back to back, two opaque screens, attached to one another at a small angle. On one screen falls the light which is to be measured; on the other falls the light from two standard spermaceti candles. By adjusting the position of the candles, the intensity of the source of light to be measured is ascertained and can be read off on a graduated bar at once, without any calculation.

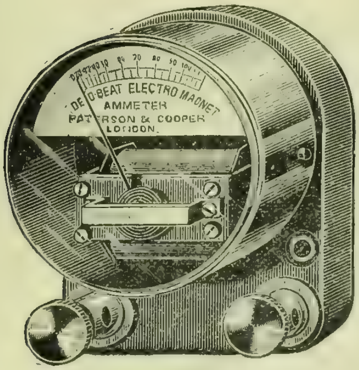


FIG. 1.

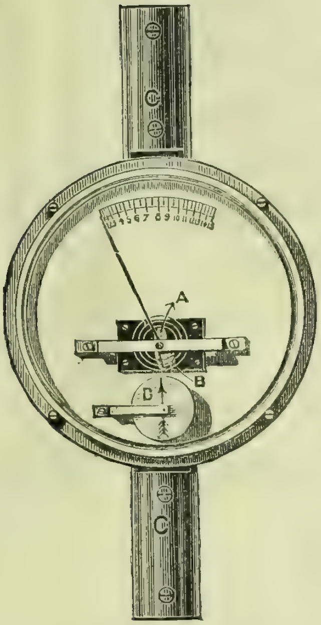


FIG. 2.

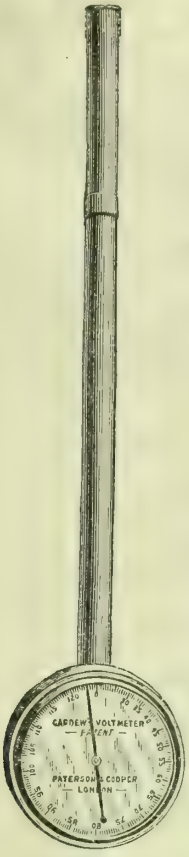

CARDEW'S VOLTMETER
— PATENT —
PATERSON & COOPER
— LONDON —

FIG. 3.

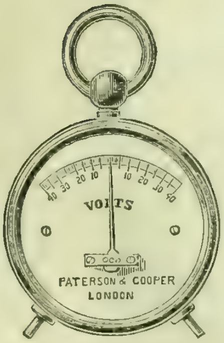


FIG. 4.

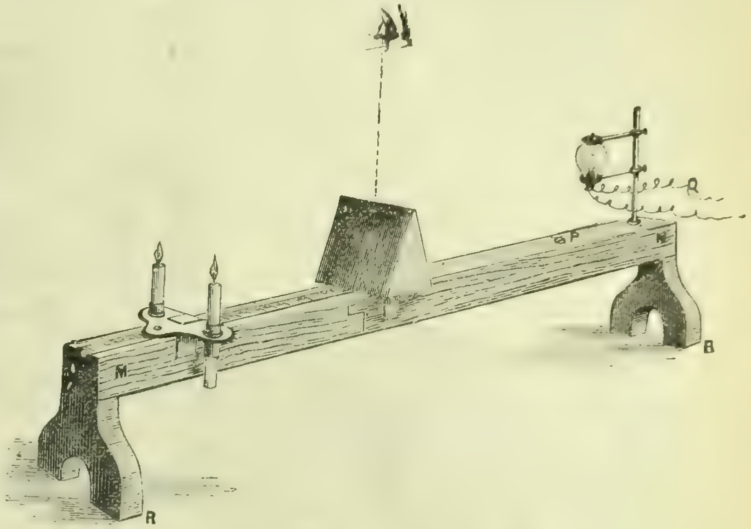


FIG. 5.

SUEZ CANAL TRAFFIC.

THE following particulars of the traffic of the Suez Canal for the year 1888 are extracted from the report of M. Ferdinand de Lesseps, presented to the shareholders of the Suez Canal Company at the annual general meeting held in Paris on the 15th May last:—

Transit and Navigation.—3,440 ships passed through the canal in 1888. From these, receipts to the amount of 63,037,618 francs were realised, while receipts from passengers amounted to 1,838,957 francs, and from the transit service to 366,045 francs. The total traffic receipts amounted therefore to 65,242,620 francs, an increase of 7,117,245 francs over the previous year, or 12·24 per cent. Vessels to the number of 192, or an increase of 20·75 per cent on 1887, passed through the canal for the first time last year. The number of ships drawing more than 7 metres of water was 971, or a proportion of 28·23 of the total; 105 had a draught of 7·49 metres and 2 of 7·50 metres.

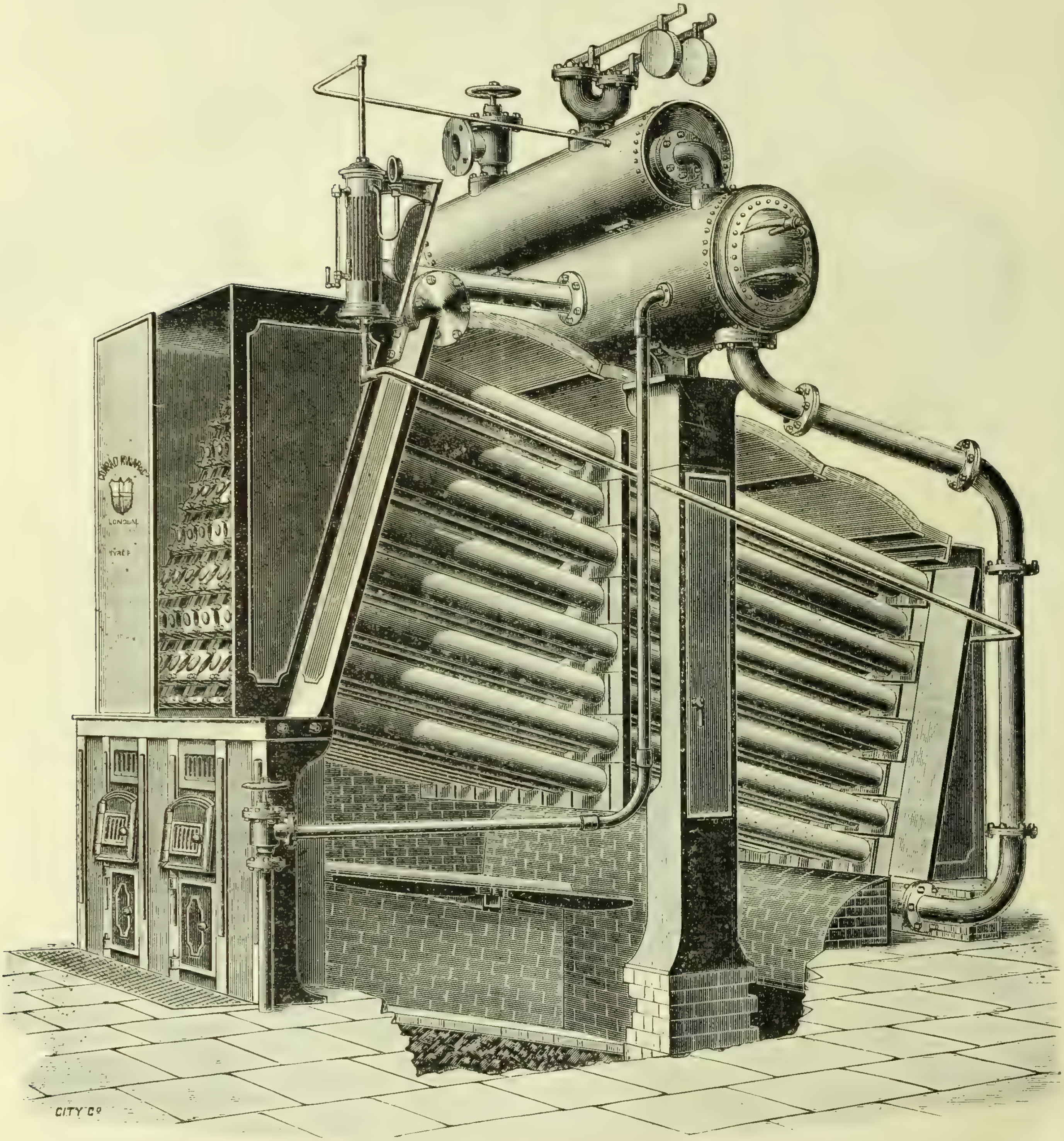
Night traffic in the canal continues to increase: in 1888, 1,608 ships, that is to say 46·74 per cent of the total traffic, have passed through with the aid of the electric light.

The average of the whole journey per ship in 1887 was 34 hours 3 minutes, a diminution of 2 hours 8 minutes on the preceding year. In 1888 the further diminution was 3 hours 18 minutes, or an average total journey of 30 hours 45 minutes only.

SMOKELESS POWDER.—This year's practice of the Prussian Artillery Brigade of the Guards at Hammerstein, in Eastern Prussia, derived considerable interest from the fact that the so-called smokeless powder was tried for the first time in Germany, and stood the test most satisfactorily. The first regiment consisted of 11 batteries, the second of eight, and each spent at least a day in firing all sorts of projectiles with the smokeless powder. At each shot all that was visible was a ball of black smoke about three feet in diameter, which quickly disappeared. The powder leaves so little refuse in the bore that it is not necessary to clean it out after every shot, but only to pass a rag dipped in oil through it now and then.

KNAP'S PATENT IMPROVED ROOT BOILER, 150 HORSE POWER.

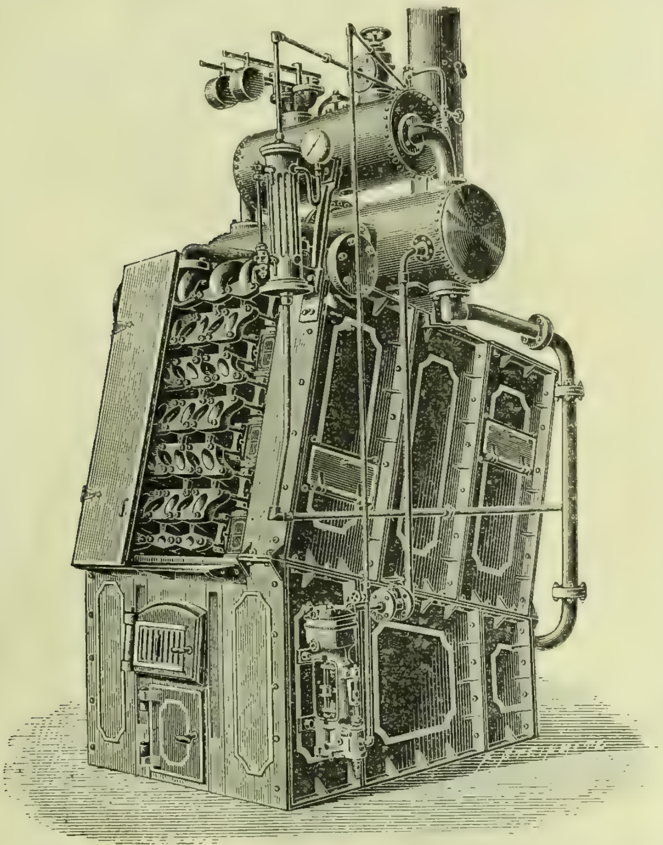
CONSTRUCTED BY MESSRS. CONRAD KNAP AND CO., ENGINEERS, LONDON.



One very noticeable feature at the Paris Exhibition is the extreme prominence of the water-tube type of boiler, and behind the great Machinery Hall, among those supplying steam for the numerous engines there, the water-tube boilers of Messrs. Conrad Knap and Co., occupy a good position. Our illustration on this page represents Knap's patent improved Root steam boiler, 150 H.P. nominal, as at work there. It has 105 best lap-welded wrought-iron boiler tubes, 5in. diameter, arranged fifteen tubes in width by seven in height, with a total tube surface of about 1,400 square feet. It is certified by the French Government inspecting engineers for a working pressure of 150lb. per square inch, and when tested by them evaporated in regular work 7,000lb. of water per hour, with very inferior fuel. The feed water was about 60 deg. Fah., and no heater was used.

A smaller engraving on the opposite page represents a 20 horse power boiler of the same kind, but enclosed in an iron casing, no other brickwork than the furnace lining being required. This type is specially adapted for use in connection with mining operations, being suitable for all purposes where facility of transport, in combination with practical efficiency and economy of working and repairs, are conditions of importance. Messrs. Conrad Knap and Co. guarantee, we understand, to make any boiler of from 5 horse power to 200 horse power in pieces weighing from 2 cwt. to 3 cwt. each, in some cases even less. These pieces are so arranged that any mechanic of average intelligence can fix them together and in position with ordinary hand tools; and the boilers thus put together are suitable for any working pressure up to 200lb. per square inch. In some cases also the fire grate is made of a very large size, to enable the boiler to be worked to full power with wood or inferior fuel.

We are informed that a large number of these boilers are working in mines and other places difficult of access, and when it is considered that the largest boiler of the type under notice can be shipped in pieces weighing 150lb. each, their adaptability for mining purposes is made sufficiently evident. These boilers are, the makers inform us, in present use in gold, silver, and copper mines in various parts of the world.



The use of steel and wrought iron in all parts exposed to pressure, the entire absence of any perishable packings, and the perfect provision for unequal expansion of parts without undue strains, are the principal new features to point out. The boilers are fitted with Messrs. Conrad Knap and Co.'s well-known interceptor for precipitating impurities in the feed water under full boiler pressure previous to entering the boiler proper.

COMPOUNDING OF LOCOMOTIVES BURNING PETROLEUM REFUSE IN RUSSIA.

We find that Mr. Urquhart's paper, published by us in our two last issues, has not yet been read at the Institution of Mechanical Engineers. At the Paris meetings its reading was postponed till a future occasion; and accordingly we deeply regret that we inadvertently published it, and we beg to offer our apologies to the Council of the Institution of Mechanical Engineers for this unintentional mistake on our part.

The largest artificial lake in the world, it is said, is in Auglaize and Mercer counties, O. This body of water supplies the St. Mary's feeder of the the Miami Extension Canal, and is about nine miles long by three broad. It was formed by building two earth embankments from 10ft. to 25ft. high, one two and the other nearly four miles long.

THE NEW BRITISH WAR SHIPS.

According to the *Glasgow Herald* the Admiralty authorities have just given official notification of the acceptance of tenders by several shipbuilding firms in the country for the construction and engining of second-class British cruisers, regarding which so many conjectural reports and rumours have been in circulation. Of these cruisers 29 are to be constructed, and the great majority are to be given out to private builders. Already 17 have been ordered, so that there are more contracts yet to place, and some of these may come to the Clyde, as all the firms have not received declinatures. It is gratifying to note that thus far the Clyde has secured a fair share, six of the cruisers having already been ordered from local builders—three from Messrs. Thomson, of Clydebank, and three from the London and Glasgow Company. We understand the following have received contracts:—

	No. of Cruisers ordered.
London and Glasgow Company	3
J. and G. Thomson, Clydebank	3
Barrow Shipbuilding Company	3
Messrs. Palmer, Jarrow	3
Messrs. Hawthorn, Leslie, and Co., Newcastle...	3
Messrs. Samuda Brothers, London..	2

These cruisers are to be 3,400 tons. In protection, engine power, speed, and coal supply they are practically reproductions of the Medea class, two of which, the Magicienne and Marathon were built by the Fairfield Company last year. They are more heavily armed than the Medea, 35ft. longer, and of about 600 tons greater displacement. The principal dimensions, &c., are: Length, 300ft.; breadth, 43ft.; displacement about 3,400 tons; speed on measured mile, 20 knots; speed at sea, continuous steaming, 18 knots. The coal capacity at a speed of 10 knots is about 8,000 knots; at 18 knots, 1,000 knots; and at 16 knots, 2,000 knots. The armament is to consist of two 6-inch (5-ton) bow and stern chasers; six 4·7-inch quick firers, broadside; nine 6-pounders and 3-pounders; four torpedo tubes. The maximum thickness of protective deck (on slopes) is 2in. steel, on horizontal portions 1in. It is proposed to wood-sheath and copper the bottoms of a large proportion of these vessels, which will involve an increase of about 200 tons in the displacement given above, and a reduction of about one quarter of a knot in the measured mile speed. The engines are of the triple-expansion type, to indicate 9,000 H.P. The diameter of the cylinders is 33½in., 49in., and 74in. respectively, with a piston stroke of 3ft. 3in. Working under a pressure of 155lb. to the square inch, they will make 140 revolutions.

The Fairfield Shipbuilding Company have booked the order to construct two sets of twin-screw triple-expansion engines, each of 12,000 indicated horse power, for two first-class cruisers building in Government dockyards; and Messrs. Earle, of Hull, are to make a similar set of machinery for a third cruiser also being constructed in the dockyards. Of these cruisers nine are to be built. Three, as already indicated, are to be constructed—one each at Chatham, Devonport, and Portsmouth. Tenders have been invited from private builders for the construction of the other six, and several of the leading Clyde firms are sending offers, so that there is a prospect of still more Admiralty work being booked before the end of the autumn. These first-class cruisers are to be 7,300 tons displacement, and have been designed to carry an armament practically identical with that of the Blake and Blenheim, now being built in the Government dockyards, and for which the engines are being constructed by a firm on the Thames. They are, however, to be of considerably less size and cost, to steam at a somewhat lower speed, and to have a smaller coal endurance than the Blake and Blenheim, although they will compare very favourably in these respects with any cruisers building for foreign navies. Their dimensions are: Length, 360ft.; breadth, 60ft.; displacement, about 7,350 tons; speed on measured mile, 20 knots; speed at sea, continuous steaming, 18 knots. The coal capacity, &c., at a speed of 19 knots, is about 10,000 knots; and at a speed of 18 knots is about 2,800 knots. The armament is to be as follows: Two 9·2in. (22-ton) bow and stern chasers, ten 6in. (5-ton) bow and stern chasers and broadside, twelve 6-pounder quick-firers, and four torpedo tubes. The protective deck, extending throughout the length, will have a maximum thickness of 5 inches of steel. The propelling engines of the vessels, for which the tenders are now asked, are to be of the triple-expansion type, with cylinders 40in., 59in., and 88in. diameter, and with a piston stroke of 4ft. 3in. Working under a steam pressure of 155lb. to the square inch, and with the forced draught in operation, the engines are to indicate

12,000 H.P., and with natural draught 7,200 I.H.P. is to be maintained during a 12 hours' trial at sea. The maximum speed under forced draught is to be 20 knots, and 18 knots under natural draught. Careful consideration was given to the question of the best system of protecting these vessels, their guns, and guns' crews before the arrangements approved were finally decided. The use of a very strong protective deck over the vitals, in association with certain novel arrangements for protecting the guns and their crews from shell fire, was preferred to alternative plans in which the broadsides to a certain extent were protected by comparatively thin vertical armour. Special care has also been bestowed upon the protection of the ammunition during its passage from the magazines to the guns, and unusual facilities have been provided for the transport of the ammunition. Some of the vessels of this type will be wood-sheathed and coppered in order to adapt them for distant service on stations where docks will not be available at least, in war time. This will add somewhat to the displacements given above, and cause a small reduction of the measured-mile speed.

TESTS OF A WESTINGHOUSE ENGINE.

By Stephen Alley.*

For many years the author has given considerable attention to high-speed single-acting engines of the Westinghouse type, and has made several tests with these engines; these all go to prove that great economy can be attained in the consumption of steam if careful attention is paid to details in their design and construction. One of the most difficult sources of waste to overcome is that due to long ports and clearances at the ends of the stroke. The great speed at which these engines run makes this detail of design the more important, as this waste is multiplied by the number of revolutions.

The advantages of high-speed engines of comparatively short strokes and high numbers of revolutions were due to the fact that the temperature of the walls of the cylinders, in short-stroke high speed engines, is subject to much less possibility of variation than in engines of long stroke and comparatively few revolutions. If the cylinders are properly covered with good non-conducting material, the loss by radiation is very small indeed.

The accompanying table gives a series of tests made in February, 1888, at Pittsburg, U.S.A., with a Westinghouse compound engine.

Table of Tests of a Westinghouse Engine, 14in. and 24in. by 14in., Compound.

Water Rates per Brake H.P. at varying Pressures and Loads.

Condensing.					Non-Condensing.				
Brake H.P.	Boiler Pressure.				Brake H.P.	Boiler Pressure.			
	120	100	80	60		120	100	80	60
200	19·62	22·53			200	23·94			
160	18·86	20·02	23·17		160	25·50	25·20		
130	18 38	19·56	21·32	24·30	130	24·32	26·24	27·70	
100	19·14	19·44	20·34	23·10	100	25·57	27·75	29·80	
70	19·80	20·05	21·43	22·57	90	26·51	28·30	29·80	31·70
40	22 90	23·12	24·75	25·25	70	29·40	30·77	32·48	36·00
					40	40·05	39·30	42·75	45·82

Unjacketed and uncorrected by calorimeter.

The amount of water consumed was arrived at by a surface condenser, so constructed that it condensed all the steam from the engine, and discharged it into a tank in which it was measured and weighed. Mr. Westinghouse rated the consumption of water on the brake horse power, or the power developed after deducting the friction of the moving parts of the engine. While working on a condenser the consumption when using 120lb. of steam was on a prolonged trial 19·62lb. per brake horse power, and when exhausting into the atmosphere, 23·9lb.

The table gives the consumption of water and power developed with the engine working at pressures varying from 60lb. to 120lb. per square inch.

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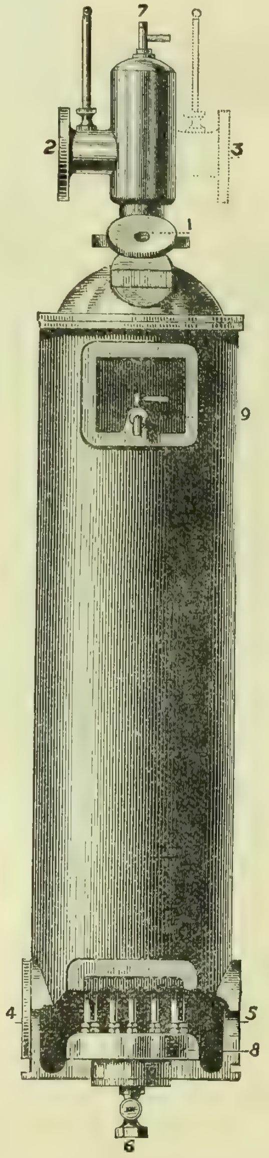
* Inst. C.E. Selected Papers.

MESSRS. KIRKALDY'S EXHIBIT AT PARIS.

The stand of Messrs. Kirkaldy Limited, in the British Section of the Paris Exhibition, is one of the most attractive and complete in the whole of the Machinery Hall. It is admirably arranged to display a great variety of this well-known firm's special manufactures, among which we examined a compactum feed-water heater, compactum double and single distillers, compactum feed make up apparatus, and a combination of steam pump, condenser, and distiller all at full work. For many years past Messrs. Kirkaldy have appreciated the great value of high temperature in feed water for steam boilers, and by their continued insistance on this point they have greatly improved the condition of many boilers at sea and on land.

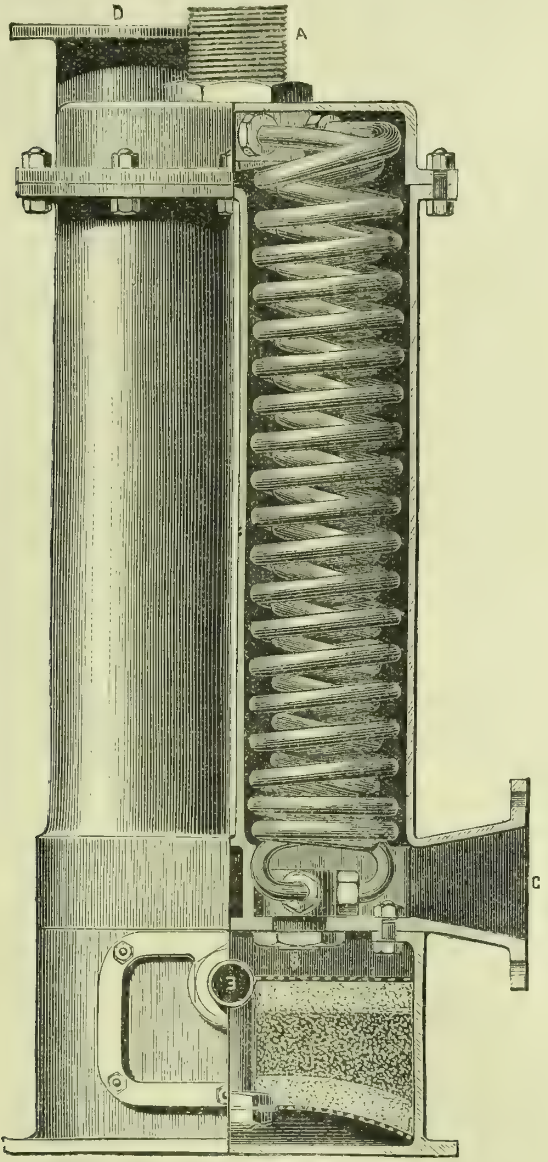


Feed-water Heater.

Feed-water heaters have proved the most effectual means of overcoming the evil effects of unequal expansion caused by cold water, and, besides saving fuel, a feed-water heater causes a great diminution of the wear and tear of a boiler. We here illustrate Messrs. Kirkaldy's form of compactum feed-water heater. We have fully described it in a previous issue, but we may say that at 1 is placed the steam admission to the tubes, at 2 the outlet for the hot feed water, or at 3, shown in dotted lines, when the pipe connections require it. The feed water supply from the pumps enters at 4 or 5, and at 6 is the outlet for condensed water into the hot well; at 7 is placed the pipe for exhausting air, and at 8 and 9 are cleaning doors, the upper one of which is fitted with a soda cock. The example shown at Paris is admirably finished and exceedingly effective in action and appearance.

The necessity of hot feed water for steam boilers is so great that it is even advisable, in many cases, to use live steam in heating, and Messrs. Kirkaldy have patented a method whereby this is done with great success. When condensing engines are used, of course, the exhaust steam is not available to any extent for feed heating, and in such cases the invention to which we refer is widely applicable, as on ship board. Another of this firm's well-known specialties is their distilling apparatus for preparing good drinkable aerated water from salt water.

We also illustrate the simple distiller. It consists of a double water-cooled coil, kept cool by a current of water. The steam enters at A, and passes out as water at the lower end B into the upper part of a small filter bed, after flowing through which it flows out at the pipe E. There is also a relief pipe, which serves the double purpose of allowing the admission or the escape of air. By passing through the filter, which is partly carbon, the water becomes aerated and palatable. The cooling water enters at C, and, passing upwards, finds its way out at D.



Simple Distiller.

The "Compactum" specialties have done excellent service in many ways connected with the use of steam on board ship, not the least being a great increase in the life of boilers using them, as well as a positive saving in fuel consumed. We have before us indicator diagrams from a marine engine, which prove in the most certain way the undeniable economy attained by the use of these appliances, in some cases as much as 10 per cent.

The other appliances exhibited are most interesting, and we must notice them in detail at a later time. Meanwhile we may say that we drank some of the distilled water produced at the stand, and found it most palatable. Paris town water is by no means so good as our English water, and visitors to Messrs. Kirkaldy's stand would do well to secure one draught of pure water while they can.

HEAT ENGINES OTHER THAN STEAM.—I.

(Continued from page 518.)

In 1824, M. Carnot published his work, entitled "Reflexions sur la Puissance Motrice de Feu," in which he enunciated the natural law known by his name. M. Carnot was one of those who at this time held the "caloric" theory, as it is termed, that is to say, he believed that heat was a material substance; he had not then realised the dynamical theory of heat, *i.e.*, that heat and motion are convertible, which is now, as I have said, universally accepted, and, therefore, although the theory as he propounded it is true, yet in some of his deductions he has since been proved to be incorrect.

You will notice, during our consideration of it, that it is hedged completely round with specified conditions, and you will frequently find (even in some of the text-books, I am sorry to say) that some one or more of these conditions is neglected or eliminated, with the result that absolutely fallacious arguments are propounded.

Carnot based his arguments on a fact which we all feel intuitively to be true, that given two bodies of different temperature in proximity the one to the other, there is a continual tendency towards the establishment of equilibrium of temperature between them. Further, he pointed out that this tendency is an invariable accompaniment of the conversion of heat into motion; and he stated (that which is obvious, if these previous statements of his are correct) that whenever there is a difference of temperature it should be possible to obtain the production of motion.

The doctrine of Carnot may be roughly defined in this way. The utmost work which can be obtained from a theoretically perfect heat engine (when the working agent does not change its state, as from steam to water) is represented by the difference between the temperature at which the working agent is received into this ideally perfect engine, and that at which the working agent leaves the engine.

Carnot himself illustrated his proposition by comparing it to the power produced by a fall of water acting on a water-wheel. I have here upon the wall a diagram used by Mr. William Anderson, in the lectures to which I have already referred. This shows graphically what was suggested by Carnot.

You will see at the top of the hill, on the left-hand side of the diagram, a reservoir of water connected by a pipe running down the hill to a turbine placed in a small house half-way down; and you will also see that a channel is carried from the tail-water of this turbine further on down the hill, till it connects with the sea at the bottom.

Now, it is evident that the only power which could be utilised to work the turbine, if the water could not fall to a lower level than that of the tail-water at the turbine itself, would be that due to the weight of water falling from the top of the hill to the level of the tail-water at the turbine, and assuming that there is no friction in the pipes, or losses in any way whatever, then the whole of the power residing in this weight of water, falling through the height shown, might be obtained.

Now, if you had another pipe, from the same reservoir at the top of the hill, carried to a turbine placed at the sea level, and arranged so that it could deliver its tail-water there, it is evident that the power that could then be obtained would be greater than before, because of the greater height through which the water could fall. Now, assume that the water in the top reservoir is represented by T, or highest temperature, and that the water at the sea level is represented by t, or lowest temperature, it is evident that the power to be obtained would be that due to the weight of water falling per minute, say W, multiplied by the difference in height between T and t, or if the tail-water at the turbine, which is shown half-way down the hill, is represented by t 1 then the proportion of the total work which could be obtained from a turbine placed here, would be represented by the proportion which the height T minus t 1, bears to the total height, T, the weight of water falling being the same in both cases; or, in other words, calling the water heat, then the total quantity of work to be got out of a perfect heat engine, is represented by the difference between the incoming temperature T, of the working agent, and its outgoing temperature, t or t 1, as the case may be.

It is further obvious that the higher the incoming temperature, or the lower the outgoing temperature, the greater will be the difference between them, and the greater the total possible work which will be obtainable from the ideal engine, and also that the only way of obtaining the total possible result from any given working agent in a perfect heat engine is to reduce the incoming temperature to the lowest possible point. I shall have again to refer to this question of the lowest possible temperature almost directly, in connection with what is known as "the absolute zero of temperature."

You will see also that if we had an ideal or perfect engine, which would utilise the whole of the difference between the incoming and outgoing temperatures of the working agent, not losing any heat in any way whatever, and also that if mechanical work is produced by the transformation of the heat in one body into motion in another, and not by the dissipation of the heat, then it should be possible to renew the heat by passing it through another engine, which should be worked by the first, and should take in the working agent at the lower temperature at which it would be rejected from the first engine, and should discharge it at the higher temperature it originally had, ready to be again taken into the first engine to be transformed into work there. The work in the two ideal engines would be absolutely equal, and the working agent would pass through a perfect "cycle" of operations, that is to say, would commence at the highest and would go to the lowest temperature, and from that again to the highest temperature, the heat being first transformed into mechanical work, and then this work re-transformed into heat.

The perfect or ideal engine, therefore, must be, according to the Carnot theory, absolutely and entirely reversible; but, let us see some of the impossibilities, in practice, this theoretically perfect engine involves.

First, we should need for the working agent a perfect gas, the volume, and therefore the pressure, of which would vary exactly as the temperature. We should also need an engine absorbing for itself no portion of the work developed—that is to say, a frictionless engine, and one also in which none of the heat imparted to the working agent was lost either by radiation or conduction, or, in fact, in any way whatever—as I have said, impossibilities.

I commenced by showing you these cubes, the black one representing a definite quantity of heat, and this smaller red one representing the amount of that heat utilised in practice in a very fair high-pressure compound non-condensing steam engine of the present day. But you will now realise that as no mechanical combination can possess the impossible qualities which we have seen must be possessed by an ideal engine, we are really not treating our steam engine fairly in making this comparison, unless we bear the above impossibilities in mind. Of course this reasoning applies equally to the gas engine and to the gas-engine cube.

(*To be continued.*)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

GAS ENGINES.

To the Editor of "The Practical Engineer."

SIR,—My attention has been directed to a letter in your contemporary, *Engineering*, by Mr. A. L. Steavenson, calling attention to a supposed omission on my part occurring in a paper on "The Theory of the Gas Engine," which I had the honour to lay before the Institution of Civil Engineers in the year 1882. Mr. Steavenson asks for an analysis of the exhaust gases leaving gas engines in order to see if any of the gas escapes unburnt. Since 1882 I have had several analyses of exhaust gases made for me with gas engines of my design, and have always found that it consists mainly of carbonic acid, nitrogen, and free oxygen. The analyses are not by me just now, so that I cannot give details, but I note that Mr. W. J. Crossley gives analysis of exhaust from an Otto engine, in a recently published paper, as made by Professor Dewer, as follows:—

Carbonic acid	10·5
Carbonic oxide	0·
Hydrogen	0·8
Nitrogen	88·7

Mr. Steavenson gives analysis of exhaust taken from a Priestman petroleum engine at two speeds—one 104 revolutions per minute, another at 153 revolutions per minute—and finds, at the low speed, from 7 to 9 per cent of carbonic oxide, and from 7 to 8 per cent of hydrogen; while at the high speed he gets 0·8 to 1·4 per cent of carbonic oxide, and 3 to 2 per cent of hydrogen. He asks me how I reconcile these results with the dissociation theory as stated in my paper?

Here Mr. Steavenson's reasoning is quite inaccurate. The cause of the variation in composition of exhaust gas is not directly due to the change in speed; it is due to the fact that at low speeds the petroleum engine was taking into the cylinder far more inflammable vapour than there was oxygen present to burn; while at the high speed, 153 revolutions, the proportion was more correct, but still not quite correct.

This is distinctly proved by the two analyses. At the low speed the exhaust contains over 15 per cent of the unburned inflammable gases, while it only has 3 per cent of oxygen. At the high speed, on the other hand, the unburned gases are a little over 3 per cent, while the free oxygen varies from 3 to 4 per cent.

I need not say that these analyses by no means represent the results obtained with a good gas engine, as in the petroleum engine the combustion seems very imperfect, while in the gas engine it is as nearly perfect as possible.

Mr. Steavenson's letter proves how difficult it is to reason accurately on any subject unless all the conditions accompanying change are clearly understood and measured. If Mr. Steavenson refers to my paper on "Gaseous Explosions," read before the Institute of Civil Engineers, in 1886, or my work upon "The Gas Engine," he will find further developments of the question of phenomena occurring during explosion. The analysis quoted shows clearly that at 104 revolutions this petroleum engine discharges unburned nearly as much inflammable matter as it burns, or, in other words, half of the fuel taken into the cylinder is discharged unused. At the high speed the mixture is better proportioned, but still far from satisfactory. This seems to prove, unless Messrs. Priestman have some explanation to offer, that their engine is still very much farther from perfect action than I have been led to suppose.—Yours, &c.,

13, Temple Street, Birmingham. DUGALD CLERK.

[We reprint below the letter from *Engineering* referred to by Mr. Clerk.—ED.]

SIR,—I wrote you on the 18th of May asking to be referred to some analysis of the exhaust gases from these engines. Up to the present time I have met with no reply, and from my researches in the literature of the subject I am inclined to think that in this country, at least, no such tests of the work done in a gas engine have been made.

To me who have up to now little experience with these machines, such an omission seems very singular. So far back as April, 1882, Mr. D. Clerk brought "The Theory of Gas Engines" before the Institution of Civil Engineers. His paper and the discussion occupy 87 pages. In the same year a handbook was published by Mr. Macgregor, containing 225 pages. Papers innumerable have been read both at home and abroad upon the subject. Careful tests were made at the Glasgow Exhibition for utilisation of gas in 1880, and many examinations by professors at the various scientific colleges, smoke abatement committees, Royal Society's tests, and all seem to have omitted to give a passing glance at the contents of the exhaust pipe—with one single exception, where I find Heinrich Gollner experimented upon a twin Otto at the German Technical High School at Prague, when we learn: "The quantity of gas used and the initial and final temperature of the cooling water were observed and analysis made of the products of combustion escaping from the cylinders." Here we have mention of the first and only analysis, but the result is not given by the translator, nor is it applied to the consideration of the mystery in question.

Mr. Clerk puts it in this way*: "The gas engine, then, differs from the hot-air engine, using air heated in the manner assumed in the first part of this paper, in this, that the temperature is sustained, notwithstanding the enormous flow of heat through the sides of the cylinder by the continuous combination of the dissociated gases."

Then he refers to No. 2 theory, which "has lately been advanced by Mr. Otto" . . . "the flame has not spread throughout the mass of the ignitable mixture in the cylinder; but as the piston moves forward the pressure is sustained by the gradual spread of the flame;" but he says, "the theory which ought to explain the so-called sustained pressure on the diagram is a false one."

Dr. Siemens seemed to think the action which had been described with reference to the diagrams by the writer was reasonable enough.

Professor Rücker seemed to think that, assuming the conditions were as stated, "there was a certain amount of dissociation," but as he proceeded with his remarks he introduced what we may call No. 3 theory, viz., the increase in specific heat of gases at a high temperature, and he says: "Here, then, was an explanation of the curious maintaining of the temperature to which the author had referred; as the gas cooled, the latent heat was given up, and the curve was thus kept up to a high temperature by the heat previously absorbed by the molecules of the gas."

Mr. Imray introduced No. 4 theory, viz., that Mr. Otto, "instead of burning in the cylinders an explosive mixture of gas and air, burned it in company with a large volume of incombustible gas, arranged in a certain way, which was heated by it, and diminished the speed of combustion."

Mr. Bousfield thought the greater the quantity of air introduced the less the rate at which ignition travelled. Guess No. 5.

Now, after all these theoretical surmises, it is rather refreshing to hear Mr. Severn saying: "He would be glad if the author would state if he had tested any gases taken from the exhaust" . . . "which would bear directly upon the question of complete or partial combustion, and be of great interest." So I should think, and yet seven years later a most elaborate report is published by the Society of Arts on the gas engines to be used for electric lighting, and the question of complete combustion of the gases, as evidenced by the exhaust, is still overlooked

The matter interests me in this way: I expect to have, in a fortnight's time, a rock drill actuated by one of Priestman's petroleum engines, and it is of importance that I should know what gases I shall have to provide for. I therefore got the assistance of Monsieur Japuis, of the Clarence Laboratory, who supplies me with the following analyses of samples taken by him from an engine running in the maker's works, at Hull, on the 6th of June.

The engine was then at its usual duty, driving two drilling machines, one planing machine, one shearing machine, and a smithy fan, and at two speeds gave these different results:—

	104 Revolutions.		153 Revolutions.	
	1	2	3	4
N	78·34	75·13	83·49	84·01
CO^2	3·75	5·41	8·40	9·60
O	1·25	3·04	4·40	2·88
H	7·50	8·66	2·91	2·07
CO	9·16	7·76	0·80	1·44
	100·00	100·00	100·00	100.00

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* See Proceedings of Civil Engineers, vol. lxix., page 239

For my purposes, the results got when running at full speed are quite satisfactory, although I propose, when we get freely to work, making a considerably extended examination into the varying effects of speed and work.

I do not pretend to offer an opinion, but if Mr. Clerk's theory of dissociation is correct, how is it that the highest speed, and of course greatest heat, shows the most complete combustion ?—Yours faithfully,

Durham, July 9, 1889. A. L. STEVENSON.

QUERIES AND REPLIES.

41. **HOT-WATER PIPES.—Inform me how to arrange and fix water-heater and pipes for a garden greenhouse, 11ft. by 16ft. What book may I get on arrangement of greenhouse ?—WATER-HEATER.**

Answer.—"Water-heater" only gives two dimensions of his greenhouse; the third is required, as it is a matter of maintaining a certain number of cubic feet of air at a constant temperature, usually about 60 deg. Fah. for a general purpose greenhouse, to do which, assuming the house to be 10ft. high, about 70ft. run of 4in. diameter pipe will be required in the coldest weather. A very general form of boiler is the common saddle kind. It should have about two square feet of heating surface exposed to the direct action of the fire, the grate area being about half a square foot. The hot-water pipes start from the highest level of the heater, pass round the greenhouse, and return to the lowest point of the heater, by which means a constant circulation of the water is obtained. There should be a drain pipe, with cock attached to the bottom of the heater, and an air cock at the highest point, to facilitate filling. At some convenient point in the circuit the feed should be admitted, a pipe being taken up for the purpose and connected to a small tank, capable of being filled by means of a ball tap, which automatically regulates the feed and keeps the whole system full of water. There should be a damper fitted in the flue to regulate the draught. If the pipes are placed in trenches covered with grating, add about 10 per cent to the length of pipe.—GREENHOUSE.

55. **TESTING LUBRICATING OILS.—I wish to know the methods of chemically testing the purity of lubricating oils. Is there any simple mode easily applied by an engineer ?—LUBRICATOR.**

Answer.—It is hardly possible to answer this question in a complete manner, and that is probably the reason why it has remained so long unnoticed. I will point out the lines only on which you might expect to work. The chemical tests employed for lubricants are numerous, and consist of the rise of temperature when stirred with sulphuric acid, the temperature at which solid fat is deposited, colour tests with reagents, beside the specific gravity, viscosity, and some lesser used methods. But it is difficult to arrive at a correct analysis of oils without much special experience, and the results of several tests of different characters should be compared in order to correct conclusions; hence the involved character of the work. Experts will form a rough judgment of the value of an oil by the experienced eye, smell, and taste. The purity of fixed oils may be determined approximately by warming gently in a porcelain capsule, and observing the characteristic odour, with which of course the experimenter must be familiar. For pure oils, but not for compound oils, the specific gravity tests are valuable, the specific gravity of any sample being compared with the standard tables given in the books. The rise of temperature with sulphuric acid is determined as follows: A certain quantity of oil, usually 30 c.c., is poured into a tall glass with a thick stem, a thermometer placed in it, and the temperature is noted. 10 c.c. of the strongest sulphuric acid (sp. gravity, 1,845) is run in steadily from a fine pipette, and both stirred with the thermometer. The total increase of temperature due to the addition of the acid is then recorded. If a plate of white glass be placed on a sheet of white paper, and a small drop of acid be added to 10 or 15 drops of oil, the colours produced will vary with the nature of the oil present. An acid test is very important with oils used for lubrication. The acid which may be present is dissolved by alcohol, and the number of c c. of a decinormal solution of soda required to neutralise the acid dissolved by the alcohol is made a basis for calculation of the quantity of acid present, calculated as acetic. The effect of an oil upon copper is also a test of acidity. The temperature at which solid fat is deposited is a valuable test for determining the adulteration of an oil. The oil is cooled until the solid fat begins to deposit. A portion of the sample is poured into a test tube, a thermometer placed in it, and the whole placed in a freezing mixture, say ice and salt, and allowed to cool gradually, when the temperature at which the fat begins to deposit is read on the thermometer. The tube is then taken out and dried. With the rise of temperature the degree at which the fat disappears is noted. To test the drying properties of an oil, a portion is spread in a thin layer on glass, and the time which it requires to dry hard is noted. The Elaïdin test has the same object in view. One way of applying this test is to mix thoroughly 10 c.c. of oil and 10 c.c. of nitric acid of sp. gr. 1·2 in a glass-stoppered jar, add a little mercury, and allow the jar to stand in a moderately warm place. The gas evolved causes, in the non-drying oils, the gradual formation of a solid, of the consistency of lard or butter, varying in tint with the nature of the oil. In drying oils no solidification is produced. In mixtures of both oils it produces more or less of solidification, according to the proportions in which they are mixed. A test for viscosity consists in passing a certain quantity of oil through an orifice of definite size at a particular temperature, namely, about 65 deg. Fah. The saponification of a mineral oil, adulterated with animal or vegetable fats, is a test. It is effected by mixing and shaking the oil with a rather strong solution of caustic soda or potash, heating, partly evaporating, and filtering. That which remains in the filter is unsaponified. The filtrate consists of a soap formed by the combination of the alkali with the fat used as an adulterant. If an excess of dilute sulphuric acid be added to this, and subjected to a gentle heat, a layer of fatty acids will arise to the surface. In oils used for purposes of lubrication simply the chemical tests alone are not sufficient. The body of an oil, its flashing point, its drying or non-drying properties, are of vital importance. And of late years the employment of mineral oils, and of compound oils formed by judicious mixtures of animal, vegetable, and mineral oils, has led to the diminution of the use of the simpler oils, and, in consequence, the chemical analysis becomes correspondingly more difficult and of less relative value Mechanical tests, by the use of oil-testing mechanism, as running a bearing for a definite period with a certain quantity of a lubricant, and noting the results, is a method commonly practised. The whole subject of oil testing is far too wide to be discussed in a brief reply, and is becoming daily of greater importance. I should advise you to read, for the chemical part of the subject, 'Commercial Organic Analysis," by Alfred Allen, of Sheffield, and for the mechanical section, Professor Thurston's "Friction and Test Work."—J. H.

62. **BORING ROLL CYLINDER.—I should feel much obliged for assistance from you, or any of your numerous readers, with the following: I have a cylinder for a roll; its length is 8ft., inside diameter 25in., and its thickness in rough metal about ¾in. I wish it bored out at the ends about 5in. or 6in. so as I can fit in arms and shaft, and to run pretty fair for outside turning. Can it be done in the lathe with any arrangement, or how would you advise me for cheapest and best, as my appliances are very limited ?—PRIMROSE.**

Answer.—If I had the job to do, I should proceed somewhat as follows: Having fitted a temporary cross centre in one end of the roll, I should fix the other end of the roll in the chuck plate as truly as possible, running the other end in the centre formed in the temporary cross bar before mentioned. Then, while the roll is revolving truly in the lathe, proceed to turn up a narrow strip on the outside, about 4in. wide and say 6in. or 8in. from each end, taking off as little as possible. This being done, build up a "steady rest" or support under the turned strip (made of 3in. planks set edgeways, the upper one being hollowed out to fit the outside of the roll) at the end furthest from the chuck plate, knock out the temporary centre, remove the travelling lathe head, and proceed to bore out the end to the depth required. This having been done, the roll may be reversed in position, the end already bored out being fixed in the chuck (using the adjacent outside turned portion for the purpose of truing it in the chuck), the other end may be supported as before, and proceed as in the previous case. Fix in the arms and shaft, and finish turning the outer surface of the roll, running the shaft in the same centres as were used when the shaft itself was turned.—OMICRON.

65. **BURSTING PRESSURE OF COPPER GLOBE.—The tenacity of copper is 40,000 per square inch. What is the bursting pressure in lbs. per square inch of a hollow globe 2in. diameter and ¼in. thick ?—J. C. W.**

Answer.—The pressure exerted on the globe is that on an area of $2^2 \times {}·7854$, or 3·1416 square inches. The mean diameter of the sphere is 2¼in. Its circumference is, therefore, $2\frac{1}{4}\,\pi$, or 7·0686in. One fourth of this is 1·7671 square inches, or the area of metal of a strength of 40,000lb. The total tenacity of the globe on any diametral section is hence 70,684lb., and as this strength is drawn on by pressure on 3·1416in., we get as bursting pressure, $\frac{70{,}684}{3·1416}$ or nearly 22,500lb. per square inch. Expressed as a simple formula, we have (1) $\frac{P = 4\,st\,(D + t)}{D^2}$ where P is the bursting pressure in pounds, *s* the ultimate tenacity, *t* the thickness of the metal, and D the interior diameter. Where *t* is small in regard to D, a sufficiently accurate formula is sometimes used of simpler form, where $\frac{P = 4\,st}{D}$ but in small spheres the results are too rough, and formula (1) must be used.—W. H. B.

Answer.—The total bursting pressure is 3·1416 × pressure per square inch, *i.e.*, area of 2in. × pressure. The resistance to tearing will be 2·25in. × 3·1416 × ·25in × 40,000lb., so that by equating we get 3·1416 × pressure per square inch = 2·25 × 3·1416 × ·25 × 40,000; therefore, bursting pressure per square inch—

$$= \frac{2·25 \times 3·1416 \times {}·25 \times 40{,}000}{3·1416};$$

cancelling and multiplying out, we obtain bursting pressure = 22.500lb. per square inch.—OMICRON.

Answer.—"J. C. W." does not say whether the 2in. named be the external or internal diameter of his globe, which will make a considerable difference in the result. I have assumed it to be the external diameter.

Let D = external diameter of copper globe in inches.

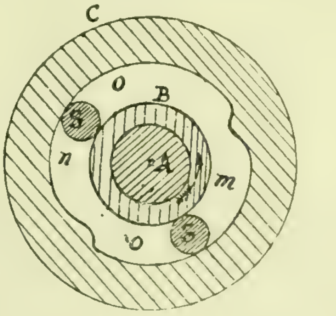
t = tenacity of copper in pounds per square inch, and $\pi = 3·14159$, &c.

While p = the internal bursting pressure per square inch.

Then $(D - \frac{1}{2})$ = internal diameter, and $(D - \frac{1}{4})\,\pi$ = circumference at mean section of metal, and therefore $(D - \frac{1}{4})\,\pi \times \frac{1}{4}$ sectional area of metal in a plane through centre of globe, whence $(D - \frac{1}{4})\,\pi \times \frac{1}{4} \times t = (D - \frac{1}{2})^2 \times \frac{\pi}{4} \times p$; therefore $(D - \frac{1}{4}) \times t = (D - \frac{1}{2})^2 \times p$, whence $p = \frac{(D - \frac{1}{4}) \times t}{(D - \frac{1}{2})^2}$, in which D = 2in. and t = 40,000lb.; and therefore $p = \frac{1\frac{3}{4}}{(1\frac{1}{2})^2} \times 40{,}000 = \frac{70{,}000}{2\frac{1}{4}} = \frac{280{,}000}{9} = 31{,}111\frac{1}{9}$lb.
—W. A.

66. **ROLLER CLUTCH.—Describe and sketch a method of employing friction rollers or spheres for causing a wheel to be locked to an axis when turning in one direction, but allowing it to run free when rotation is reversed.—J. C. W.**

Answer.—A is a shaft carrying a circular boss B, keyed fast, and a wheel C, a loose fit, upon it. The interior of the wheel is formed into a pair, or more, spiral chambers, each containing a roller *s s*. When the shaft revolves in the direction of the arrow it carries round the boss B and rolls the little cylinders into the narrowing spaces *n m* until they wedge fast and hard, and so cause the wheel C to revolve with them, the whole forming a solid combination. If the shaft revolves in the opposite direction the combination is unkeyed, and the rollers fall back into the spaces *o o*, which are wider than the diameter of the rollers. The reverse arrangement, by which a wheel drives a shaft, is also equally secured by this clutch. An elastic connection may be secured by making the small rollers of indiarubber, and spheres may equally well be employed in suitably-formed paths. In the practical construction of such a form of clutch, regard must be had to the tendency towards bursting exercised by the rollers on the outer case in which they work, especially as all the work may at any change be transmitted wholly through a single roller. Some designers, therefore, might be tempted to place a light spring to the back of each roller to secure simultaneous action, each roller being kept in absolute contact with both surfaces at all times, and ready to wedge on the slightest reverse occurring.



Answer.—You will find full details of a large clutch of this kind, as used in the Otto and Langen gas engines, in Clerk's work, "The Gas Engine," p. 140. —ED.

67. TRAVELLING CRANE.—In a travelling crane of 40ft. span, the load is supported on a carriage which runs on two similar girders, the axles of the carriage being 8ft. apart, and a load of 23 tons coming on each wheel. Obtain a diagram to show the maximum bending moment at every section of girder, and give numerical values at 10ft., 15ft., and 20ft. from one end.—J. C. W.

Answer.—The finding of the bending moment in a beam by the graphic method is very simple. In a crane beam of 40ft. span, loaded by two wheels at 8ft. centres with a load of 23 tons each, the following would be the method pursued: To make the present problem illustrative (see fig. 1), the pole *o* is purposely taken out of the horizontal line. To proceed, then draw the line *ab* between perpendiculars 40ft. apart. On the perpendicular *ac*, set off the load of 23 tons each. A convenient scale is one half that for the loading, $\frac{1}{16}$in. = 1 ton. Anywhere convenient, take a pole *o*; let it be taken a distance from *ac* = 20 to the scale of the beam span. Next join the divisions on the load line to the pole *o*, drawing *ao*, *co*, D*o*. Then from the point *a* at one end of the span draw *ax* parallel to *ao*. In the present case it coincides with *ao* simply because the load diagram has been taken for convenience, starting from *a*. The line *ax* will cut the perpendicular drawn through the first load of 23 tons at a point *e*. From this point *e* draw *ef* parallel to D*o*, and cutting the perpendicular through the second load of 23 tons at *f*. Through *f* draw parallel to *co* the line *fg* to the vertical through the span end *b*. In the present case *fg* is simply a continuation of *co*. Join *ag*. We now have a diagram of bending moments *a g f c a* from which we can measure. The bending moment at any point in the span is the depth of this figure, measured on the load scale, multiplied by the pole distance OY = 20. The greatest depth is 18½, and 18½ × 20 = 370 tons moment at the point of the beam under the loads. The greatest bending moment in a beam occurs under a loaded point. In the position of our two equal loads, placed at equal distances on either side of the mid span, it is clear that the greatest moment coming under a loaded point must come under each load, and our diagram shows that from our loaded point to another the vertical intercepts between the closing line *ag* and the moment polygon *a e f g* an equal from *e* to *f*, and then of course decrease to the point of support. Theoretically, then, the lower flange of the beam should be horizontal for 4ft. on either side its centre, and of uniform section. With equal loads it is clear that the two loads can be moved anywhere without increase of the central bending moment so long as they are on opposite sides of the mid span. The limiting position is when one load stands over the mid span, for it is in that position that the bending moments for all other sections of the beam will be maximum (for that half of the beam in which both loads are) for the load position which gives maximum bending. We will, therefore, place our load central, and, proceeding as before, obtain the dotted diagram of moments, which measures 18¼ tons under the middle load, giving a moment of 367 tons, a more accurate result than we got before; of course, the two results should have been equal, and would have been with a correct drawing. As stated, the maximum bending moment for any section occurs with a load at that section, and the other load between the section and the farthest abutment. Hence, for 15ft. and 10ft. from the abutment the bending moment comes out as 18 × 20 = 360, and 15 × 20 = 300 tons. Arithmetically calculated, the results are 362¼ and 299, proving the substantial accuracy of the rough sketch. The diagrams for 15ft. and 10ft. are each dotted in a different style of dot for clearness; the depth of each diagram being indicated by the arrow heads. Those unaccustomed to such diagrams may redraw them separately or trace them off. The meeting of the lines from the abutments show the centre of gravity *cg* of each pair of loads, whilst the proportion of total load in the two abutments is shown by the ratio into which the load line *ac* is divided by lines drawn from the pole *o*, parallel to the various closing lines *ag*, *am*, *an*, *ah* of the different moment polygons. To make a diagram such that the bending moment at any part of the span may be found for any position of a system of loads, trace from fig. 1 the lines *ab*, *ax* (fig. 2), and some one of the load polygons, say, for example, *a*, *n*, *p*, *o*, *a*, and lay this tracing upon fig. 1 so that the points *a* coincide with the lines *ax*. Then, for any position of the loads on the beam, move the tracing, keeping the traced line *ax* upon *ax*, or *ax* produced, until the verticals through the loads also come together. Then from that point where the polygon is cut by the abutment vertical *bk* draw a line to the point *a*, in fig. 1. This line will be the closing line of the polygon of moments for the load position chosen. By this means any load diagram may be used in the tracing, and moved about until a position of maximum moment be found. Perhaps it may be simpler to move the tracing horizontally, preserving a coincidence of the lines *ab*; and joining the points on the abutment verticals which are intersected by the polygon, on its last side produced, for the position of the load chosen. This line forms the closing line of the moment polygon for that position. These two simple plans serve to examine the actions of a series of loaded wheels coming upon and leaving a girder. The apparent complexity of the diagrams is only so because of the superposition of several. In practice, to a reasonably large scale, the process is most simple. If desired to obtain moment polygons in which the closing line is horizontal, the pole point *o* of the load diagram may now be placed on a horizontal from the points *d*, *m*, *n*, or *h*, and the polygons reconstructed with new inclinations of the lines *ao*, *co*. The closing lines *ag*, &c., will then come out horizontal, according as the pole *o* is horizontally placed as regards *g*, &c. There is no practical utility in this, for the vertical depths of the polygon to the closing line remain unaltered.—W. H. B.

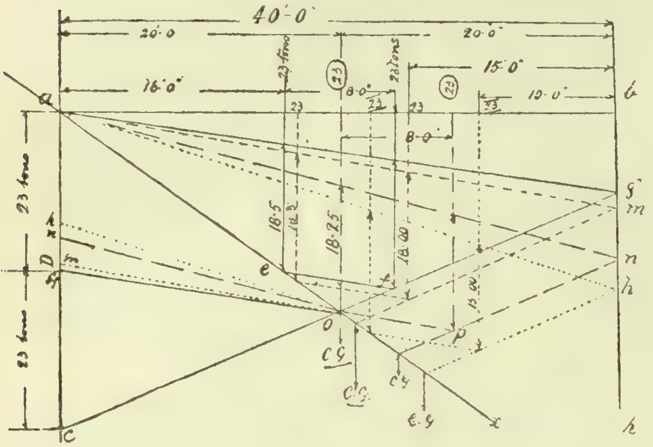


FIG. 1.

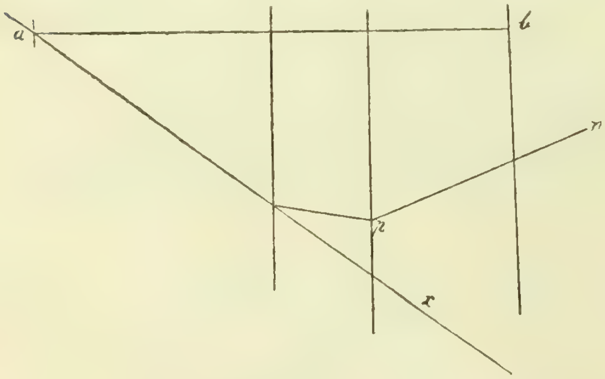


FIG. 2.

68. CHANGE WHEELS FOR SCREW-CUTTING LATHE.—Could any of your readers kindly inform me, through your paper, the rule for finding the wheels for screw-cutting in the Buckton lathe, leading screw two threads per inch?—ROPPET.

Answer.—"Roppet" will find the general rule applies to all lathes, and the following method of obtaining the proper wheels for screw-cutting will be one easy to remember, viz.:—

$$\frac{\text{Pitch of screw to be cut}}{\text{Pitch of leading screw}} = \text{ratio of gearing.}$$

Taking a numerical example, heading screw having two threads per inch, and it is required to cut a screw having eight threads per inch. Pitch of leading screw = ½in.; pitch of screw to be cut = ⅛in.

$$\therefore \tfrac{1}{8} \div \tfrac{1}{2} = \tfrac{1}{8} \times \tfrac{2}{1} = \tfrac{1}{4} = 4 \text{ l. s. to } 1 \text{ m.} = \text{ratio of gearing to be used.}$$

Now, if we place a pinion of 20 teeth on the mandrel, we shall require a wheel having 20 × 4 = 80 teeth on the leading screw.

Take another example, with a leading screw having three threads per inch, and the screw to be cut to have a pitch of 2½in. Here—

$$2\tfrac{1}{2} \div \tfrac{1}{3} = \frac{5}{2} \times \frac{3}{1} = \frac{15}{2} = \text{ratio of gearing.}$$

In this case we have to resort to what is called compound gearing, as no two in an ordinary set of lathe wheels could be found giving the required ratio. Now—

$$\frac{15}{2} = \frac{150 = \text{m. wheel or driver}}{20 = \text{screw pinion or driven}}.$$

We must now introduce another pair of wheels, still retaining the ratio $\frac{15}{2}$. If we were to place on the stud two wheels, each of 100 teeth, driver and driven, the ratio would remain unaltered, and stand—

$$\frac{150 \text{ m.}}{20 \text{ l. s.}} \cdot \frac{100 \text{ driver}}{100 \text{ driven}}.$$

If we adopt the expedient of altering the numerator of one fraction, and the denominator of the other, we shall obtain numbers that will agree with the teeth in the set of wheels usually supplied. Thus—

$$\frac{150}{20} \cdot \frac{100}{100} = \frac{70}{20} \cdot \frac{100}{50} = \text{ratio as before.}$$

I would recommend "Roppet" to try and obtain a copy of a very useful little book, entitled "Turners' and Fitters' Handbook," by Thomas Greenwood, where the above and other kindred subjects are very fully treated. Price (I think) 1s. 6d.—J. R.

69.—HOLDEN AND BROOKE'S EXHAUST STEAM INJECTOR.—Will some reader kindly explain the action of the above exhaust steam injector?—T. W.

Answer.—The explanation of the action of the exhaust steam injector will best be effected by supposing an actual case, which I will put before "T. W." as follows: We require to feed a boiler working at 60lb. per square inch, the temperature of the feed-water supply being 60 deg., and to do which we have a supply of steam from the exhaust pipe of the engine, the end of which is freely open to the atmosphere, so that the steam may be assumed to be of the same pressure or 0lb. by the gauge, and the temperature of which will be 212 deg. Fah.

Now, the formula for the velocity with which saturated steam flows into steam of inferior pressure, which in our case is a partial vacuum, as deduced from experiment, is—

$$V = 96\sqrt{\frac{P - p}{W}},$$

in which V = the velocity of flow in feet per second.
P and p = the pressures of the steam respectively.
W = the weight of a cubic foot of the denser steam in pounds;

and by practice, we know that water can be fed into a boiler at 190 deg. Fah.; so that taking this as our feed temperature, we have first steam at 212 deg., which has a pressure of 14·7lb. per square inch, flowing into the combining nozzle of the injector at a temperature of 190 deg., equivalent to 9·5lb. per square inch, and the weight of a cubic foot of steam at atmospheric pressure = ·036, so that in our case—

$$V = 96\sqrt{\frac{14{\cdot}7 - 9{\cdot}5}{{\cdot}036}} = 1152\text{ft. per second.}$$

This steam is condensed by contact with the feed water in the combining nozzle; but although it is by this means reduced to very small bulk, it still retains its great velocity, nearly 800 miles per hour; and by its losing 22 deg. in temperature (viz., 212° – 190°) it has acquired the energy of motion which is utilised to perform work. It is found by experiment that of the water entering a boiler, one-eighth, when forced in by the exhaust injector, consists of the condensed steam, the other seven-eighths being water. Accepting this fact, we should expect the combined jets to have one-eighth the velocity of the steam, or $\frac{1152}{8}$ = 144ft. per second, to overcome the outflow from the boiler, which would issue, if not prevented, with a velocity given by the hydraulic formula—

$$V = 12{\cdot}19\sqrt{P};$$

in which V = the velocity of flow in feet per second;
P = the pressure in pounds per square inch within the vessel from which the water flows;

and as our boiler is to be worked at 60lb. pressure by the gauge, the total difference of pressure between the boiler and the containing cone of the injector will be

$$= 60 + (14{\cdot}7 - 9{\cdot}5) = 65{\cdot}2,$$

which will be the value of P in the above formula for the case under discussion, so that the velocity—

$$V = 12\ 19 \sqrt{65{\cdot}2} = 98{\cdot}4\text{ft. per second;}$$

to overcome which we have a jet entering at a velocity of 144ft. per second, or allowing 25 per cent for losses due to friction, &c., in the nozzle, we shall still have a balance of 9·6ft. per second in favour of the injector, which will feed our boiler under the conditions laid down with ease.—INJECTOR.

70. TWIN SCREWS.—Will some reader kindly inform me of the advantages of twin screws? What are the advantages over one screw in speed and economy, and when were they first used?—MARINE.

Answer.—"Marine" asks a question which must of necessity produce a diversity of opinion. The advantages justly claimed for the twin-screw system over the single are, first, a ready means of steering in the event of the loss or disablement of the rudder. Second, should one engine become disabled, the progress of the vessel is still assured. Third, for light draughts and equal power the twin screws have no rival. On the point of economy, I think no one now claims it for the twin system, although at one time it was strongly asserted to be the most economical of the two modes of propulsion. Nearly all war vessels are now fitted with twin screws, which should be considered conclusive evidence of their great value.—J. R.

50. SMALL AIR PUMP.—I wish to make a small air pump, double-acting, of 3in. diameter and 3in. stroke. How should I place the inlet and outlet valves so as to allow air from each end of the pump to escape into one outlet pipe? What type and dimensions of valves should be used?—APPRENTICE.

Answer.—An air compressing pump of 3in. diameter and 3in. stroke of the horizontal kind should have two ½in. inlet and two ½in. outlet valves of the common clack kind, kept as near the cylinder as possible, to reduce the clearance to the lowest point. If the inlet valves are placed below and the outlet above the cylinder, a wrought-iron pipe can easily be made to connect the two discharge valve casings, which should be bolted to the cylinder, and have screwed caps above the valves, to get at them for inspection. The pump is a very small one, but we have frequently used smaller for exhausting purposes only.—D. C.

---

53. DASH POTS.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made and what is the approximate cost?—CRANK PIN.

63. SCREWING MACHINE DIES.—Can any reader inform me of the best way of advancing and withdrawing dies in a screwing machine, with three die bits? The machine I have at present has four dies and cuts badly besides making an unequal thread.—D. W.

71. HARDENING STEEL SPRINGS.—Will any of your readers kindly inform me, through your paper, the best way to harden steel wire springs?—SPIRAL.

72. BOOK ON BOILERS AND TEMPLATES.—Can any of your readers inform me where I can get the best book on boiler-making and templates?—BOILER.

73. PROCESS FOR COOLING WATER AT COATES' MILL.—I shall be obliged for any particulars of the process for cooling water to be employed at Messrs. Coates' new mill, at Paisley.—LEVER.

74. FLATTENING SAWS AND PLATES.—Will some reader kindly inform me how to hammer buckles out of saws 4ft. 6in. diameter? Also if the same method does for square plates?—BLACKSMITH.

75. BOOK ON SCREW-CUTTING AND GAUGING.—Could any of your readers inform me what is the best book to be had on screw-cutting; also one which deals with the proper travel of a gauge or inside callipers in fitting one body into another?—D. H. D.

76. PUMPS.—What is the most economical pump to use for filling a tank about 30ft. high, and containing about 9,500 gallons of water: to be filled in about eight hours? How would the Pulsometer do?—A. J. E.

77. AIR PIPE IN LOCOMOTIVE FUNNEL.—What effect would an elbow-shaped pipe have which was opened to the atmosphere, in front of a locomotive, at one end, and projected up the funnel at the other?—X. Y. Z.

78. SHEARING STRESS AND STRUTS.—What is the proper allowance for shearing stress per square inch in the web of a plate girder of wrought iron, in proportion to its depth? I believe it is usual to allow a higher factor of safety as the depth of the girder increases. Also, in reference to the subject to struts, I should like to know something about the following: Assuming a wrought-iron rolled joist to act as a strut, would a strut composed of two tee bars, having together a section equal to the joist, and fixed edge to edge, have an equal strength with the joist?—TYRO.

TO CORRESPONDENTS.

A. S. JOHNSTONE.—You can get full information regarding the journal—*Indian Engineering*—by writing to T. Cole, Esq., C.E., 6, Westminster Chambers, London, S.W.

COOT.—The process you mention is that commonly used in the manufacture of metallic cartridge cases, and also for other metallic shells, and is public property. If there is any patent in the process, it must be in some detail only, and, providing that you do not use that detail, you are perfectly free to adopt the general method.

MISCELLANEA.

LOOKING INSIDE BOILERS WHILE UNDER STEAM.—It is reported that a German scientist, Mr. E. Blass, has devised an incandescent lamp arrangement, by which the interior of a boiler may be inspected while it is under steam. A think black tube is inserted through a stuffing box, through which a small incandescent lamp is introduced, which is connected with a battery. By means of a thick glass plate, located in the shell of a boiler at a convenient place, the illuminated interior of the boiler may be inspected. While this appears at first sight but a scientific experiment, brought into practical shape it might prove a valuable aid in investigating the conditions prevailing in a boiler at work, and thereby be the means of providing remedies for many of the existing uncertainties in boiler manipulation.

THE LIVERPOOL OVERHEAD RAILWAY.—We understand that the contract for the Liverpool Overhead Railway has been awarded to Mr. J. W. Willans, of London, Liverpool, and Manchester, and that Messrs. Dorman, Lang, and Co., of the Britannia and West Marsh Ironworks, will supply a large proportion of the structural ironwork. This important undertaking is the first of the kind in England, though the type of railway is well known across the Atlantic. The total length of the railway is six miles, and the line runs parallel to the whole length of the docks. The structure is composed of iron girders, having a water-tight flooring (Hobson's patent) for the whole length, and is carried on strong wrought-iron pillars. It is intended that the trains shall be worked electrically. The engineers are Sir Douglas Fox and Mr. J. H. Greathead.

THE COAL SUPPLY OF POLAND.—The production of mineral coal is the only one which has developed and made real progress in the last few years, the network of railways having been completed in such a way that the greater part of the collieries are connected with almost all the factories in the country. The use of mineral coal has become general, and its consumption increases yearly. All the known coal mines are in the Dombrowa hollow, near the Prussian-Silesian frontier. They number 28, employ 9,572 workmen, 7,824 horse power, and yield annually nearly 1,902,305 tons of coal. Surveys made in the mines belonging to the Franco-Italian Company have shown the average thickness of the beds to be from 49ft. 2in. to 57ft. 6in., giving a quantity of 56,426,000 tons. It may, therefore, be estimated that with proper working, the beds already worked may feed all the industries of the country, and supply all their requirements for hundreds of years to come.

THE LARGEST GIRDERS IN THE WORLD.—In the addition to the American Museum of Natural History will be the largest riveted box girders ever used in the construction of a building. These girders were designed to support the floors and partitions and obviate the use of pillars, the object being to give unobstructed floor room. An American paper says there are 28 of these girders, measuring about 62ft. in length, and weighing 40,000lb. each. They were recently landed in the neighbourhood of Fiftieth Street, and the possibilities of modern trucking have been taxed to transport them to their destination at Manhattan Square. The longest and strongest trucks to be found were brought into requisition, and with twelve horses harnessed to each truck the attempt began. Two collapsed, while a third, which was fortunate enough to reach the square without mishap, buried its wheels to their hubs, and stuck fast as soon as it left the pavement. The contractors have found it necessary to construct a tramway across the square from Ninth Avenue to the building for the transportation of the girders.

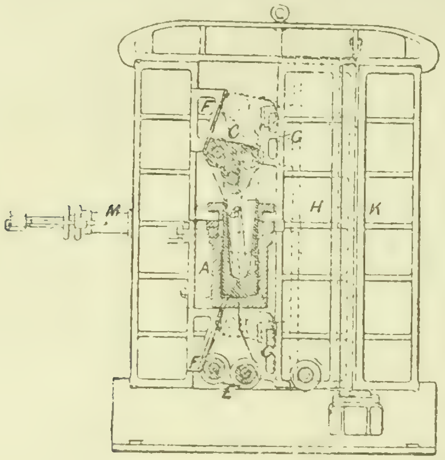
A MOUNTAIN ELECTRIC RAILWAY.—One of the most interesting achievements in modern engineering is the electric mountain railway recently opened to the public at the Burgenstock, near Lucerne. The rails describe one grand curve formed upon an angle of 112 deg., and the system is such that the journey is made as steadily and smoothly as upon any of the straight funicular lines. The Burgenstock is almost perpendicular; from the shore of Lake Lucerne it is 1,330ft., and is 2,800ft. above the level of the sea. The total length of the line is 938 metres, and it commences with a gradient of 32 per cent, which is increased to 58 per cent after the first 400 metres, this being maintained for the rest of the journey. A single pair of rails is used throughout, and the motive power, electricity, is generated by two dynamos, each of 25 horse power, which are worked by a waterwheel of nominally 125 horse power, erected upon the river Aar, at its mouth at Buochs, three miles away, the electric current being conducted by means of insulated copper wires. The loss in transmission is estimated at 25 per cent.

The Tyrone cantilever bridge, on the Louisville Southern Railroad, crosses the Kentucky river, near Tyrone, and is now being erected. The central span is 551ft. between pier centres, and the two shore arms are 267½ft. long each. The trestle approaches are 420 and 240ft. long respectively. The entire structure is built of steel. The two towers are each 137ft. high and rest on eight wrought-iron cylinders sunk to bed-rock. Each cylinder is 12ft. in diameter and is lined with a 13in. brick ring laid in Portland cement and the interior filled with concrete. These cylinders extend 4ft. above high water and are capped with 24in. hard limestone. From the bed of the river to the rail the height is 268ft. Work was commenced in April last, and the cylinder, foundations, masonry, west approach and west pier are now finished, and the whole bridge is to be completed by August 15. Colonel John Macleod, M.Am.Soc.C.E., is the chief engineer, and M. W. Venables, C.E., engineer in charge. The Union Bridge Company has the contract for the superstructure, and H. S. Hopkins and Co. put in the foundations. This span exceeds by one foot the longest heretofore existing American span other than wire suspension.

ILLUSTRATED PATENTS.

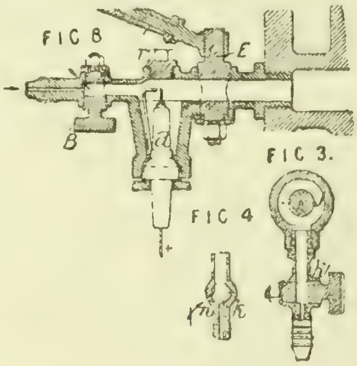
2783. Hydraulic Presses, R. H. Tweddell, 14, Delahay Street, Westminster, and J. Platt and J. Fielding, Atlas Ironworks, Gloucester.

Relates chiefly to that class of presses employed for bending, cutting, and punching metal plates, and has for its object to obtain an equable movement of a long follower, To effect this the hydraulic cylinder A is arranged with its axis at right angles to the direction of motion of the follower H, this motion being effected by providing the plunger B with two or more crossheads, C, E carrying rollers, which bear against inclines arranged to distribute the strain over the length of the follower H. The inclines may be curved so as to vary the force applied to the follower at different parts of the stroke of the plunger. In the press shown in the drawing, which is arranged for bending metal plates between the follower H and framing K, the rollers are shown as bearing against inclines F on the framing and straight portions G on the follower, but the position of F and G can be interchanged, and G can be made inclined. When the press is arranged with the cylinder A, vertical as shown, an auxiliary cylinder M serves to draw back the follower H at the end of the stroke, but the cylinder may be arranged horizontally so that the follower falls by its own weight. The machine may be provided with shear blades, punches, or dies for operating upon metal plates.—February 24, 1888. [8½d.]



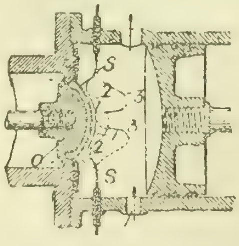
2805. Gas Engines, J. Y. Johnson, 47, Lincoln's Inn Fields, London. *(E. D. Deboutteville and L. P.C. Malandin, Fontaine le Bourg, France.*

Starting.—The cylinder is charged through a special cock by turning the flywheel by hand, and the charge is ignited by electricity. The cock *k*, fig. 3, is in communication with the space behind the gas valve through an indiarubber tube. By turning the flywheel gas and air are drawn through the cock *k*, the air through *n*, fig. 4, into the cylinder through the igniting chamber J. The cock *k* is closed and the charge then slightly compressed in the cylinder by turning the flywheel in the reverse direction; it is then ignited by a spark produced by completing the primary circuit of an induction coil. When a flame or other non-electric igniter is used, the arrangement in fig. 8 may be used; the starting supply cock B and the igniter *d* being cut off from the cylinder by the cock E after starting. Access may be obtained to the igniting terminals by means of the plug *r*. February 24, 1888. [8½d.]



2913. Gas Engines, W. von Oechelhaeuser, Dessau, Germany.

Cycle.—The gas or other combustible is rapidly injected into the air charge in the cylinder, and ignited by a continuous igniter therein, the combustible part of the charge being of such a nature that it will not ignite without the admixture of air. Several means of carrying out the invention are shown. In the figure the combustible charge is admitted through the valves *o*, which is protected by the perforated plate S, clearance between the valve and plate being provided against. The plate may be hemispherical, flat, or may take the form of a perforated tube projecting into the cylinder.



Igniting.—Different arrangements of incandescent igniting wires are indicated at 1, 2, 3. A continuous spark may be employed for igniting. February 28, 1888. [8½d.]

Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

July 9th.

10995 Condensing Steam, E. F. Piers, Manchester.
11005 Steam Hammers, W. M. Wilson, Manchester.
11010 Twisting and Doubling Yarns, J. Robertshaw, J. H. Stott, and W. H. Ingham, Halifax.
11012 Brakes, F. Lansberg, Glasgow.*
11015 Finishing Machines, W. Oliver, Fleetwood.
11018 Electric Railways, D. G. Weems, London.*
11019 Electric Railways, D. G. Weems, London.*
11021 Smelting Ores, P. H. Adams, jun., and O. T. X. Adams, London.*
11024 Exhaust Steam, R. Holt, Rochdale.
11027 Vices, C. A. Chandler, London.*
11028 Spring Balances, E. F. Bergman and C. R. Slack, London.*
11032 Electric Meters, J. Oulton and J. Edmondson, Bradford, Yorkshire.
11033 Hose Pipes, R. Hope, Dalkeith.
11035 Boiler Tubes, T. Lambert, Plymouth, Devonshire.
11038 Gas Engines, C. White and A. R. Middleton, London.
11039 Looms, W. Taylor, Halifax.*
11044 Batteries, W. P. Thompson, Manchester. (P. H. Alexander, United States.)*
11046 Cores, W. P. Thompson, Liverpool. (The Westinghouse Electric Company, United States.)
11049 Dynamo-electric Machines, J. J. Wood, London.
11050 Guns, P. Giffard, London.
11055 Alloys, H. S. Holt, London. (J. Clegg, United States.)
11056 Metal Tubes, A. S, Elmore, Rothwell, Leeds.
11058 Furnaces, E. J. Francis and C. Banfield, London.
11066 Metal Tubing, G. J. Stevens, London.
11067 Insulation, C. T. Snedekor, London.*
11075 Dynamo-electric Machines, S. C. C. Currie, London.*
11081 Exhaust Apparatus, J. Y. Smith, London.*
11082 Flashing Lamps, C. H. Gardner, F. L. Rawson, and W. S. Rawson, London.

July 10th.

11106 Boats, J. S. Baker, London.*
11108 Aerial Carriages, G. Robinson, Chatham.
11121 Artificial Fuel, S. A. Mackie, London.
11123 Wrenches, V. J. McDonnell, London.*
11125 Retorts, F. Sanders, London.
11138 Dressing Skins, J. Hall, London.

July 11th.

11144 Ventilators, H. T. Johnson and T. S. Wilson, Manchester.
11157 Consuming Smoke, H. Lister, Huddersfield.
11163 Roller Mills, A. H. Wallis, Basingstoke.
11178 Check-valve Socket, E. Martin and T. Ricketts, London.
11179 Electric Meter, Siemens Brothers and Co. Limited, London. (Siemens and Halske, Germany.)
11192 Ingot Cranes, W. Shapton, London.

July 12th.

11199 Flying Engine, J. K. Smythies, Essex.
11203 Placing Belts on to Pulleys, G. H. Hughes, Manchester.*
11206 Safety Lamps, J. Rayner, Wakefield.
11208 Gas-motor Engines, J. Fielding, Gloucester.
11220 Dredger Buckets, E. Y. Harrison, London.
11221 Brick Presses, R. W. Davies, London.*
11234 Metallic Packing, F, H. Trevithick, London.
11241 Wheels, E. Hammesfahr, London.

July 13th.

11243 Propelling Ships, J. F. Buston, London.
11248 Steam Boilers, J. G. Williams, Liverpool.
11250 Indicator, K. Leverkus, Manchester.
11254 Packing, J. Fursland, Swansea.
11255 Balance, S. W. Suffield, Birmingham.
11269 Electric Meters, G. A. Nussbaum, London.
11284 Valve, O. Rose, London.*
11289 Valve, M. McLellan, Glasgow.
11293 Gas and Steam Engine, A. B. Drautz, London.

July 15th.

11302 Packing Rings, T. Carr, Barnsley.
11306 Indicator, C. H. Cobbold and W. Wood, Rose Hill, Dodworth.
11307 Fire Alarm, A. W. Hidden, Galata, Constantinople.*
11309 Stop Valves, R. Hope, Dalkeith.
11311 Signalling, A. Appleby, Birmingham.
11315 Arc Lamp, A. W. Richardson, Manchester.
11316 Marine Telegraph, S. J. Browning, Portsmouth, and B. Nicholson Gosport, Hampshire.
11317 Gas Engines, H. Whiteside-Cook, Essex.
11319 Tram Car Starting Gear, A. Duke, Dublin.
11323 Hoist, R. Chew and H. Barmby, Preston.
11329 Lubricator, J. Wildemann, jun., London.
11333 Propelling Vessels, P. A. M. Brunel, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

CHEAP PREPAID RATES FOR ADVERTISEMENTS OF

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THE

PRACTICAL ENGINEER,

AUGUST 9TH, 1889.

FIRELESS LOCOMOTIVES.

THE problem of constructing locomotive engines suitable for use upon tramway lines in the crowded streets of our cities is by no means an easy one, and it has led to many attempts among engineers. The conditions are very complex and the difficulties serious, necessitating the utmost mechanical ingenuity and constructive skill in order to arrive at a compromise which shall be workable with anything like satisfaction to the general public and the authorities. The present tramway engines, as used upon the lines of most of our large towns, are admirable examples of what can be done in the way of combining conflicting conditions, and in locomotives using fuel and furnaces it is difficult to conceive of mechanical combinations much more perfect than they present.

They still cause, however, great inconveniences, and although in great part the visible emission of steam is suppressed, yet the invisible fumes from the coke fires used are uncomfortably evident to those who travel in the cars. The sulphurous atmosphere they produce is most distressing, and also deleterious to those obliged to inhale it.

Many attempts have been made to supply motive power in such form that fires can be dispensed with on the engine, and a class of engines has arisen known as fireless locomotives. Strictly speaking, compressed air and electric locomotives should be included, but generally, when fireless locomotives are referred to, we do not think of such engines, but only of those in which steam is still used, but some contrivance adopted whereby the fire is dispensed with on the engine itself, and transferred to some convenient stationary position.

The simplest form of this type of engine is that in which highly heated water is forced from a stationary boiler into a reservoir upon the locomotive of considerable dimensions, carefully protected against loss of heat by radiation and conduction, and the steam from the hot water is used to drive the ordinary engines until its pressure is reduced to a considerable extent. The difficulty with this type of engine consists in the necessity for very great water capacity and high pressures when charging, as otherwise the steam supply would be insufficient to insure a reasonable length of run. The latent heat of steam is so great that, even with comparatively great weights of water carried, but a small fraction is available as steam to supply the engine.

The heat taken away from the hot water is so considerable that the temperature of the whole mass is very speedily reduced, and the steam pressure accordingly falls off with comparative rapidity. Taking water, for example, heated high enough to give an available pressure of 200lb. per square inch (absolute), the temperature is about 407 deg. Fah., and the amount of heat required for one pound of steam is about five times that needed to raise one pound of water from the freezing to the boiling point; consequently one pound weight of steam taken away necessarily reduces the temperature of about 900lb. weight of water by one degree. That is, one ton weight of water would only supply about 2·5lb. of steam, with a reduction of 1 deg. Fah.; and assuming the steam pressure to be utilised by the engine until it fell to 30lb. per square inch (absolute), or only a little over 15lb. per square inch available, then the temperature would have fallen to 250 deg. Fah., or through 157 deg. This gives for one ton weight of highly heated water a supply of 392lb. of steam, varying in pressure from 200lb. per square inch to 30lb. per square inch, both pressures absolute.

Now, assuming the locomotive to develop 10 indicated horse power, and to consume 35lb. of water per hour horse power, a moderate estimate under such conditions of working, then our assumed ton weight of water gives steam for a little more than one hour's work. Taking practical losses into account, much more water would be required, as there must be considerable losses by radiation and conduction, and accordingly it is found in practice that such fireless locomotives require to carry considerable weights of water, and need frequent re-charging. Notwithstanding those difficulties, the Lamm and Francq system, in which this method is used, has been used in France for the past nine years by the Compagnie des Tramways du Department du Nord, and is also adopted by a tramway company in Lyons, in both of which services it is stated to give satisfaction. The engine weighs in all about sixteen tons, but is intended to haul four carriages about the same size as those common on our own steam tram lines.

The bulk and weight are greatly in excess of that required with the ordinary steam tramway engine, and several methods have been proposed to get a greater amount of energy stored up in a smaller bulk. The Honigmann caustic soda engine is one of these, and in it advantage is taken of the fact that caustic soda, when dissolved in water, possesses a very high boiling point, the higher the more concentrated is the solution. Moreover, its chemical affinity for water is so great, that steam passed over solid caustic soda is readily liquefied, and continues to be liquefied by the solution formed so long as the concentration is such that its boiling point is higher than the temperature of the steam to be condensed.

Accordingly, if an ordinary hot-water engine has its receiver jacketed and its jacket space fitted with solid soda or a strong solution of it, and if then the exhaust steam from the engine be turned into the jacket space, it is at once condensed by the soda solution and a comparatively high temperature is produced. This heat serves to boil the water within, and produce the condensation of the exhaust steam. In this way the steam pressure is kept up much longer than when the heat of the water only is drawn upon to supply the heat of evaporation, but it is supplied not really by the latent heat of the exhaust steam, but by the chemical action of the caustic soda upon water. So long as this action is not weakened too much by the dilution of the solution it remains efficient, but immediately the solution becomes too weak the steam ceases to be condensed, heat ceases to be evolved, and the exhaust must be dealt with in the usual manner.

This system has the advantage of giving a greater power for a certain weight of water, and the jacket serves at the same time as a condenser, so that so long as it lasts other action is not required. The disadvantage, however, is very obvious. The soda solution, when too dilute, requires to be boiled down, and this is done at stationary boilers in fixed positions, so that the heat given out on the locomotive is only obtained at the expense of a very considerable consumption of fuel at the fixed evaporating station. In addition to this, there are rather formidable detail troubles arising from the great affinity of caustic soda for the carbonic acid of the atmosphere, and resulting in time in the complete conversion of the caustic soda into the carbonate of soda, or the ordinary washing soda of commerce. When this occurs it is useless for steam raising and condensing, as its affinity for water is very weak comparatively, and although soda crystals raise the boiling point of a water solution considerably, yet they do not influence it to a sufficient extent to be valuable for motive power purposes. In addition to this trouble, which necessitates considerable expense in renewal or treatment of the soda, there is, unfortunately, a chemical action upon iron by all caustic solutions.

It is very usual to consider that iron is not attacked by alkalies, but is rather protected by them from oxidation, and this is no doubt true for dilute solutions at low temperatures. With strong soda solutions, however, at high temperatures, iron is very liable to attack with the evolution of hydrogen and the formation of a ferrate, or a body of that nature. This is especially the case when a difference in the nature of the plates adjoining each other causes an electrical action, when a very speedy deterioration is produced. Difficulties so troublesome have hitherto prevented the development of this system, ingenious and convenient as it is in many ways. Something yet remains to be done before we can say that we have succeeded in producing a tram locomotive in every way adapted to its work, and of such nature that it works without annoyance to passengers and the public.

Many attempts have been made to apply gas or petroleum as motive power in cars, in the form of explosion engines, but although several have been run experimentally, and one has been at work in Australia for a time in public use, yet the power is not yet sufficiently within control to warrant its adoption. Such engines, although really fireless in the ordinary sense of the term, have not been usually included under this heading. A mode of using gas or petroleum has been patented recently which seems to offer some escape from the difficulties, but we fear that it is not yet sufficiently developed. In it the gas or petroleum engine is used to compress air into a small receiver, where it is kept at a constant pressure by automatic arrangements. From this receiver cylinders of ordinary construction are supplied, so that the engines may be reversed and handled by regulator and link as usual, without disturbing the gas engine, which continues to move at a uniform rate in one direction.

On the whole the present steam tram engines seem best adapted for our local traffic, but if some substance as effective as caustic soda, without its property of attacking iron or absorbing carbonic acid, be discovered, such an engine would possibly prove a formidable rival. The absence of fumes from combustion is a great recommendation, and to those of us who have had occasion to use the Metropolitan Company's underground railway in London the freedom from suffocating gases would be a most inestimable boon. The loss of health and life by the constant daily breathing of a mixture of carbonic oxide and sulphurous oxide with one's air supply must be quite appreciable in a city like London, and on lines with so great a daily traffic.

THE BIRMINGHAM ELECTRICAL EXHIBITION.

This Exhibition, to which we have referred on more than one occasion, was opened in the Bingley Hall, Birmingham, on Thursday, August 1st, by Lady and Lord Randolph Churchill. We visited it for a brief survey on Saturday last, and found, as we expected, that a good deal still remains to be done before it can be said to be really completed. It is very evident, however, that the promoters have spared no expense or thought to make it attractive and complete. The Bingley Hall has been transformed in a marvellous way, considering the short time it has been in the hands of the committee, and it presents a bright and attractive appearance. The musical and amusement element, now considered indispensable for all exhibitions—Invention, Fisheries, or Electrical—is amply provided for, and the bright red coats of the band enliven the stand erected above an artificial fernery and fountains. Among the numerous attractions we may mention the Telpher line, conveying passengers round the Winter Gardens, which, by the way, is nicely got up, and a model coalmine, excavated under the hall, where the visitor may form some idea of the appearance of a pit without the slightest risk.

The electrical exhibits were not quite completed when we saw them, but many good firms are represented and are busy with their preparations. The electric lighting engines and dynamos are not yet all of them at work, but will be, no doubt, by the time this is published. Messrs. Galloway supply the steam boilers, and among others, Messrs. Ruston Proctor and Co., Messrs. Robey, and Messrs. Greenwood and

Batley supply engines to drive the dynamos. The latter firm have one of their Armington-Sims American engines in action. It will be remembered that the principal peculiarity of this engine is the piston valve, controlled by a heavy-weight governor acting within the driving pulley, and varying the cut-off and stroke of the valve by a double eccentric, which increases the compression and shortens the stroke of the valve simultaneously. The Thomson-Houston system of electric welding is shown, and should prove most attractive. The Acme Electric Co., Lawrence, Paris, and Scott, Woodhouse and Rawson, the Edison and Swan Co., are all here, but the electrical element is not so considerable as we expected to find. A good number of gas engines are shown, of which, as well as the steam engines, we shall have more to say when all is smoothly at work. At present it would be hardly fair to criticise too much. We may mention, however, that Messrs. W. T. Avery exhibit a fine example of Snelgrove's electrical weighing machine, and that the Otto gas engine is, as usual, well represented.

THE EXPANSION OF STEAM.

A LOCAL mechanical contemporary, in a recent leading article on the expansion of steam, surely errs in supposing engineers to stand in need of the class of information there given. We had always supposed, until we read the article in question, that any lad engaged in a drawing office upon the important, but juvenile, occupations of mixing ink and tracing was fully aware of the difference between pressure above atmosphere and absolute pressure. The distinction is so elementary and evident, that surely a very little thought on the part of the tyro will imprint it upon his mind once and for ever, and it is really too much to ask us to believe that "some of the highest authorities upon the subject of steam engineering have sometimes committed blunders in dealing with the question."

We shall be much interested to know the names of these "authorities," and their conclusions will be well worthy of careful criticism, if it is found that they are really capable of such gratuitous carelessness.

We would also call attention to a common practice in some journals, when dealing with steam, of always assuming isothermal expansion, as is done in the case we mention. Such expansion never occurs in practice, and it is only under some circumstances that the combination of causes produces even the appearance following such a line.

AN IMPORTANT TRADE MARK DECISION.

TRADE marks, although not so commonly used among engineers as in other industries, such as the chemical and textile, are yet of increasing importance, and accordingly we think that it may interest our readers to detail the result of an appeal in the case of a trade mark in which the words "Fruit Salt" occurred. It appeared that Mr. Eno registered the words as an old trade mark under two classes, one as a dry preparation for making an effervescing beverage, and the other as an old trade mark for proprietary medicine for human use. He extensively advertised the expression, and in the public mind no doubt the words "fruit salt" invariably associate themselves with Mr. Eno's name. Lately a Mr. Dunn sought to register the words "Fruit Salt Baking Powder" in combination with a design, and he was naturally opposed by Mr. Eno, who found, however, in the course of the case that he was unable to uphold his exclusive right to the expression as a trade mark, because it was admittedly descriptive, and was not used by him as a trade mark previous to 1875, but only as a descriptive label upon his goods. He accordingly allowed his mark to be removed from the register, but still opposed Mr. Dunn's application on the ground that it was a false description, and inferred and would cause the impression among the general public that it was a development of his invention, in some way associated with his business.

Lord Justice Cotton held that this was so, and that Mr. Dunn was not entitled to register these words as part of his mark, because of the erroneous impression which their use would be sure to originate in the minds of those familiar with the words in connection with Mr. Eno. Lords Justices Lindley and Fry, however, held that the mark ought to be registered, because, although Mr. Dunn was undoubtedly endeavouring to utilise the popularity of the expression, yet he was quite justified in doing so, as Mr. Eno had no exclusive right to it, and the article sold by Mr. Dunn was so different in its purpose from Mr. Eno's that it could not by any possibility be confused with it. Accordingly the mark was ordered to be registered.

The case first came before Mr. Justice Kay, and he decided for Eno against Dunn, and in the Court of Appeal one judge out of three also takes that view; so that as it stands at present, although Dunn's mark is ordered to be registered, yet two judges have decided for and two against registration.

Our readers will understand that the decision does not give Mr. Dunn the exclusive use of the words "fruit salt," any more than Mr. Eno, but only allows of these words in a certain combination, forming a trade mark.

The case emphasises the great difficulties likely to occur in registering descriptive words in combination with designs, and the constantly increasing difficulty of arranging perfectly distinctive trade marks suitable for all industries.

ARTIFICIAL SILK.

IN a letter appearing in the last issue of our contemporary *Engineering*, Mr. J. W. Swan, of Bromley, claims the process of producing filaments by squirting from a jet a coagulable filament forming liquid into a setting or coagulating liquid, and states that he exhibited some of the products from this process at the Inventions Exhibition, London, in 1885. If this is so, it would appear that the invention described by us as shown at Paris is anticipated.

THE PARIS EXHIBITION.

(*From Our Own Correspondent.*)

THE various sections installed in buildings facing the Seine form in themselves a large exhibition covering a greater area than the whole of either the Manchester or the Glasgow Exhibition. The Agricultural Section alone, for example, occupies two parallel galleries with nearly one mile length of floor space between them, and extending over half a mile of the Quai d'Orsay. As the whole length of the Quai d'Orsay, within the Exhibition, is a little under a mile, the Agricultural Section is by far the most extensive in that part. The buildings are not continuous, but are separated at intervals to allow of ready communication with the different portions, and also to allow of the usual traffic over the Pont de l'Alma, which opposes the Avenues Rapp and Bosquet. The Exhibition and the city streets are intermingled here in a puzzling manner, but the arrangements for allowing and separating the traffic of both are well carried out. At the Pont de l'Alma, a tasteful bridge connects the two portions of the Agricultural Hall and spans the street, so that the traffic over the Seine is not interrupted in any way, while the continuity of the Exhibition enclosure is still preserved.

Just at the entrance to the Agricultural Galleries is stationed a panorama of the Company Transatlantique, which seems an object of much interest to the Parisians. The building is of the usual octagonal type, and is built upon piles in the river. The exterior is decorated with effective maps of the various routes taken by the company's steamers painted upon the octagonal walls, and the interior is divided into two parts. The upper portion, as we enter, seems to be the deck of a transatlantic liner, and we find ourselves apparently upon the bridge, with the wheelhouse beside us, containing hand and steam steering gear and the usual signalling apparatus for communicating with the engine-room and the captain's cabin, together with Sir Wm. Thomson's well-known mariner's compass, with the short needles and light card. Looking forward from the wheelhouse windows, the scene is most realistic, and represents the bow of the ship crowded with passengers, and the crew engaged in their various duties. A sailor stands by us in the uniform of the company, and explains the working of the steering gear and the arrangement of the compass, and between the real bridge deck, wheelhouse, and details, together with the live tar and several skilfully-modelled officers just out of reach on the main deck, explaining the scene to waxen lady passengers gracefully reclining on deck chairs, it is most difficult to say where reality ends and the painting begins. Looking round, we observe that we are leaving the harbour of Havre, and see the various Atlantic liners of the company all around, flying their distinctive flags. The sea view almost persuades us, with its ripple and appearance of horizon and freshness, that we are far away from busy Paris and really at sea again. We must leave this attractive scene, however, and descend to the lower tier of pictures, where we can examine at leisure the cabins of various vessels apparently filled with busy passengers—dining, reading, smoking, and endeavouring to amuse themselves during their voyage as best they can. There we also see representations of the furnaces, stokers, engine-rooms, and scenes illustrative of the art of iron shipbuilding, showing the huge liners upon the stocks, their iron ribs rising high skyward, and also parts in the process of forging, by the aid of glaring furnaces and huge steam hammers.

The whole of the pictures are most realistic, and no doubt many inland dwellers of France will get from them vivid ideas of great ships and shipbuilding such as would otherwise be quite beyond them. To islanders like ourselves, however, familiar with ships and shipbuilding, the whole panorama seems too familiar to be novel, and too real to be striking. Before we leave this panorama, we may say that the Exhibition and Paris are rich in such displays. Within the Exhibition there are three panoramas, and a terrestrial globe, which is of the panorama class. Two of these we have now described—that relating to petroleum and the one above. The third is very attractive, but can hardly be classed as of direct engineering interest. It is situated in the Esplanade des Invalides, near the entrance, and is a view of the streets of Paris in the immediate vicinity of the Grand Opera House, in which the visitor is supposed to occupy the centre of the Place de l'Opera, and to view the surrounding boulevards. The streets are crowded with the celebrities of Paris, seen together at one time in numbers never to be found in reality. The portraits are many of them excellent, and give us a good idea of what the eminent Parisians are like. Engineers will be interested in the portraits of M. Eiffel and M. de Lesseps, the latter riding on a fine horse at the head of his children, mounted on ponies.

We shall now return to our engineering, and apologise for our digression, but we think those of our readers who visit the Exhibition will, no doubt, find interest in much which cannot be strictly considered engineering detail.

The entrance to the Eiffel Tower end of the Agricultural Galleries is close by the Transatlantique Panorama, and here our attention is at once arrested by a solar motor intended for hot countries where there is some hope of obtaining motive power gratuitiously. Many attempts have been made to utilise the sun's rays for motive power purposes, but so far, we think, without any substantial success. The experiments of M. Mouchet, some years ago, attracted considerable attention, and his apparatus consisted of a huge mirror arranged to focus the sun's rays upon a point at which was stationed a steam boiler, blackened on its exterior, and shielded by glass from loss by contact with cold air. The steam raised was utilised to actuate a small steam engine. If we remember aright, this motor was shown at the Paris Exhibition of 1878, but the dimensions required for a given power were excessive, and delicate mechanism was applied to keep the mirror changing its position to compensate for the relative change in the sun's position throughout the day. This difficulty, combined with the unwieldely and expensive nature of the apparatus, prevented its continued use even in Egypt, where it was utilised as a water distiller for some time. The problem was a favourite one with the late Captain Ericsson, of New York and hot-air engine fame, and we understand that he was engaged upon it to the time of his death. He attempted also to utilise mirrors, but adapted his hot-air engine as the motor. We do not know that he achieved any substantial success.

The solar motor now exhibited in the Agricultural Gallery is constructed on a very novel principle. It is the invention of a Frenchman, and is made by J. Cumming, engineer, Orleans. It consists of a vacuum engine and a surface for absorbing the sun's heat; this surface is most conveniently arranged as a metallic roof constructed of corrugated sheet, and made double so as to form an air-tight case of considerable area, and stiff enough to stand a slight pressure from within. Into this case there is pumped a saturated cold solution of ammonia gas in water, which thereby becomes heated, and the ammonia is evolved and conducted by a pipe to the engine. It enters the cylinder, and suppose it moved at first by hand, the gas fills the cylinder at or near atmospheric pressure, and it is then discharged into a condenser containing cold unsaturated water. Ammonia has such an intense affinity for water, that it at once dissolves and creates a considerable vacuum, which allows the ammonia gas entering the other end of the cylinder at atmospheric pressure to press down the piston. When the bottom of the stroke is reached, the exhaust valve opens communication with the condenser, and the ammonia is admitted at the opposite end again. In this manner the engine is driven by vacuum obtained by ammonia, instead of steam.

The advantage of this type of motor is found in the fact that the solubility of ammonia in water lessens very rapidly with increasing temperature, so that the difference between the heat of the metallic case roof and the temperature of cool well water is quite sufficient to furnish considerable power. It is stated that in Paris during the hottest months a surface of about 40 square feet is sufficient to give one horse power, and in the South of France in ordinary summer weather very much less roof surface is sufficient. To prevent loss of heat by contact with cool air it is advisable to cover the roof with glass, and so have the advantage of the hothouse effect. The motor is arranged with condenser and suitable pumps for refrigeration and circulation of the saturated and non-saturated water through the roof surface and the condenser. It is exceedingly ingenious, and deserves success. We fear, however, that in very hot countries the cool water supply may prove inadequate, and in countries like our own, of course, it is impossible to obtain the necessary and continuous heat.

We regret that Mr. Cumming does not show the solar motor in action, more especially as the roof of the gallery furnishes ample area for the metal heater, has a good exposure to sunlight, and an ample supply of cool water is available from the Seine.

Mr. Cumming exhibits at this stand three portable steam engines, of very neat design, and one semi-portable, with horizontal locomotive type boiler, but having the fire box in a vertical cylinder, riveted to the end of the horizontal barrel, which vertical portion carries the steam dome and safety valves and other fittings. This peculiarity is very common among French portable and semi-portable engines. The boilers are all neatly lagged with polished sheet brass, which makes a brilliant finish to the machine, too showy, perhaps, for our British eyes. We imagined that this brass lagging would be specially used on exhibition engines, but we were informed by the attendant that engines were very commonly set to work so finished.

Passing on, we observe a variety of wine presses, with screw driven by lever and ratchet. The levers were so arranged that to give a final squeeze a second lever could be coupled to the first, to give a slow and powerful movement when wanted. One of the principal engineers dealing with work of this kind is J. Ollagnier, of Tours.

Messrs. L. and A. Pécard Frères show a great variety of their manufactures, engines of various types and good workmanship, pumps, and agricultural machinery generally. At the stall of J. Hignette, Paris, are some fine examples of the latest cream separators, also of excellent design and finish. Messrs. Egrot, of Paris, show a great selection of distilling plant as applied to the production of brandy, and also appliances for dealing with wines in quantity, the motive power for which is supplied by a Lenoir petroleum engine. A very interesting exhibit in this section is a huge wine cask, standing over 20 feet high, supported upon wine bottles and decorated with growing grapes. The cold air mechanical refrigerator by Paul Giffard is worth inspection, as showing the points of departure from our own practice as exemplified in the Belt-Coleman refrigerators, used so extensively in this country, and the well-known mechanical refrigerator by the Pulsometer Company, as recently illustrated in our columns.

The English Section in the Agricultural Galleries is situate at the end next the Decauville Railway Station, the Gare de la Concorde, and it contains, among other things, a "model" of the Norham Castle, owned by D. Currie and Co., and the stalls of Messrs. Burrel and Sons, Thetford; Smith and Sons, Peasenhall; Massey and Co., London, all of whom show agricultural specialties, portable engines, threshing machines, and reapers. Mr. J. H. Carter, of Mark Lane, London, exhibits his well-known disintegrator. Perhaps the most prominent firm in the English portion of this section is Messrs. Thos. Robinson and Son's, Rochdale, who have gone to enormous expense in fitting up a complete working roller flour mill, as well as a great number of woodworking machines, in the Machinery Hall. The flour mill in full action attracts great attention, and is very nicely arranged, so that the processes going on in the interior may be readily visible to the crowds who constantly throng the vicinity. From the general interest excited we do not doubt but that Messrs. Robinson will greatly extend their reputation and business by so good an advertisement. We hope to give full details of this mill in an early issue.

A NEW TOOL FOR MARINE ENGINEERS AND SHIPBUILDERS.

Messrs. Tangyes Limited have long been known as inventors and manufacturers of hydraulic machinery and tools, and accordingly we have much pleasure in describing a very handy little tool which they have recently introduced. It is the invention of Mr. A. E. Seaton, of Hull, the well-known marine engineer, and it is intended for forcing hard-set bolts out of screw shaft couplings, but it can also be used as a pushing jack for moving the screw shafts in or out of the tunnel, and that without impairing its usefulness as a lifting jack when required.

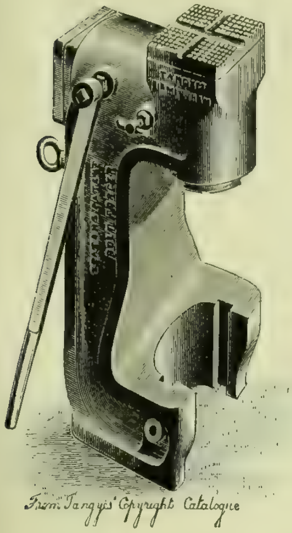
From Tangyes' Copyright Catalogue

Fig. 1.

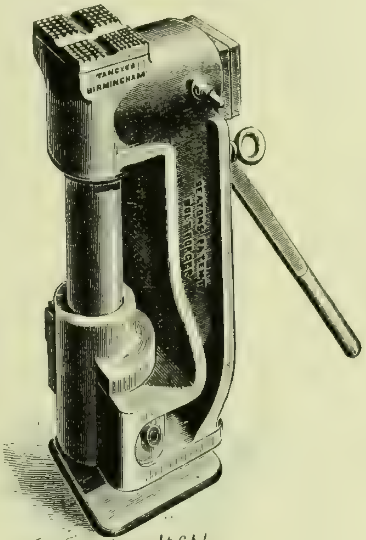

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Fig. 2.

The common methods adopted by marine engineers for freeing hard-set bolts are at best cumbersome and laborious, while, on account of the restricted working space, it is often very difficult, and sometimes impossible, to get them started. Drilling has then to be resorted to, involving great expense, and, what is often more important, a great loss of time. Some of the coupling bolts are almost invariably destroyed, and have to be replaced at the shipowner's expense.

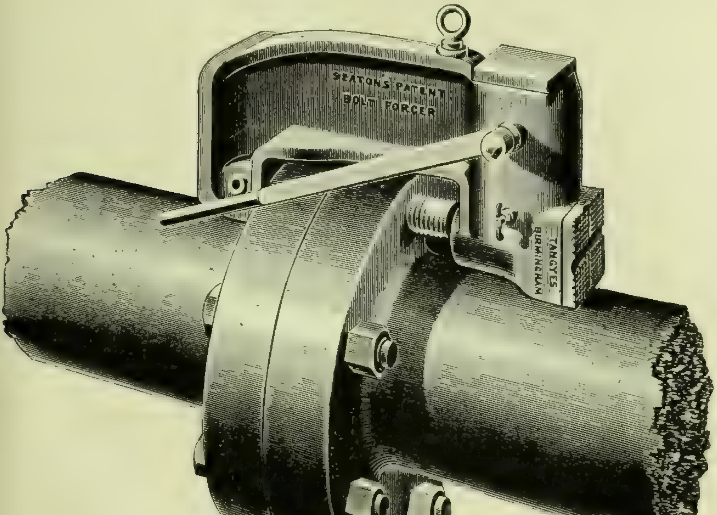

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Fig. 3.

The hydraulic bolt forcer will start a bolt, however fast it may be, in two minutes without dubbing the end or injuring it in any way. It is simple and handy, and the small size can be worked by one man. Fig. 1 shows the tool as a bolt forcer; fig. 2 when used as a hydraulic jack, or pusher; and fig. 3 shows the tool in position forcing the bolt from a shaft coupling. It will be seen that it is entirely self-contained. The body, with gap to span coupling flanges and coupling bolt ends, water cistern (which also contains the pump), and cylinder, are all cast in one piece; a claw at one end grips the coupling flanges, and is hollowed out to clear the bolt heads; the ram is placed exactly opposite; the pump, placed in the cistern, can be worked from either side of the machine, as the handle-shaft is brought through both sides for that purpose.

To meet various requirements three sizes are being made—

No. 1.—15 tons with 9in. gap for couplings up to 6in. thick.
„ 2.—20 „ 12in. „ „ 9in. „
„ 3.—28 „ 15in. „ „ 12in. „

Nos. 1 and 2 are for small and medium size shafts.

No. 3 for large passenger ships and war vessels.

To dock proprietors and marine engineers generally the utility of the tool will be obvious. In the case of large passenger and war ships it should be invaluable for operations at sea, and no doubt when it becomes known the large shipping companies and the Admiralty will see that each of their vessels is supplied with this most useful apparatus, especially as it would add much to the safety of the ship and the confidence of those on board.

STEAM ON COMMON ROADS.—II.

Maceroni.—Among the inventors who had steam carriages on the road fifty years ago, we think that a very prominent position must be reserved for Colonel Maceroni, who was one of Hancock's most useful contemporaries. Maceroni's father was an Italian merchant, residing in England, and for several years he occupied a quasi country house in the suburbs of Manchester, where in 1788 Francis Maceroni was born. We cannot afford the space to give any particulars of his early days or his many adventures. In 1814 he was living in Italy, and became aide-de-camp to the King of Naples. From 1825 to 1828 we find Maceroni helping Gurney, in London, to overcome the monetary difficulties associated with his faulty steam carriages; but feeling convinced that Gurney's efforts would never succeed, in 1829 Maceroni abandoned the steam carriage business and went to Constantinople. Having returned to England in 1831, "Mr. J. Squire came to me," says Maceroni,* "and informed me that he had built a steam carriage, which performed very well, and asked me to join him in the undertaking. Finding the little carriage much superior to any that Gurney had made, but unfortunately fitted with a somewhat defective boiler, I undertook to join him in the construction of another on my plan, for which a valid patent could be obtained, but I was without much money, having, through the 'fortunes of war,' returned from Turkey with even less than I went out with. However, I mentioned my dilemma to a gentleman, the like of whom there are too few in this world, who provided me with the funds for taking competent premises, purchasing lathes, tools, and establishing a factory on the Paddington wharf. I placed Mr. Squire in a house on the works as foreman, and we set to work on an enlarged scale." In 1833 two well-made steam carriages had been put together. The first was intended to carry eleven passengers, and the excellent boiler worked at 150lb. steam pressure per square inch. The second carriage was larger, and designed for carrying sixteen persons, and ample room had been provided for baggage. Numerous trips were made with the first carriage to Windsor, Uxbridge, Harrow-on-the-Hill, and other places, which were reported in the papers. We have only room to give the following account of a steam trip to Watford, which appeared in "Turner's Annual Tour," in 1834.

"Drawn out of a hut on Bushy Heath by the appearance of an unusual commotion amongst the inhabitants of the village, we saw a steam coach which stopped there. The apparition of a vehicle of this kind, in such a place, was unaccountable. Bushy Heath forms the plateau of a mountain, which is the highest point of land in Middlesex, and, although so far inland, serves as a landmark for vessels at sea. The access to it, from the London side, is by a difficult and steep road. Being accosted by Colonel Maceroni, in whom we were glad to recognise an old acquaintance, he informed us that the journey had been performed with ease, adding that it was his intention to proceed to Watford. Now, if the road from Edgware to Bushy Heath was steep and difficult, the descent from Bushy Heath to Watford was much worse. We told our friend that he might go by steam to Watford, but that we were quite certain that he would not return by the same means of locomotion. Nevertheless, at his pressing instance, we consented to hazard our own person in the adventure. We set off, amidst the cheers of the villagers. The motion was so steady that we could have read with ease, and the noise was no worse than that made by a common vehicle. On arriving at the summit of Clay Hill, the local and inexperienced attendant neglected to clog the wheel till it became impossible. We went thundering down the hill at the rate of 30 miles an hour. Mr. Squire was steersman, and never lost his presence of mind. It may be conceived what amazement a thing of this kind, flashing through the village of Bushy, occasioned among the inhabitants. The people seemed petrified on seeing a carriage without horses. In the busy and populous town of Watford the sensation was similar —the men gazed in speechless wonder; the women clapped their hands. We turned round at the end of the street in magnificent style, and ascended Clay Hill at the same rate as the stage coaches drawn by five horses, and at length regained our starting place."

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* Memoirs of the "Life and Adventures of Colonel Maceroni," late Aide-de-camp to the King of Naples, 1838.

In 1834 Maceroni and Squire dissolved partnership in the steam carriage business, after which Maceroni became very short of money, and allowed Asda, an Italian Jew, to take both the carriages to the Continent, he having promised to pay Maceroni fifteen hundred pounds for a share in the patents taken out in France and Belgium. Asda solemnly stipulated that one of the carriages should be returned in six weeks. One carriage was running well in Brussels, long reports having appeared in the Belgian journals. Another was doing equally well in Paris. The king took a ride, gave Asda a valuable present, who styled himself the inventor, constructor, and sole proprietor of the carriages. A rich party of capitalists paid Asda sixteen thousand pounds for the patent, of which Maceroni never received a shilling. All his tools and effects at the factory were taken by his creditors, and Maceroni was on the verge of starvation. In 1837 Colonel Maceroni attempted to form a company to construct and run steam carriages built under his directions, but the matter fell through because he had no carriage to exhibit to those who had never seen either of those of which he was so cruelly robbed. A year later another attempt was made to float a company, but without success. However, in 1841, "The General Steam Carriage Company" had commenced to construct carriages in accordance with Maceroni's patents. Mr. Beale, of Greenwich, made the first carriage. The following report of a trip is given: "Having been accustomed to drive some of the best appointed fast coaches, I was invited to accompany a party of gentlemen on an experimental trip with Colonel Maceroni's steam locomotive. It started from Beale's works, E. Greenwich, and proceeded through Lewisham to Bromley, a distance of eight miles, performing the journey in half an hour; we returned at the same rate. So confident was Beale in the performance of the engine that he determined to try Blackheath Hill, which was ascended in gallant style with a load of seventeen passengers. We proceeded over Blackheath to the top of Shooter's Hill at the speed of fourteen miles an hour, descended the hill, and reached the factory at a quick rate. Several shareholders were delighted." Maceroni had agreed to supply the carriages at eight hundred pounds each to the company. Mr. Beale's bill was eleven hundred pounds for this first locomotive, having charged over two hundred pounds for alterations and running some hundreds of miles on experimental trips. The committee refused to pay this unreasonable amount, and Beale would not let the carriage go out any more. The quarrel was between the board of directors and the manufacturing engineer, but Colonel Maceroni was the greatest sufferer, because he lost everything, his furniture, books, models, and was now in a state of great distress. Beale, in one of his letters, said: "I believe Colonel Maceroni has done more than any other man in the kingdom towards steam locomotion on common roads, and that if his scheme were properly supported it would succeed, and be of vast utility to the community. J. T. Beale, E. Greenwich steam-engine works." Towards the end of 1841 Maceroni offered for sale the patent rights of his steam boiler, which had been proved, by daily journeys on the most hilly roads. It had, during eighteen consecutive months, propelled a steam carriage at the rate of twelve miles an hour, making little noise, and emitting no smoke. The patent had seven years to run, but in that time, the advertisement went on to say, "a great fortune might be made on common roads." Colonel Maceroni was a constant contributor to the *Mechanics' Magazine*, from 1830 to 1840, but we fail to find a single line from his pen after his patent boiler advertisement had appeared, except a letter to the editor in 1843, showing that Squire's steam boiler, just then patented, was really an infringement of his patent boiler. Colonel Maceroni was most unfortunate in every transaction connected with steam locomotion, notwithstanding that he built two of the best carriages ever made.

Gibbs and Applegarth.—In 1831 Mr. Gibbs gave evidence before the Committee of the House of Commons upon steam locomotion on common roads, in which he stated that he was building a steam carriage, and had travelled more than one hundred miles on Sir Charles Dance's coaches on the Gloucester and Cheltenham road, in order to gain an experience that would be of service to him in his project, and to note the behaviour of the locomotives in passing over the rough roads and in mounting steep inclines. In the early part of 1832 Gibbs completed a steam drag. The chief characteristic of this locomotive, which was intended for drawing the passenger carriages behind it, was the boiler, with a spirally descending flue placed behind the driving wheels. In September, 1832, Gibbs and Applegarth patented a superior steam carriage with a tubular boiler and oscillating engine cylinders. Two spur pinions on the crankshaft of different diameters geared into two wheels on the main axle, either pair of which could be geared together and clutched to the driving axle for running the engine at two speeds. The power from the axle was transmitted to the driving wheels through friction bands, arranged on the bosses of the wheels, so that one or both wheels could be coupled to the axle. Friction driving bands similar to those introduced by Gibbs and Applegarth were used on some traction and steam ploughing engines until quite recently. Very little is said respecting the trials of the above engines; special mention is made by Gordon in reference to the boiler with the spiral downtake, which was said to be a good steamer.

Watts.—About this time a road locomotive was built by Mr. Watts, engineer, Norwich, for running from Norwich to Yarmouth, which answered, we are told, exceedingly well.

Roberts.—Mr. Roberts, of the celebrated firm of Sharp, Roberts, and Co., engineers, Manchester, constructed a road locomotive, which was subjected to a public trial in December, 1833, which, while it served to reveal a few constructive imperfections easily removed, tended to establish the soundness of the principle on which the carriage was constructed. The second trip took place in March, 1834. The carriage started from the works in Falkner Street, under the guidance of Mr. Roberts, with forty passengers. It proceeded about a mile and a half up Oxford Road, where, owing to the apprehension of a deficiency of water, a sudden turn was made, which was attended with some difficulty, as the road was narrow; it then proceeded back to the works, where it arrived without accident. The maximum speed on the level was nearly twenty miles an hour. Hills were mounted easily. No doubt existed of the engine being speedily put in complete and effective condition for actual service. We regret to say that during another experimental trip, in April, 1834, an accident occurred to this locomotive, which was reported to have been more serious than it actually was. Maceroni grossly exaggerates the accident by stating that "the boiler burst in the streets of Manchester, severely wounded several persons, and set fire to an apothecary's shop."* It appears that the engine had travelled more than a mile from the works, when it was found that the pump on the engine did not work properly. The water in the boiler being dangerously low, the fire was quickly drawn; the boiler was filled with water to the proper level from a wayside pond, and the fire re-lighted. Mr. Roberts directed the carriage to be turned round, and it soon commenced its journey home, carrying from forty to fifty persons. It proceeded at a fair rate until it arrived near the corner of Rusholme Lane, where some of the boiler tubes gave way, and the steam, escaping, blew the firebars down, and scattered the coke about in all directions, breaking several squares of glass in three shop windows near, slightly hurting a man and a boy who were hanging on behind the carriage. No one was seriously injured, and none of the crowd of passengers were hurt. The carriage was removed to the works, drawn by four horses.

Several writers on steam road locomotion have accorded the credit of the invention of compensating gear to Mr. F. Hill, of Deptford, but it is our pleasure to be able to show that Mr. Roberts, the celebrated Manchester engineer, was the inventor of the compensating gear, which he used on the steam carriage we have just described. This compensating or differential gear is a device that superseded claw clutches, friction bands, ratchet wheels, and other complicated arrangements for obtaining the full power of both the driving wheels, and at the same time to allow for the engine turning the sharpest corner without any difficulty. This compensating arrangement, introduced by Mr. Roberts nearly sixty years ago, is now universally adopted on modern traction engines, but as we presume that all our readers are acquainted with its principles, we need not occupy space in describing it.

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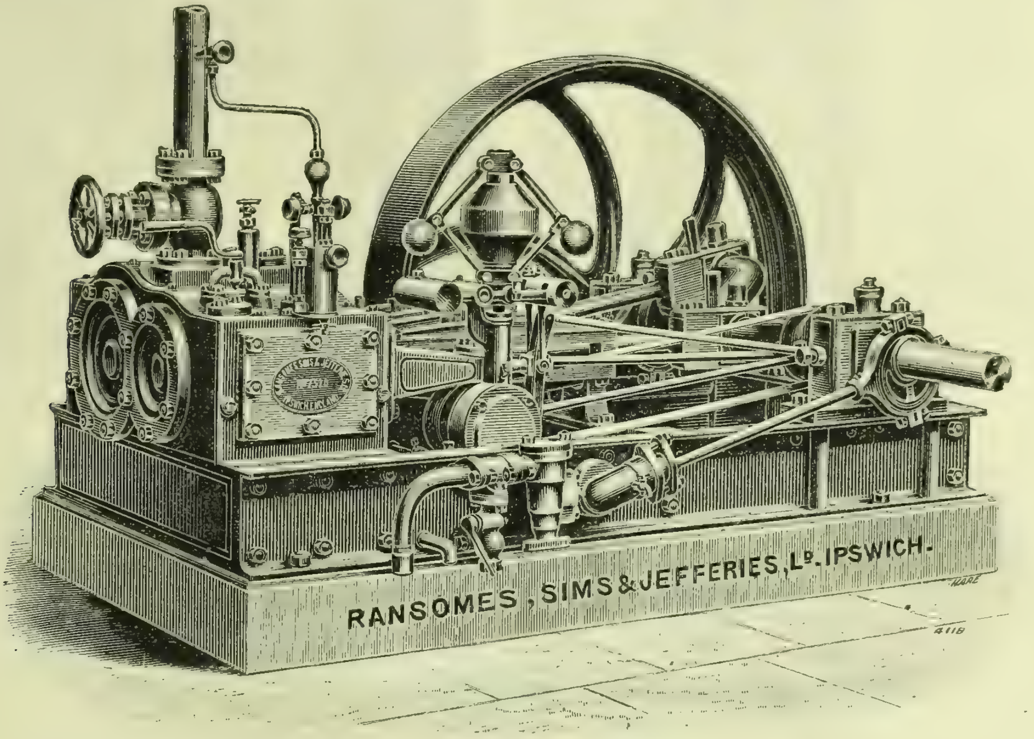
* "Steam Power on Common Roads." Maceroni, 1835.

Dr. Smiles, in his delightful book, "Industrial Biography," says that in 1839, Mr. Roberts invented an arrangement for communicating power to both driving wheels at all times, whether turning to the right or left.

Mr. Canett Marshall used the gear on a little locomotive which he exhibited at the London Exhibition of 1862, and from an accurate description of the gear given by Mr. Marshall, who admits that Roberts was the inventor, we are able to announce that Mr. Roberts was undoubtedly the inventor of the most useful compensating arrangement. It is to be regretted that no particulars appear to have been given respecting the design of Roberts's interesting road locomotive. Emanating as it did from a famous engineering works, it doubtless far excelled in arrangement and workmanship the steam carriages produced by contemporary makers.

Mr. Roberts died in straitened circumstances in March, 1864, at the age of seventy-five years. One writer says Mr. Roberts "helped others in their difficulties, but forgot himself. Many have profited by his inventions without even acknowledging the obligations they owed to him. They have used his brains and copied his inventions, and the inventor is all but forgotten. It is lamentable to think that one of the most prolific and useful inventors of his time should in his old age have been left to fight with poverty." As is our usual method of treating our benefactors, we allowed Mr. Roberts to live in obscurity and die in want, and after his sufferings were ended a memorial was reared to his memory.


RANSOMES, SIMS & JEFFERIES, Lᴰ. IPSWICH.

RANSOMES, SIMS, AND JEFFERIES' COMPOUND STATIONARY ENGINES.

Messrs. Ransomes, Sims, and Jefferies have recently made considerable detail improvements in the construction of their compound engines. We lately described and illustrated their undertype engine combined with a boiler of the locomotive type. We now illustrate above their separate engine of the same type, but, adapted to be supplied from any boiler, the governor and expansion gear are identical with that we have noticed, and the wrought-iron girder frame is also similar; the feed pump has treble brass valves and seatings, and is worked from an eccentric on the crank shaft. When required an improved jet condenser is attached, placed behind the cylinders on an extension of the wrought-iron framing arranged for it. The air pump is worked by an extension of the piston rod from the low-pressure cylinder. An automatic sight-feed lubricator supplies the cylinders with oil. The whole engine is admirably designed both for durability and economy in consumption of fuel.

MINERS AND MACHINERY.

The *Newcastle Daily Chronicle* states that the official reports of the Inspectors of Mines for the State of Illinois have just been published for the past year, and they furnish some details which are of the utmost interest to miners everywhere, and which may convey a moral to others interested in mines also. In the State named, there have been strikes which were not successful generally, but which seem to have been followed by the introduction of a large amount of machinery into the mines. It may be said that Illinois has an output of nearly 12,000,000 tons of coal— a large output for any American State except Pennsylvania. This production is that of what is called "lump" coal, and is in addition to the small coal and slack left at the screens, so that the produce of Illinois would be probably nearer 14,000,000 tons than that stated. But out of the smaller quantity it may be said that probably about a quarter of the total is now produced by means of mining machines. It is evident that so large a production by means of machines must have its effect on the labour market of the State; and the method in which it will operate is indicated by the statement that it is claimed that whilst every keg of gunpowder used in machine-worked mines produced 97 tons of coal, in the hand-worked mines every keg of powder produced only 37 tons. The opinion of the inspectors of mines seems to be in favour of the working with these machines. Thus Mr. Walton Rutledge, the inspector for the fourth district, says that the general tendency will be to adopt machine mining as new mines are opened, because "coal can be mined much cheaper by the machines, and brought out in better condition for the market." Mr. Taylor, the fifth district inspector, adds that the system will no doubt reduce the number of accidents; in the third district machines have "reduced the average cost of powder for blasting," owing to the lessened needs; in the second district, the system is "probationary;" and in the remaining one the statement is made that the production is for "each machine 4,591 tons," or the same quantity as "thirteen men in hand-mining" yield. The facts that so large a quantity of coal is won by machine, and that the testimony of the inspectors of mines is so generally in favour of that working, must be held to be significant. Whenever the rate of wages is forced up rapidly, the tendency is to foster the employment of machinery, so as to reduce the amount paid for labour in proportion to the work accomplished. In the American mines most of the labour is highly paid for, because of the many outlets which there are in that country; and it is quite probable that the high rate of pay has had something to do with the more general employment of mining machines there than here. The subject of relative cost cannot be readily pronounced upon, because not only has the actual sum paid for labour to be considered, but also that of the

MESSRS. SELIG, SONNENTHAL, AND CO.'S EXHIBIT AT PARIS.

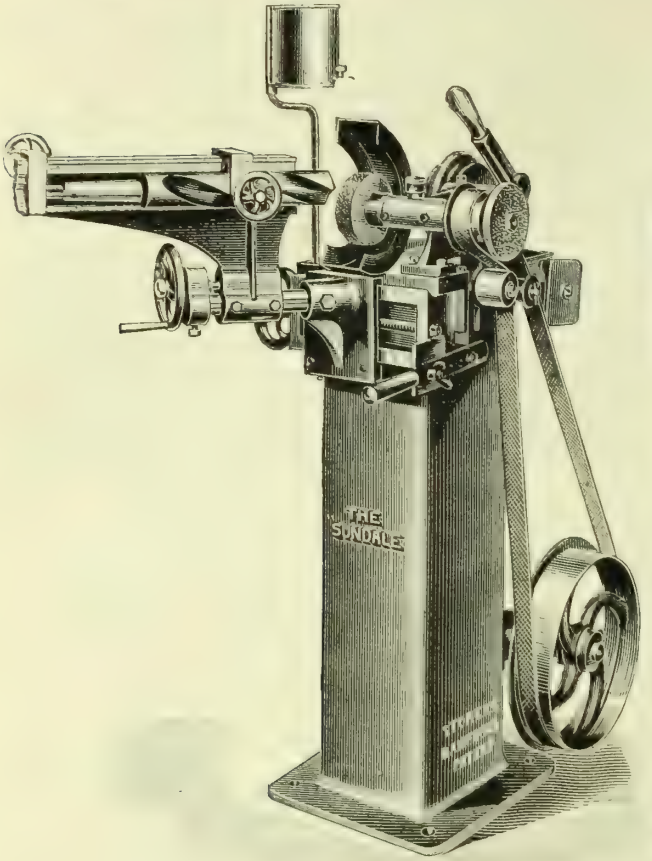


Fig. 1.

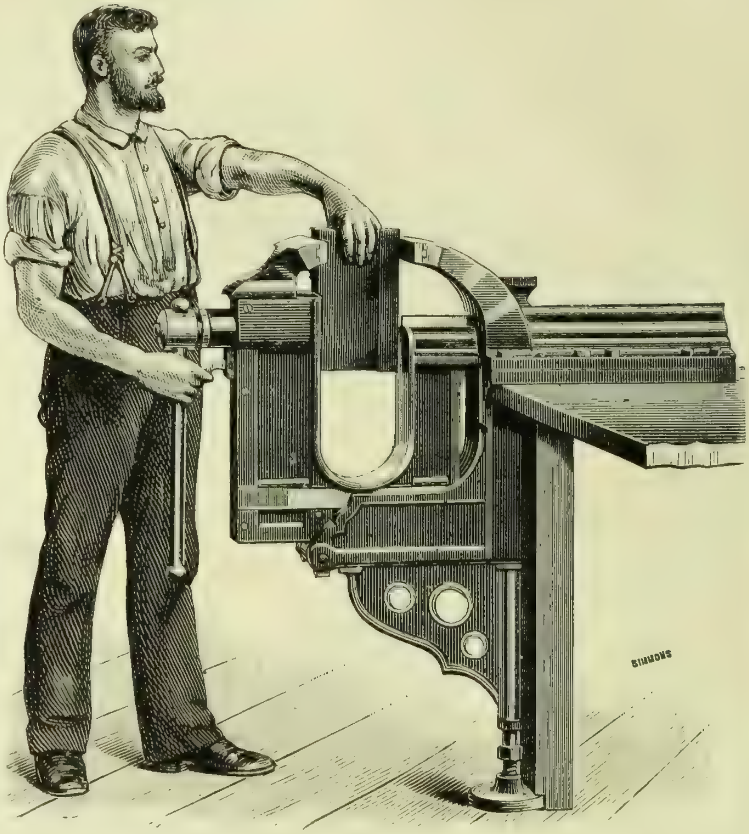


Fig. 3.

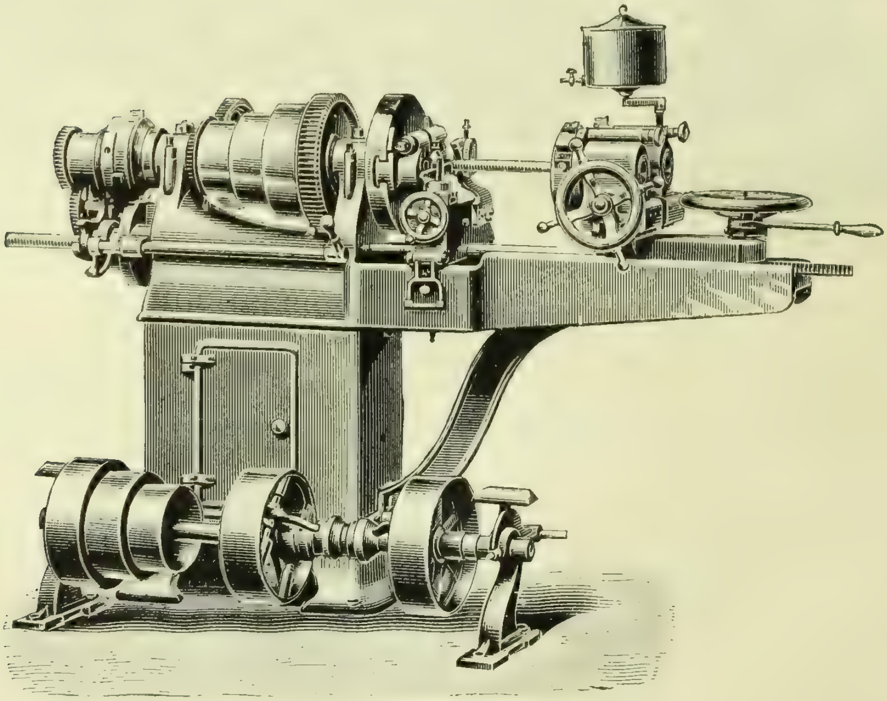


Fig. 2.

interest on money invested, the comparative cost of powder, timbering, &c., and the facts are not given to enable a reliable deduction to be made. But the large use of machinery in the mines of Illinois is one of the features of the coal trade that is significant at the present juncture, and it points to a possibility that both employers and men would do well to bear in mind in Durham just now.

Messrs. Selig, Sonnenthal, and Co.'s stall at Paris is filled with many interesting novelties in engineers' appliances, a few of which we did ourselves the pleasure to inspect on our visit to the Exhibition, and among them the "Sundale" twist drill grinder is worthy of careful examination. There are many efficient machines for this purpose in the market, but in all the proper motion to give the necessary clearance is obtained by acting on the drill itself. In this case the drill is held stationary and the emery wheel is moved.

The twist drill to be sharpened is simply clamped in a V-shaped rest; a small slide fits into the groove of the drill to bring it into position. After grinding one edge, the drill is rotated until the small slide fits into the opposite groove, thus insuring a rotation of 180 deg. An adjustable stop butts up smoothly against the shank, so that when the drill is rotated it is held in exactly the same position for grinding both sides.

By moving the lever, which is connected with a vertical slide, shown on side of machine, more or less clearance can be given to the drill to suit various kinds of metal. A graduated index shows usual amount of clearance for different sizes of drills. With this machine, a labourer or boy can grind a twist drill as well and accurately as a skilled mechanic, and give the proper clearance, same as in a new twist drill. We illustrate this very handy and simple machine on the opposite page at fig. 1. Another novelty is the Victoria bolt-screwing and nut tapping machine (shown at fig. 2), which has a hollow spindle and chuck adapted to hold properly the various sizes, and to take work of irregular shapes. It is powerfully back-geared, and the gears are thrown out, as in an engine lathe, for small work.

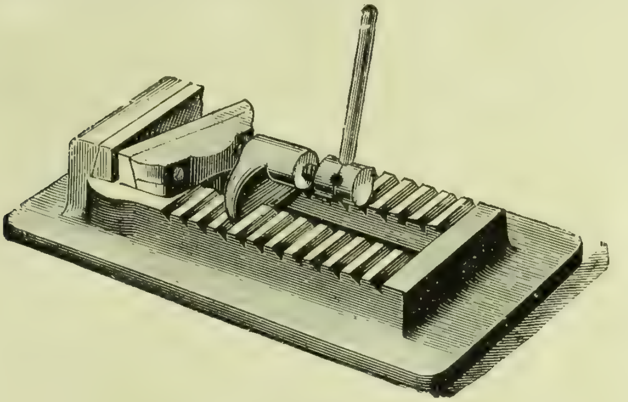


Fig. 4.

The dies are carried in two equal discs set side by side, and brought together or separated by a right and left screw, each die being divided, the half in one disc opposite to the half in the other, in such a manner that a complete working die is made by bringing the wheels together to the stops, and the finished screw released by separating them, thus saving running back over the screw. Each die has its independent stop pins controlling its cut, which are readily shortened or lengthened, enabling a perfect adjustment to be maintained, all the different dies standing ready for use, so that any size may at once be brought into line by turning the discs to the proper places.

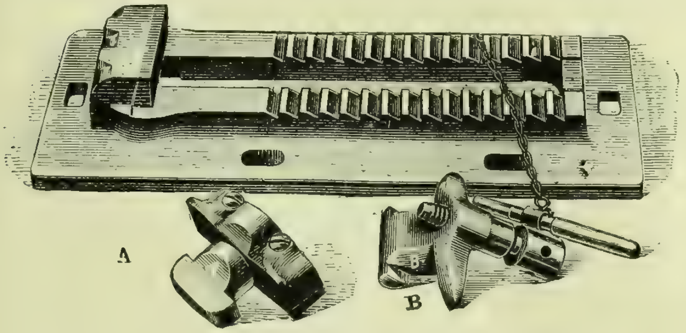


Fig. 5.

For insuring accuracy in difficult work, such as long coarse or square-threaded screws for chairs, vices, presses, &c.—never heretofore successfully cut with dies—a leading screw and gears are supplied, enabling such work to be done with this machine in the most accurate manner, and with great economy, without the use of the lathe.

An attachment is supplied for cutting off bars in front of the chuck.

The deep gap sudden grip parallel vice is also a most convenient tool, which will be readily understood from our illustration, fig. 3. The manipulation is very simple, and easily understood. By taking hold of the lever and raising the trigger with the fore-finger, as shown in the illustration, the movable jaw may be readily drawn out as far as necessary to admit the work between the jaws; then give the lever a slight turn, and the work is securely gripped. One turn of the lever to the left is sufficient to release the work. It is stated that the largest size vices work with the greatest ease, even with the heaviest work.

The deep gap appears to us a great advantage for many kinds of work, and should the front jaw become loose after some years' use, it can be readily readjusted by means of two set screws, which are easily got at with a screwdriver. If the U-shaped part should ever work loose, the fixed jaw should be removed and the faces filed as may be required to take up the wear.

This firm also exhibit an interesting form of machine vice for holding small work accurately and firmly for the various operations of drilling, milling, or planing.

Fig. 4 shows the vice as it appears when holding a piece of taper work. To hold the work, it is placed between the jaws, and the loose jaw and plate pushed to it, and the screw tightened in the grip plate against the back of the loose jaw, when the work is tightly held, and at the same time pressed down firmly and uniformly upon the surface of the vice.

Referring to fig. 5, A is a loose jaw, and B is a grip plate. The loose jaw is free to slide backwards and forwards in the longitudinal slot of the vice, as is also the grip plate, when tilted slightly forward, thereby disengaging the two strong teeth shown on the back of the grip plate from those on the body of the vice.

Messrs. Selig, Sonnenthal, and Co. are, we are informed, the foreign export agents for these patent machine vices, and we have no doubt but that they will find ready application to many purposes.

ON GAS ENGINES, WITH DESCRIPTION OF THE SIMPLEX ENGINE.*

Historical.—Nearly a century has elapsed since the appearance of the first definite description of a gas engine; and many years passed before this ingenious idea was practically developed into a working machine. No sooner had the first gas motor become an accomplished fact, than improvements rapidly suggested themselves, and contributed to ensure its success. It is not intended to review in detail the numerous inventions relating to gas engines; but it will be of interest to note those which have been conspicuous by the importance of their results.

From 31st October, 1791, when John Barber published the first description of a gas engine, until 24th January, 1860, when Lenoir brought out his well-known arrangement, thirty-eight patents were taken out in France and elsewhere; and in glancing through these old documents it is surprising to recognise in them all the ideas which are supposed to have originated only yesterday, besides others which may turn out to be the success of to-morrow. Since the later date nearly 700 patents have been taken out, and from an examination of these it would seem as though there were nothing further left to invent; nevertheless, each year gives rise to ideas that are new in their application, even if not novel in themselves. Such efforts cannot fail to result in a radical change of the former plans.

Up to 1860 the various inventors may be said to have worked in ignorance of one another's doings, and their designs clearly show that their ideas were original with themselves, and that their efforts were directed not to the improvement of previous inventions, but to the search after combinations which they supposed to be new. But when the first gas engines were got practically to work, the new ideas followed the current of the time. The inventors who followed Lenoir set themselves to improve the double-acting engine; now they are endeavouring to apply the four-cycle plan of Beau de Rochas. Is this arrangement likely to be final? Will no better plan be discovered for rendering the gas engine a successful rival of the steam engine? As yet it is impossible to answer so intricate a question; but pending some radical change, it is possible to improve existing engines, and to simplify their construction and working. Until very recently the gas engine has been specially applied where only small power is required; its application for such powers as have hitherto been considered the province of steam is reserved for the future. A rapid examination of the most important inventions since 1791 will enable a notion to be formed of what has already been done, and of what still remains to be accomplished.

At that date gas was not an industrial product, and accordingly John Barber described what he considered the best processes for its production. He proposed to distil coal, wood, oil, or other combustibles in a retort, and then by means of a pump to inject the product into a cylinder where explosion takes place. A second pump injects air in suitable proportions, and ignition is effected by the flame of a match or candle. To avoid excessive heating, he proposed the injection of water by a pump. Although Barber's machine could never have been a practical success, it is interesting as the first idea of an engine driven by explosive gas.

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* Paper read before the Institution of Mechanical Engineers at Paris. By Mr. Edward Delamare-Deboutteville, of Rouen.

Three years later Robert Street described a gas engine consisting of a cylinder and piston, with a slide valve containing the flame for igniting the explosive mixture, which he produced by allowing a few drops of oil of turpentine to fall on the bottom of a cylinder superheated by a stove, while the piston, raised by the flywheel, sucked in air, and the latter, combining with the vapour of turpentine, rendered it explosive. The flame in the slide valve ignited the mixture, whereby the motive power was produced.

William Barnett's invention, under date of 18th April, 1838, marks an important step in the history of gas engines. He describes three kinds of motors, the first single-acting and the second double-acting, while the third and most interesting is on the compression principle. In this last the gaseous mixture was admitted on both sides of the piston. Two pumps, driven at twice the speed of the motor, compressed the air and gas separately; and the compressed air and gas were mixed in the cylinder at the end of each stroke, and were there ignited. A third pump was used for clearing the cylinder of the burnt gases after their expansion. It is in this arrangement that the advantage of compression is first clearly pointed out, and to this novelty must be added the method of ignition also. Recognising the difficulty of igniting an explosive mixture in a state of compression, Barnett proposed to use a hollow cock containing a gas burner. This cock has a revolving movement, whereby in one position it brings the burner into contact with an external flame which lights it, and in its further motion shuts it off from the external air, and brings its flame into contact with the compressed gas in the cylinder. This mode of conveying the flame certainly could not ensure a regular ignition; but it marks the first step in that direction, and on this account is worthy of notice.

John Reynolds in 1844 proposed an electric battery, the current from which was to heat a platinum wire to incandescence, and thereby cause ignition. A contact-breaker transmits the current at the instant required.

Shepherd in 1850 used an electro-magnetic machine for igniting the mixture.

Eugène Barsanti and Felix Matteucci in 1857 described an atmospheric motor, the precursor of the well-known Otto and Langen engine, which it closely resembled in external appearance, although as a practical success it was by no means all that could be desired. The only detail worthy of special notice is the employment of a Bunsen battery, connected with a De la Rive multiplier, the sparks from which caused the ignition. Subsequently, in the Lenoir engine, the De la Rive multiplier was replaced by a Ruhmkorff coil.

In 1858 and 1859 Degrand gave descriptions of a whole series of engines of different types, and in particular a four-cycle compression engine is minutely specified: but unfortunately the mechanical details which he proposed to employ are not of a practical nature.

This brings us to 1860, which will always be a remarkable year in the history of gas motors. Early in that year Lenoir brought out the first commercially successful gas engine, of which he may therefore be fairly considered to be the first actual inventor. His engine is too well known to require any detailed description; but it is interesting to remark that in its final form it embodied six successive additions to the original invention; and it is only by studying this long course of improvement that the ingenuity of the inventor and the merit of his invention can be fairly appreciated. Unfortunately he did not reap the full success which his invention deserved, its two chief drawbacks being a defective mode of ignition, and an extravagant consumption of gas.

No sooner was Lenoir's engine brought to public notice than it became the subject of lively discussion, not only in regard to its practical advantages and disadvantages, but especially as concerned the scientific conditions of its working. A fresh stimulus was given to inventors, but their efforts were no longer confined to fresh combinations of details more or less novel, but were directed to new conditions of working. Many fresh cycles of operation were suggested, but their description in detail would be too lengthy. One specification, however, is worthy of particular notice, not only on account of its special bearing on the subject of this paper, but also for the remarkable clearness with which the scientific conditions of a rational mode of working are laid down, and the precision with which the author has stated in detail how the conditions required to attain the most economical result are to be realised.

In 1862 Mr. Beau de Rochas published a specification dealing in detail with several scientific questions. Those only which relate to the gas engine will here be considered, but as fully and completely as possible. The theories broached by him have already led to remarkable results in practice, and a more careful study of them will probably be repaid by many further improvements. Neglecting the non-compression motor, we come at once to that in which compression is adopted; but before proceeding to describe the arrangements by which he proposes to fulfil the conditions theoretically required, Mr. Beau de Rochas lays down the law that there are four such conditions necessary to realise the best results from the elastic force of gas—(1) the cylinders should have the greatest capacity with the smallest circumferential surface; (2) the speed should be as high as possible; (3) the cut-off should be as early as possible; (4) the initial pressure should be as high as possible.

1. For a given expenditure of gas the greatest diameter of cylinder will correspond with the most effective utilisation of heat. Therefore, whenever possible, only one cylinder should be employed for each distinct motor.

2. But time is a factor in the dissipation of heat. Other things being equal, the slower the speed the greater will be the loss of heat. For the same power a greater speed means a smaller cylinder; but the antagonism between this and the last-named condition vanishes if it is remembered that for a given expenditure the proportion between the stroke and the capacity of the cylinder need not always be the same.

3. In a gas engine, just as in one actuated by steam or other elastic vapour, the greatest range of expansion gives the best result. But under the conditions last stated the maximum range is limited by the circumstances of each special case. Therefore that arrangement which allows the freest range of expansion, or in other words which permits the earliest cut-off practicable, will give the best result.

4. Lastly, the utilisation of the elastic force of gas depends on another element connected with the advantage of a high grade of expansion. This element is the pressure, which, to give the best result, should be as high as possible. It is evident that it is a question of expansion in a heated state after compression in a cold state, or of increasing the expansion by a method inverse to that which consists in creating a vacuum; such an inverse method would not be applicable to steam, since all compression must involve a corresponding condensation, so that, even if steam were combustible, instantaneous heating would thereby be rendered impossible.

The fundamental idea of Mr. Beau de Rochas is thus clearly seen to consist in the compression of the gaseous mixture to the greatest extent practicable before ignition. Manifestly the only way to do this is to use a single cylinder, first on account of the advantage of having as large a one as possible, and next, to minimise the resistances of the mixture. Consequently, for one end of the cylinder, the following sequence of operations takes place during four consecutive strokes: *a*, inspiration during an entire stroke; *b*, compression during the second (return) stroke; *c*, ignition of the dead point, and expansion during the third stroke; *d*, expulsion of the burnt gas during the fourth (return) stroke. This engine, he claims, fulfils the condition of the largest possible cylinder, and the still more important condition of initial compression. Moreover, the speed of the piston in proportion to its diameter is the greatest possible, since the work usually performed in two strokes is accomplished in one.

In 1863 Mr. Hugon brought out his motor, in which ignition was effected by a gas flame controlled by a slide; the arrangement was ingenious, but the motor had only a moderate success.

In 1867, at the Paris Exhibition, Messrs. Otto and Langen brought out their atmospheric motor, bearing a strong resemblance to that of Barsanti and Matteucci. Its construction was ingenious, and its working a practical success. The rack and clutch motion was worthy of special notice, the slide valve was ingenious, and the increased economy of consumption considerable; but its working was both noisy and violent. A description of this engine was given to the institution in 1875.

The Bischoff motor appeared in 1870, but its success was confined to engines of very small power, of which a large number were made. It would probably have been still more extensively adopted, had it not been for the Otto engine, which was brought out six years later, in 1876.

Dr. Otto's inventions were two in number: the first, in 1876, related to two kinds of engines, one without and one with compression; while the other, in 1877, had reference to improvements in the slide valve and other details of the compression engine;

and this type of engine alone need now be discussed, as at the present time the non-compressing engine may be considered to be abandoned, on account of its excessive consumption. The fundamental idea of the engine is based on the four-cycle principle of Beau de Rochas, already described. In connection with his 1876 invention, Dr. Otto enunciated a special theory, which has been called the theory of the threefold mixture. The mixture was composed, firstly, of a portion of the products of combustion from the preceding stroke; secondly, of a modicum of pure air allowed to enter at the commencement of the admission; and, thirdly, of a combustible mixture of air and gas admitted afterwards. This threefold mixture resulted in a less violent explosion, a successive combustion of one molecule after another, more regular and more silent working, and great economy in consumption. This theory—which, owing to the limited knowledge of the subject at that time, was accepted without question—can no longer be admitted, as its fallacy is demonstrated by every-day practice. As these theories have been refuted by the most competent authorities on the subject, they may be passed over; but though Dr. Otto has thus been unfortunate from the scientific point of view, from a practical point few inventors have achieved so decided a success, and for many years he was the only maker of gas engines.

(To be continued.)

THE CAPACITY OF AIR PUMPS.

(Concluded from page 497.)

Now, it will be evident to the engineer that, in fixing on the best capacity for an air pump, one of the factors to be taken into account is the power required to drive it, for if this be increased so that the extra power would only balance the gain in power resulting from a better vacuum, due to a larger pump, it would not be any advantage to increase the size of the pump. Figs. 12 and 13 below are theoretical cards from the spaces above and below the bucket of a vertical single-acting air pump with foot valves. They are constructed in accordance with the assumptions made about the action of such a pump. The full lines represent cards from an air pump of ·16 or $\frac{1}{6\cdot25}$ of cylinder, and the dotted lines those from a pump of one-half that size. It will be seen by taking both cards together that the total power (exclusive of friction) required to drive one pump differs but slightly from that required to drive the other. The friction of the large pump would, of course, be greater than that of the small pump, probably twice as great, if the capacity is altered by altering the stroke.

FIG. 12.

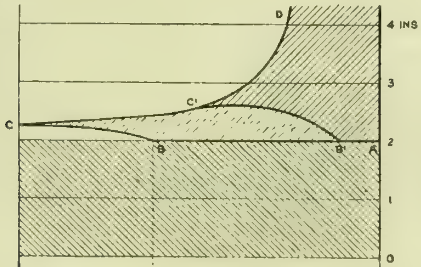
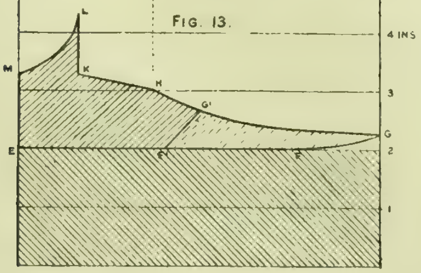


FIG. 13.



TEMP° OF DISCHARGE - 102° F

▨ REPRESENTS VAPOUR PRESSR
▨ CARD OFF SMALL PUMP
▨ " " " LARGE " "

For a pump working under the conditions set forth in fig. 11, page 497, the increase in vacuum gained by making the capacity of the pump = $\frac{1}{6\cdot25}$ instead of $\frac{1}{12\cdot5}$ would be ¼in., and if the back pressure on the piston be lowered by the same amount the gain in power would be equal to ¼in. × 12·5 = 3·1in. pressure acting on the bucket of the smaller pump during both strokes. If, then, the loss of power by increase of friction, &c., is not greater than this, there would be a gain of power to the engine by increasing the size of the pump, but that gain would be so trifling that it need not be considered if there be no other reason for making the pump larger. If the conditions be such as described in fig. 9, page 445, the gain of power would be greater, for the vacuum would in this case be increased by ½in. instead of ¼in.

Lastly, under such conditions as those from which the curve in fig. 10, page 497, is plotted, the gain in the vacuum would be 1¾in. by increasing the size of the pump from $\frac{1}{12\cdot5}$ to $\frac{1}{6\cdot25}$ of the cylinder capacity, and it would probably be better in this case to increase the size of the pump still more. One of the advantages to be gained by making the pump large in all cases is the provision this course affords for maintaining a good vacuum, even when there is leakage into the pump, condenser, pipes, or cylinder.

One of the disadvantages is that, if the capacity be increased by increasing the length of the stroke, the bucket strikes the water when moving with a greater velocity, and the strain on the bucket and valves is greater both near the lower and upper end of the stroke. If the capacity be increased by increasing the diameter only, the bucket will strike the water with less velocity, since in this case the water charge of the pump fills the barrel to a less height, so that the pressure intensity is less than in the case of the smaller pump; but it is more difficult to make the parts strong enough to stand a given pressure per square inch on account of their larger diameter. If both the stroke and diameter be increased, then the effect will be intermediate between those described.

Air pumps attached to surface condensers have an advantage in this respect, for in many cases the water charge will only fill the barrel to a height of ¼in. to ½in., while with jet condensation this may become 5in., more or less.

From this it would follow that a bucket speed which would be disastrous to a pump of the latter kind might be quite safe for one of the former, but would not be safe if it had to work with jet condensation.

The question of the strength of the working parts is, however, beyond the scope of this paper, except in so far as it limits the bucket speed, for in the theory here advanced there is an assumption all through that the speed is kept within moderate limits, otherwise it might require some modification.

As an example, take the assumption that during the upstroke of such as those shown in figs. 3, 4, and 5, page 444, the evaporation proceeds at such a rate that the vapour pressure is not much short of that due to the temperature. It is evident that this will be more nearly correct for low speeds than for high ones, but the actual error can only be found by taking cards off the pumps at work. It is not sufficient to know the rate of evaporation from a free still surface when the vapour pressure is less than that due to the temperature by a given amount, for the agitation of the water introduces an unknown factor. The correctness of other assumptions can likewise only be tested by comparing the results of trials with those which could be predicted by the foregoing; and with this object in view, the writer has consulted all the published reports of steam-engine trials which he could find, but owing to the fact that these trials were directed towards testing the engines as heat engines, some data essential for arriving at a knowledge of the action of the air pump were omitted.

This will not be a matter for surprise, if the tabulated list of requisite data given at the end of this paper be read through, as such a collection would only be brought together if a complete test of air pump performance was aimed at. Such tests may have been made, but the writer is not acquainted with any, and he regrets that in consequence he has had to abandon his original intention of comparing predicted with actual results, and so determining with what degree of accuracy the preceding methods are applicable to practical work.

Although such rigid tests cannot here be applied, it is hoped that the facts stated and the conclusions arrived at will help to explain the anomalies to be found in current practice. Thus it has been shown that under ordinary conditions, if the capacity of the air pump be considerably less than usual, the bad results will be marked. If, on the other hand, the proportions vary between the usual limits, the results will vary too, but in ordinary cases the variation in results will be slight, though under some circumstances pumps with nearly the minimum usual capacity will give appreciably worse results than if they had been made with the largest capacity. If the capacity be increased beyond the limits common in practice, the result will not be appreciably better. The variation in dissolved gases in the temperatures of the injection water and of the discharge in the terminal pressure of the steam, and the quantity evaporated during exhaust, all have an influence on the results achieved by the air pump.

As the working conditions are seldom known with accuracy beforehand, the practical engineer will make the air pump of such a size that it will maintain a good vacuum under the most disadvantageous circumstances in which it is likely to be placed.

If the conditions be such extreme ones as those which are assumed in the calculation of the curve in fig. 10, page 497, he will be justified in making the pump one-fourth of the cylinder capacity; but if it is certain that the most adverse conditions will be those from which fig. 11, page 497, is obtained, there is nothing to be gained by making the pump more than one-eighth of the cylinder capacity.

If the preceding methods and results shall give some assistance to any who may have to design air pumps to work under special conditions, or if they give rise to a discussion which shall prove a valuable addition to the present scanty literature of the subject, the object of this paper will be attained.

HEAT ENGINES OTHER THAN STEAM.—I.

(Continued from page 536.)

In order to utilise to the utmost the quantity of heat represented by this black cube, we should require that that heat should be delivered to the engine at the highest possible temperature which can be attained, and we should require to take all the heat out of it, so that when we rejected the working agent from our engine, it would be at the lowest possible temperature.

As to this question of the lowest possible temperature, I have already shown you that the addition of heat to a gas causes the volume of that gas to increase if the pressure remains constant. Now, if we can imagine the reverse of this process carried on sufficiently far, we can realise that the volume of the gas will be infinitely reduced, so that when the whole of the heat has been abstracted from it, it would have entirely disappeared. We should then reach that which is called the "absolute zero of temperature." Let me illustrate this to you.

It has been proved that air or any similar gas expands by 1·492nd of its bulk for each additional degree of temperature, if the pressure is kept constant; that is to say, if we increase the temperature of a gas by 492 deg., its volume will be doubled. Now, if you will look at the diagram, you will see on the left-hand side the vertical line representing the temperature, and you will see the horizontal ordinate, at 32 deg., representing the volume of the gas at that temperature as one. If we now increase the temperature by 492 deg.—that is to say, up to 32 deg. + 492 deg. = 524 deg.—the volume will be doubled, or will become two. Now, if we join the two points, we shall find that at 212 deg., or at boiling point of water, the volume would be 1·3665, but if we carry the sloping line joining these points on downwards till it cuts the vertical line, it will do so at a point which represents a temperature on that vertical line of – 460 deg., or 460 deg., below zero, equal to 460 deg. + 32 deg. below freezing point, and this point of – 460 deg. is called the "absolute zero of temperature."

I have purposely neglected the small fraction of a degree, which would only complicate our illustration, the fact being that the correct absolute zero is only – 459·130 deg., and not – 460 deg., but for all practical purposes the – 460 deg. is sufficiently near, and is generally used.

You will see, therefore, the assumption is that if in an air thermometer a reading could be taken showing such a degree of temperature, we should find that the volume of the air had been reduced infinitely. Professor Clerk Maxwell, however, points out that it is almost certain, even at this temperature, the air would occupy some space, and that we can only imagine the effect of such a degree of cold, and can know absolutely nothing definitely about it. As yet temperatures of – 220 deg. Fahr., or 220 deg. below zero, are, it is said, the lowest which have been obtained even in laboratory experiments.

The text with which I commenced to-night adopts the steam engine as a standard of comparison of the relative advantages of heat engines. It is necessary we should have something that we can grasp and readily understand to base our comparison on, and we will, therefore, take the steam engine for this purpose. It is that heat engine which is most largely in use, which has been most fully considered and investigated, although there are some who tell us that we, even now, know nothing of the more abstruse points in connection with its working.

I do not at all propose to discuss this, or to delay about it, but will only use, for our comparison, the record of the practical results in efficiency which have been obtained.

Unfortunately, in taking the steam engine as our basis, we are met with the initial difficulty that such an apparatus consists, as a fact, of two distinct and separate forms of heat engine, each with its own mechanical efficiency, or rather want of mechanical efficiency. Perhaps it will be as well that I should now define precisely what is meant by "mechanical efficiency." It is that percentage of the units of heat put into an engine which is utilised by it—*i.e.*, that proportion of the total heat units, which is transposed by the machine into mechanical work, or delivered from it in such a state as to be capable of doing mechanical work.

I have already told you that a "heat unit" is the amount of heat necessary to raise 1lb. of water 1 deg. Fah. There is one more term which I shall have to define, and that is the one used by engineers when they speak of the work performed by an engine. They say it is so many "horse power."

James Watt adopted this term horse power in order to give the lay mind some idea of the work which could be done by any given engine or machine. He made many experiments as to the amount of work which a horse was capable of doing, with the result that when this work was reduced to that which was equivalent to the raising of a weight in a given time, he found that the average horse could do as much work as was represented by lifting a weight of 22,000lb., there or thereabouts, through a height of one foot in one minute of time; but so that his customers should not grumble, complaining that the engines with which he supplied them were not capable of doing as much as the number of horses which he stated was the power of the engine which he sold them, he determined to give an ample margin, and he therefore estimated each horse power in his engines as represented by a weight of 33,000lb. (an excess over the true value stated above of 50 per cent) lifted one foot high in one minute of time, or 33,000 foot-pounds. This is the horse power which the engineer commonly uses, and of which I shall have frequently to speak.

Now, as I have shown you that heat is convertible into mechanical work, it follows that a heat unit can be represented by some proportion of a horse power.

If you will remember the experiments by which Count Rumford proved that heat and mechanical work were convertible, you will realise that it would have been possible to have obtained from these some equivalent which should represent exactly the quantity of heat in a given amount of mechanical work.

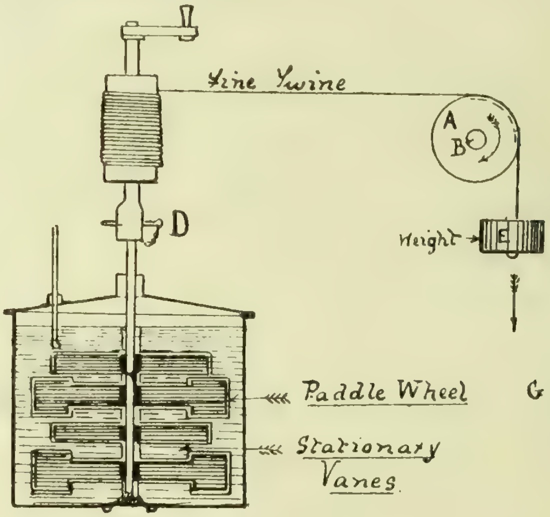


Fig. 1.

With this question of the mechanical equivalent of heat, the names of Mayer—a German scientist—and Dr. Joule are inseparably connected. About the year 1842, each of them published (Mayer as the result of calculations, and Joule as the result of experiment) a statement as to the value of the mechanical equivalent of heat.

In the year 1849, Dr. Joule, when he had been experimenting for over seven years, read a paper before the Royal Society, in which he stated that he considered it important that the relations between work and heat should be definitely ascertained, and with absolute accuracy, or, in other words, that that which we now speak of as the mechanical equivalent of heat, or perhaps more commonly as Joule's equivalent, should be ascertained with absolute certainty. He proceeded to describe the experimental apparatus which he had devised and employed for the purpose of discovering the true value of this, also describing the method of using this apparatus which he had adopted.

Shortly stated, it consisted of a series of revolving paddles (fig. 1) placed in a closed vessel containing a definite amount of water, at a given temperature, these paddles being caused to revolve in the water (and thus to churn it as it were) by means of cords passing over pulleys actuated by a falling weight or weights. Repeated experiments were made, and, as a result, it was found that a weight of 772lb., when falling through a distance of 1 foot, would increase the temperature of 1lb. of water 1 deg. Fah. Precautions were taken to measure exactly the loss of heat by radiation and conduction, and every circumstance which could possibly affect the result was taken into consideration. Dr. Joule's communication of this date to the Royal Society winds up with the following conclusions:—

1. The quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to the force expended.

2. The quantity of heat capable of increasing the temperature of 1lb. of water (weighed *in vacuo*, and taken at between 55 deg. and 60 deg. Fah.) by 1 deg. Fah., requires for its evolution the expenditure of a mechanical force represented by the fall of 772lb. through the space of 1 foot.

Please remember, therefore, that the mechanical value of a British heat unit is always taken as representing 772lb, weight lifted 1 foot high, or falling through the same distance, and that this is known as Joule's equivalent.

It follows, from what I have just said, that Joule's equivalent being 772lb. lifted 1ft. per minute, or 772 foot-pounds, and the indicated horse power being 33,000 foot-pounds, 42¾ heat units expended per minute, or 2,565 heat units per hour, is the equivalent of an *indicated* horse power. You will notice that I use the term "*indicated* horse power," emphasising the *indicated.*

You, all of you, know that the engineer is nothing if not accurate. I am sorry to have to say it, but the accurate engineer has no less than five forms of horse power of which he speaks, and unless you pin him down to telling you exactly what horse power he means—whether indicated horse power, or brake horse power, or nominal horse power, or whatever it may be—he will most likely succeed in confusing you, and probably himself. Mr. Preece and other electricians now want to put another sort of horse power upon the unhappy engineer, and they want him to have and to use a special electrical horse power. However, I do not wish to trouble you with any of these other kinds of horse power; I always propose, in these lectures at least, to speak of indicated horse power—that is, horse power developed in the cylinder, and capable of being shown by the indicator on the indicator diagram, which I shall have presently to describe.

Now, the best Welsh steam coal has been proved by frequent analysis to contain combustible material which, when burnt to destruction, would be capable of developing about 14,500 heat units for each 1lb. weight of coal; therefore, as 2,565 heat units per hour equal 1 horse power, it follows this should, theoretically, be obtained for ·17, or 16-100ths of 1lb. of such coal consumed per hour. This would be the consumption in the ideal engine; but this, as I have shown you, is an impossible machine.

Here is another instance of the lucidity, the simplicity of statement, adopted by the engineer. You will see that he states his horse-power as pounds weight lifted 1 foot high in a *minute* of time, while he talks of his fuel consumption as that used per horse-power in an *hour* of time.

Referring to our cubes again, this red cube represents the fuel utilised by a steam engine consuming practically the smallest quantity of fuel, of which there are absolutely certain records, and you will see that the horse power there is only obtained for about 1½lb., or 150-100ths, instead of 17-100ths of 1lb. of coal, and that the mechanical efficiency therefore it is not quite 1-9th, practically about 11 per cent.

Let me once more say that I am not suggesting for a moment the possibility of realising the ideal steam engine. Remember, that in order to utilise the whole of the fuel, or, in other words, to obtain an indicated horse power for 17-100ths of 1lb. of coal per hour, you would, among other impossible things, require steam of a temperature and of a pressure such as would make its density equal to that of water; while the products of combustion of the fuel which had raised the steam to this temperature must escape at the temperature of the atmosphere, and the steam must be expanded to such an extent as to bring it down to the absolute zero of temperature.

I have told you that the initial difficulty in taking the steam engine as our basis of comparison is, that it really consists of two distinct and separate forms of heat engine—the one the boiler, the other the engine itself.

Let me now show you what is really the efficiency of the engine alone and without the boiler. Look at this black cube again, and assume that it now represents the amount of heat units which are supplied to an engine using some 18lb of water per horse power hour, delivered to it from the boiler in the form of steam, at 150lb pressure, the steam exhausting from the engine, or leaving it at the pressure of the atmosphere, and therefore at a temperature of 212 deg. Now, this other red cube, which represents the efficiency of such an engine is, as you will see, much larger in proportion to the black cube, representing the heat delivered to it, than was the red cube of the efficiency of the engine and boiler combined.

These cubes represent the fuel and efficiency of such an engine and such a boiler as those tried by the judges at the Royal Agricultural Society's Show at Newcastle in 1887, or at the electric motor trials of this society. In fact, they may be called very fair, or even exceptionally good examples of the ordinary commercial high-pressure compound non-condensing engine. The efficiency of the modern quadruple-expansion marine engine is slightly greater than this, but not so much so as to affect the argument which I shall base upon these cubes.

I have purposely shown you the efficiency of the engine and of the boiler combined, and then that of the engine alone, because, as I shall have to tell you again later on, almost all of the " heat engines other that steam " are engines in which the boiler, or its equivalent, is entirely absent, and in which the heat is produced in the cylinder of the engine itself; and I am prepared to suggest that, to some extent, the efficiency of these other heat engines is due to the fact of the absence of the equivalent of the boiler, and to the fact that the heat is developed in the engine cylinder itself, and that there is no separate vessel in which it is produced.

I know that there may be quoted against this statement the fact of Watt's great invention—that of the separate condenser. Here, increase of efficiency was obtained by utilising the heat in two vessels in succession, instead of in one, and I may also be referred to the increase of efficiency in marine and other engines, due to the use of the triple, or even quadruple cylinders, in which, in succession, the steam is expanded, but I think a little consideration will show that an increase in the number of vessels in which the heat is utilised is not an advantage, *per se.*

Further, we shall find that one of the most promising suggestions for the improvement of these other heat engines is that the number of cylinders in which the working agent is used in succession shall be increased—*i.e.*, that the engine shall be made compound, or even triple compound. But you will see that these additional cylinders are intended to utilise the heat which is at present lost by passing away in the exhaust, or, in other words, the object is to increase the range of the temperature through which the engine works, not by adding to that which is initially developed, but by utilising a portion of that which is at present thrown away.

(To be continued.)

A WATER RAILWAY.

THE "SWITCHBACK" SURPASSED.

THE Paris correspondent of the *Daily News* writes: "A press view took place recently of the so-called 'Chemin de Fer Glissant,' or 'slide railway,' on the Esplanade des Invalides, within the Exhibition. The new invention is a singularly original contrivance for enabling trains to run, by means of water power, at a speed hitherto undreamt of. Arriving there without any intimation as to what a 'sliding railway' might be, I at first mistook it for an overgrown switchback, with the humps smoothed away. The train consisted of four carriages, affording room for about a hundred passengers. The carriages had no wheels, being supported at the corners by blocks of iron of a size somewhat larger than a brick, which rested upon a double line of iron girders. In the middle of the line, at regular intervals, jutted out irregularly-shaped pillars, the use of which was not yet apparent. Having taken our seats and the signal being given, we glided along very gently for the space of a few yards, when suddenly we gathered speed; two or three tugs were felt, and we were flying on at the pace of an ordinary train, but as smoothly as a boat on a river. There was a clicking noise on the rails, but this, I was assured, was due to a defect in the construction of the slides, and would be remedied. The absence of any vibration, shaking, or 'tail motion' was wonderful. A slight jerk there was at regular intervals; but then, again, I was told that it was due merely to the shortness of the course and the inability to get up a proper pace. In a hydraulic train travelling at full speed—that is to say, at the rate of 140 to 200 kilometres, or 87 to 124 miles an hour—there would be almost no consciousness of motion. The journey down the length of the Esplanade only occupied a few seconds. Upon our safe return, Mr. Pilter, chairman of the company which owns the invention, gave a full account of it. The sliding railway was invented in 1868, by an engineer named Girard, who was killed in the Franco-German War, and it has been improved to its present state by one of his assistant engineers, M. Barré. As has already been mentioned, the hydraulic carriages have no wheels, these being replaced by hollow slides fitting upon a flat and wide rail, and grooved on the inner surface. When it is desired to set the carriage in motion, water is forced into the slide or skate of the carriage from a reservoir by compressed air, and seeking to escape it spreads over the under surface of the slide, which it raises for about a nail's thickness above the rail. The slides thus resting not on the rails, but on a film of water, are in a perfectly mobile condition; in fact, the pressure of the forefinger is sufficient to displace a carriage thus supported. The propelling force is supplied by the pillars which stand at regular intervals on the line between the rails. Running underneath every carriage is an iron rack, about six inches wide, fitted with paddles. Now, as the foremost carriage passes in front of the pillar, a tap on the latter is opened automatically, and a stream of water at high pressure is directed on the paddles. This drives the train on, and by the time the last carriage has gone passed the tap (which then closes) the foremost one is in front of the next tap, the water's action thus being continuous. The force developed is almost incredible. There is some splashing on the rails at the start; but this diminishes the faster the train goes. To stop the train the small stream of water that feeds the slides is turned off, and the latter coming in contact with the rails, the resulting friction stops the carriages almost instantaneously. A water train running at over 100 miles an hour could, I was told, be pulled up within thirty yards; could climb up gradients of sixteen inches in the yard, descend them with equal safety, and run on curves of forty-four yards radius. This system would seem peculiarly adapted for elevated railways in cities, being light, noiseless, smooth, without smoke, fast, and thoroughly under command. The danger of running off the rails is reduced to a minimum, the centre of gravity of the carriages being scarcely more than a couple of feet from the rails. The cost of a metropolitan system would only be a third of one on the old plan, while in the open country its cost would be somewhat higher than the ordinary railway; but M. Barré tells me the expense would be in France an average of £8,000 a mile. Where no natural water supply is available, a propelling machine every twelve miles or so would be sufficient to keep trains going at full speed. The consumption of coal per passenger would be one-tenth only of the usual quantity. The importance of this may be realised by considering the statement that the Paris-Lyons Company alone has an annual coal bill of two millions sterling. Nevertheless, it would be rash to predict the general introduction of the water system on railways. One objection, for instance, that occurs to me is its apparent unsuitability for goods traffic. M. Percil, the manager of the Chemins de Fer Glissants, believes it will all but do away with the locomotive engine. With respect to England, he believes that the disadvantage of the present slow method of crossing the Channel will become so apparent that all opposition to the tunnel will vanish. 'I am ready,' he said with enthusiasm, 'to wager any sum that when the tunnel is made and our system is given a trial, people will go from London to Paris in two hours.'"

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

COAL-CUTTING MACHINERY.

To the Editor of "The Practical Engineer."

SIR,—The North of England Institute of Mining and Mechanical Engineers have appointed a committee to report upon the use of coal-cutting machinery, &c. I shall deem it a favour if any of your readers will furnish me (on behalf of the committee) with particulars, prospectuses, plans, &c., of any machinery used for cutting coal, and especially as to the names of the collieries where coal-cutting machinery may be seen at work.—Yours, &c., J. WALTON BROWN.

Newcastle-on-Tyne.

COMPRESSED AIR TRAMCARS.

To the Editor of "The Practical Engineer."

SIR,—In your impression for July 26th I notice you print an extract from the report of the British Consul at Nantes, as to the "Mekarski" system in use there, but as the consul is evidently not in the position to know that Mekarski's originality is doubtful, and he is not the inventor of the plan he employs of giving a dose of heat to the compressed air before it enters the cylinder, I wish, with your kind permission, to place the real facts of the case before your readers.

In order to ascertain the truth of the matter, it will only be needed to examine and compare three patent specifications, which can easily be done at any of the free libraries or institutions in the kingdom, and these are, first, the patent specification of James Glazebrook, No. 2164, of 1797; second, No 2504, granted to the same party in 1801; and third, that of L. Mekarski, No. 3498, of 1875. It will then be seen that Mekarski was anticipated in his "invention" by an Englishman, nearly a century before.

Some eight or nine years since a set of outside stock jobbers and company promoters in London got hold of this invention, and made two attempts by starting two companies, both of which failed. Fortunately, on the facts becoming known to some of the respectable persons they had obtained as directors, both schemes were quickly knocked on the head, and though they got over and put up some machinery, and had some cars made, which were designed by a great and eminent engineer, and put to work in the North of London, still it would not do either for the tramway people or the public. It is now rumoured that, after lying on the scrap heap for some two or three years, they have been removed to somewhere in the neighbourhood of Manchester, evidently in the expectation of finding the people less wide-a-wake and enlightened.

No doubt a great deal of use will be made of the opinion and influence of the eminent engineer who works with them, but before looking at the matter at all let each examine and consider the specifications I have named. Forewarned is forearmed.—Yours, &c., C. E.

London, Aug. 3, 1889.

QUERIES AND REPLIES.

53. DASH POTS.—I shall be much obliged for information on the construction of dash pots for two 4in. double-faced valves. How are they made and what is the approximate cost?—CRANK PIN.

Answer.—These consist of a cylinder with a partition in the centre, forming two separate cylinders, in fact. In this work two pistons (having no packing rings) with a trunk in front, working through a guide hole in the front cover. Around the trunk is a strong spring bearing against the piston and the front cover to bring the piston home. The back face of the piston, or opposing face of partition in cylinder, should be faced with leather to help to deaden the sound at time of contact. Each piston in coming home drives the air out of two holes in the side of cylinder, until about one-fourth of the stroke is uncompleted, when these holes are covered by the piston, and the compressed air is then driven through two smaller holes with a screw valve adjustment to regulate the speed at which the air shall escape. These adjustable valves may be made to open wide in the reverse direction when the piston is pulled out. The piston rod passes right through the trunk, and is fixed through the piston; it is made of a thin flat bar, so as to adjust itself to the movement of the lever on the valve spindle. The piston should be about 5in. diameter by 8in. stroke, large air-holes ⅝in. diameter, small air-holes ¼in. diameter, spring about 3in. diameter, ¼in. wire, ¾ pitch. Approximate cost, if all gun metal, but without fixing, about £15.—G.

61. CENTRIFUGAL FORCE.—I have been attempting to analyse the formula $\frac{W\,v^2}{g\,r}$, and have met with a doubt, which a brother subscriber will perhaps be kind enough to clear up.

A body moves in a circular path in a horizontal plane, and with a given angular velocity, and is maintained in that path by a string, whose length is equal to the radius of the circle. Required, the tension in that string, expressed in pounds.

First, I learn that, taking a very small arc of the circular path, I may without sensible error consider the body to be moving along the chord of that arc, and in so doing being pulled centripetally along the smallest side of a right-angled triangle, whose hypotenuse is the chord aforesaid; whence I understand that the speed "set up," as it were, by the centripetal pull bears the same relation to the speed along the chord as the latter ("v") in turn bears to $2\,r$. Would it then be allowable to reason as follows: The force of gravity, acting for one second, produces in a unit mass a speed of 16·1ft. per second by exerting upon that unit a pull of one pound. Each unit mass in my circular-travelling body is travelling at $\frac{v}{2\,r}$ feet per second, a speed which is x times greater than 16·1ft. per second; hence the pull which produced that speed must be x times greater than one pound, and must equal y pounds for each unit of mass in the body. If my reasoning is thus far correct, I have eliminated $\dfrac{W\,r}{r\,\underbrace{2 \times 16{\cdot}1}_{“g”}}$, and I can easily see that the pull in my string in pounds, arrived at by those elements of the formula, will increase with the speed in the proportion $\frac{\text{new speed}^2}{\text{original speed}^2}$

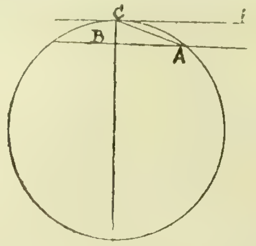
I want to feel assured that to get the pull in my string in pounds for a body whose W = 64lb., for example, moving in a circle of 2ft. radius, at a velocity of 100ft. per second $= \frac{m\,v}{g\,r} = 3\frac{1}{8}$lb.; and under similar conditions, except that the velocity is 200ft. per second, the pull will be

$$3\tfrac{1}{8}\text{lb.} \times \frac{\text{new speed}^2}{\text{original speed}^2} = 12\tfrac{1}{2}\text{lb.};$$

whereas, if I use $\frac{W\,v^2}{g\,r}$ in both cases, I simply obtain comparative values, represented by 1 and 4 respectively, and these are no guide as to the actual pull in my string. The formula last quoted is used most recklessly at examinations, and the resulting values are pressed into service as pounds, tons, anythings, because one is not told that the results are merely numerical comparisons, and not actual values expressed in any one system of units. SHINY BOOTS.

Answer.—In reply to "Shiny Boots'" question on Centrifugal Force, to determine the amount of which we may proceed as follows:—

Let CA be represented by ds = the increment or differential of the space passed over by the body in its orbit, during the increment or differential of time = dt, and let r = radius of the orbit, while v = the orbital velocity of



the body; then $\frac{ds^2}{2r}$ = BC, the increment or differential of deflexion of the body from the right line CE, while moving in the circle during the increment of time dt.

And by the law of falling bodies, $dt^2 \times \frac{1}{2}\,g$ = the space moved through by a body urged by the force of gravity during the increment of time dt. Then $\dfrac{\frac{ds^2}{2\,r}}{\frac{1}{2}\,g\,dt^2}$ = the ratio of centrifugal force to that of gravity $\frac{ds^2}{g\,r\,dt^2}$, but $\frac{ds^2}{dt^2} = v^2$; therefore $\frac{v^2}{rg}$ = ratio of centrifugal force to that of gravity.

The equation $\frac{v^2}{rg}$ we have seen to be the ratio of the centrifugal force of a given mass to the gravitating force of the same mass; the weight of which mass we may call unity. Hence the centrifugal force F of any weight W will be $F = W\frac{v^2}{rg}$, in which, as g is measured in feet per second, so also must v be, and r measured in feet; while F will be of the same denominational unit as W.

Whence, if W = 64lb., and r = 2ft., while v = 100ft. per second, then $F = 64 \times \frac{\overline{100}|^2}{2 \times 32{\cdot}2} = \frac{640000}{64{\cdot}4} = 9937{\cdot}8$lb.

Again, if $r = 1$, and the body revolves once round its orbit in each second of time, or its velocity = 6·2832ft per second, then $\frac{\overline{6{\cdot}2832}|^2}{32{\cdot}2} = 1{\cdot}226$, or centrifugal force = 1·226, the force of gravity.

And since centrifugal force (F) varies directly as the weight (W) of the body, the radius (r) of the orbit in feet, and the square of the number of revolutions (N^2) per minute.

Or $F = W\,r\,N^2 \times C$ where C is a constant.

Then, as above, when $W = 1$, $r = 1$, and $N = 60$, $F = 1{\cdot}226$.

Therefore $C \times 1 \times 1 \times 3600 = 1{\cdot}226$, or $C = \frac{1{\cdot}226}{3600} = {\cdot}00034$.

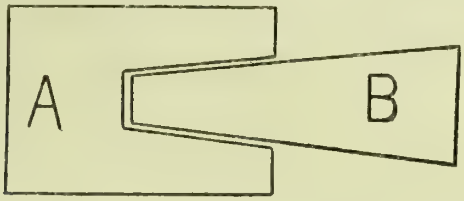
Whence the rule $F = {\cdot}00034\ W\ r\ N^2$, in which F is of the same denomination of units as W.—W. A.

63. Screwing Machine Dies.—Can any reader inform me of the best way of advancing and withdrawing dies in a screwing machine, with three die bits? The machine I have at present has four dies and cuts badly, besides making an unequal thread.—D. W.

Answer.—By all means use only three dies, and have them fixed in a die holder having a projection on one side, working in curved slots in a revolving plate. The curved slots should be arranged nearer to the centre at one end, so that on revolving the plate the dies approach one another.—G.

64. Inside and Outside Tapers.—Will some reader kindly inform me the best way to "turn" outside and inside tapers, so that they may be the same? For example, the end of a piston rod and cross-head.—Anxious One.

Answer.—"Anxious One" will find the following sketch represents one of the most satisfactory methods of gauging tapers, and one that is reliable in careful hands. A and B are pieces of thin sheet iron, the female, or part A, being made to accurately fit the finished piston rod, and the male gauge B then fitted to A, and the cross-head afterwards bored to the gauge B. In small work, the best plan is to test the boring of the cross-head by means of the rod itself.—J. R.



71. Hardening Steel Springs.—Will any of your readers kindly inform me, through your paper, the best way to harden steel wire springs?—Spiral.

Answer.—Steel wire springs must be hardened by carefully heating in a muffle made of a flat iron plate, with a U shaped iron plate on top. The whole to be put in the forge fire, covered up with fuel, and made red hot. The ends can have a flat plate against them to keep the fuel out. Heat the springs to a red heat and harden in oil. If they require letting down, place them on a hot plate and quench as soon as the required temper is obtained. Dark blue at a temperature of 550 deg. is required.—G.

Answer.—In most engineering shops springs are hardened as follows: Springs made of $\frac{1}{16}$ spring steel and cast steel springs for compression are put into the fire until heated to a blood red, and then thrown into water. After this the spring is heated over a slow fire until warm, when tallow is rubbed over it with a brush. The temperature of the spring is allowed to get higher and higher, until at last the tallow on it ignites. The hardness of the spring is now sufficiently reduced, and it is dropped into oil to cool. For cast-steel springs, up to $\frac{3}{8}$in., for tension—heat blood-red hot, and then cool out in good oil. Then take the spring and draw the temper back in the same way as before, only that the tallow on the spring has to catch fire twice, which it will do in about five seconds. The reason is that the cast steel is so much harder than the spring steel, and is very apt to snap.—Loco.

72. Book on Boilers and Templates.—Can any of your readers inform me where I can get the best book on boiler-making and templates?—Boiler.

Answer.—The writer has seen many books on boilers and boiler-making, but the only one giving reliable instruction on templates is Nicholls' "Theoretical and Practical Boiler-maker," published only by the author, which went through three editions, but is now out of print. "Boiler" will, no doubt, be able to procure a second-hand copy by advertising for it in the columns of *The Practical Engineer.*—F.

Answer.—There is a dearth of books on this subject. For templating, I should recommend "The Boiler-maker's Assistant," by John Courtney, published by Lockwood; and for a thoroughly practical book on boiler work, that of Wilson's, by the same publisher, is very reliable.—J. H.

75. Book on Screw-cutting and Gauging.—Could any of your readers inform me what is the best book to be had on screw-cutting; also one which deals with the proper travel of a gauge or inside callipers in fitting one body into another?—D. H. D.

Answer.—Hutton's "Templeton" for screw-cutting, and the old edition of "Templeton" for gauging.—G.

76. Pumps.—What is the most economical pump to use for filling a tank about 30ft. high, and containing about 9,500 gallons of water: to be filled in about eight hours? How would the Pulsometer do?—A. J. E.

Answer.—For raising say 1,200 gallons an hour to such a moderate height, I should recommend either a double-acting rotary pump, with flywheel, and the slide valve cutting off steam at five-eighths of the stroke, or a duplex pump having two cylinders and two pump barrels, the slide valve of each cylinder being mechanically operated by the piston rod of the other. This type of pump is much liked; it cannot fail to start; it works well at low speeds. It could have fitted to the suction pipe, at a trifling cost, a self-acting exhaust steam condenser, which would produce 10lb. per square inch of vacuum, thereby increasing the economy and efficiency of the pump. These duplex pumps are now made by Tangye, Birmingham, Owens, London, and Pearn, Gorton, near Manchester.—F.

78. Shearing Stress and Struts.—What is the proper allowance for shearing stress per square inch in the web of a plate girder of wrought iron, in proportion to its depth? I believe it is usual to allow a higher factor of safety as the depth of the girder increases. Also, in reference to the subject to struts, I should like to know something about the following: Assuming a wrought-iron rolled joist to act as a strut, would a strut composed of two tee bars, having together a section equal to the joist, and fixed edge to edge, have an equal strength with the joist?—Tyro.

Answer.—The allowance for shearing stress on the webs of plate girders is four tons per sectional square inch of vertical area. No higher factor is allowed as depth increases, but the fact is that we cannot make plate webs nearly so light as theory indicates, for under central, or uniformly distributed loads, the thickness of the web vanishes at the centre of the span. In regard to struts, the two tee bars would, assuming equal width and equal sectional area, be stronger than the rolled joists, for the rolled joists, chiefly of Belgian make, are notoriously rotten and in no way to be trusted. A month since I saw one fall off a wagon in Liverpool Street, London, and snap like a carrot. In my own work I never permit Belgian joists to be used.—F. C.

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73. Process for Cooling Water at Coates' Mill.—I shall be obliged for any particulars of the process for cooling water to be employed at Messrs. Coates' new mill, at Paisley.—Lever.

74. Flattening Saws and Plates.—Will some reader kindly inform me how to hammer buckles out of saws 4ft. 6in. diameter? Also if the same method does for square plates?—Blacksmith.

77. Air Pipe in Locomotive Funnel.—What effect would an elbow-shaped pipe have which was opened to the atmosphere, in front of a locomotive, at one end, and projected up the funnel at the other?—X. Y. Z.

79. Galloway Boiler.—What is the nominal and actual power of a Galloway boiler, 28ft. long, 7ft. diameter, with 33 conical Galloway tubes, and working at a pressure of 70lb. per square inch?—Boiler.

TO CORRESPONDENTS.

A. C., Paisley.—You cannot see Mr. Melvin's specification until the final is filed. The Comptroller has no power to give you any information whatever as to its nature, and you will probably have to wait for nine months from the date of application. Patentees have now to take the risk of anticipation. Your best plan is to obtain provisional protection for your invention. It costs very little; and if you find your patent anticipated, then you need not file your final specification.

Student, Cornholme.—In some cases the arm of a spur wheel will be stronger cast hollow than solid, but only when the diameter is so great that the metal draws seriously from the centre. In such cases great internal strains are set up, which weaken the metal very much.

MISCELLANEA.

British Patents.—The number of applications for patents in 1888 exceeded those of the previous year by nearly 6 per cent., and were 19,103 in number. Of designs, 25,923 were applied for, 568 of which were refused registration on account of their similarity to designs already registered. The total number of applications for trade marks was 13,315, as compared with 10,584 in 1887.

Meteorites.—Three new meteorites are reported from New South Wales, weighing, respectively, 31½lb., 48lb., and 67½lb. From former discoveries of the same kind it would seem that there, as in Northern Mexico, a great shower of aërolites had fallen at some unknown period. The natives who saw them fall would probably think what our own philosophers use to think—that they were shot from the moon.

Swedish Trade Marks Legislation.—A despatch, dated the 8th of June last, has been received at the Foreign Office from Sir F. R. Plunkett, Her Majesty's Minister at Stockholm, reporting that the decree of the King of Sweden, dated the 9th November, 1888, prohibiting the importation into Sweden of goods manufactured abroad bearing marks intended to imply that they have been manufactured in Sweden, was to come into force on the 1st July.

Colour Blindness.—The subject of colour blindness amongst seamen of the mercantile marine is one that has given rise to a considerable amount of discussion during the past few years. It is now announced that the Government have appointed a Departmental Committee of the Board of Trade to investigate the question, and, as the committee is to be provided with scientific assistance, it may be hoped that some satisfactory issue will result from the inquiry.

Sun Spots and Cheap Bread.—According to the Italian astronomer, Zacchini, the solar spots continued to decrease in number until towards the close of July. There will probably be no further decrease, the minimum being now reached. The present year is one of the years of fewest sun spots, recurring in periods of 11 years. In like manner, 1878 was a minimum sun-spot year, 1867, &c. According to Sir William Herschel's theory, since there are few spots on the sun's face, it should be a year of cheap corn.

Industrial Property Convention.—A communication, dated the 16th May last, has been received from Mons. J. H. Vernet, the Agent and Consul-General for Switzerland in London, enclosing a circular note from the Swiss Government to the effect that Switzerland has completed its legislation for the protection of industrial property, by the adoption of the two following laws: 1. A law on invention patents, of the 29th June, 1888, which came into force on the 15th November following. 2. A law on industrial designs and models, of the 21st December, 1888, which came into force on the 1st June, 1889.

Salicylic Acid.—An interesting discovery respecting salicylic acid has been communicated to the Chemical Society by Dr. Griffiths. He has extracted this substance from the leaves and stems of tulips, hyacinths, and other plants of the lily order. The occurrence of this organic acid in nature has long been known, and, notwithstanding the artificial methods of preparing it, the acid got from the plant winter-green (*Gaultheria procumbens*) is still preferred by medical men, because of its greater strength and purity. But it was not known to exist in plants of the *Liliaceæ.*

Gas Lighting in the North-Eastern Railway Trains.—The gas-lighting apparatus adopted some time ago by the North-Eastern Railway Company on two trains running on the Tynemouth line having given great satisfaction, the system is being further developed. One train on the Hartlepool line has been furnished with an installation, and the system has also been applied to a train running daily between Carlisle and Newcastle. The company have thus four trains running daily now, which are at night-time illuminated with gas, and it is intended gradually, as circumstances will permit, to still further extend this system of lighting on the company's lines. In all probability the mode of lighting the carriages with oil will, in the course of a short while, be abolished.

A New Sight-feed Lubricator.—Messrs. Woodhouse and Rawson are manufacturing a new sight-feed lubricator (Fairbairn's patent), which is said to possess all the advantages of other sight-feed lubricators, without the disadvantage of the necessity of fixing to a steam pipe. It is perfectly independent, and is applicable to any bearing or other working surface, and the position of the rod above the cup clearly indicates to an attendant at a distance the amount of oil contained in the lubricator. The cover on the top of the oil cup is removed and the piston drawn out; the cup is then filled with oil, and the piston and cover replaced. An adjustment screw allows any desired number of drops of oil per minute to float up through water contained in a glass tube at the side, from the top of which the oil flows down a small metal tube to the stem below.

The Locomotive a Fire Engine.—It is stated that the Pennsylvania Railroad Company has decided to make another innovation in its service by placing on engines a connection with the steam pump, by which a hose can be attached, and in case of fire be of great service. Whenever a smash-up or wreck of passenger cars takes place, especially in the winter, when the car stove is doing its best, a great many lives are lost by fire. The new arrangement, it is hoped, will prevent a great many casualties. A few days ago it was given a test. The apparatus was attached to an ordinary shifting engine, and at a given signal the pump was put in motion. The hose, which will be about the length of six cars, will be carried on the tender. It is also proposed to equip the crews of the various trains, and train them in the fire drill. If they prove successful, a number of passenger engines will be equipped.

A Tramcar Starter.—Every time a tramcar is started from a state of rest—and this happens many times during every journey—a distressing strain is put upon the horses, which tells upon them and makes horseflesh a very heavy item of expenditure in tramcar service maintenance. Several unsuccessful attempts have been made to produce a mechanical contrivance which would assist the horses by imparting an initial motion to the car at the moment of starting. This is now satisfactorily accomplished by the tramcar starter of Messrs. Vereker and Yeates, which has been in use for the past six months on a car belonging to the Southwark and Deptford Tramway Company. The apparatus consists mainly of a coiled spring in connection with a clutch arrangement and a spud on the driver's platform. A simple movement of the driver's foot will throw the apparatus into or out of gear, and one revolution of the car wheels is sufficient to charge the spring for the purpose of restarting. On starting the car, the first forward movement of the horses causes tension on the traces and at once releases the spring, which, acting upon the wheels, causes the car to move gently forward several feet, the car, in fact, following the horses up. The apparatus, when being wound up, acts as a powerful brake; it can be used as an emergency brake, and can be operated from either end of the car. One of these starters is now being fitted by the London Street Tramways Company to one of their cars. The invention is being introduced by Mr. John Record, of 5, Frederick's Place, Old Jewry, London.

Argentine Railway Statistics.—A despatch, dated the 3rd June last, has been received at the Foreign Office from Mr. G. F. B. Jenner, Her Majesty's Minister at Buenos Ayres, enclosing copy of a table extracted from the *Nacion*, showing the number of kilometres run and the passengers and merchandise carried by the Argentine railways during the 10 years 1878-87. The following is compiled from the table in question:—

Year.	Kilometres run.	Number of Passengers carried.	Quantity of Merchandise carried.
	No.		Tons.
1878	2,261	2,644,022	731,823
1879	2,261	2,762,375	779,739
1880	2,311	2,929,034	802,428
1881	2,479	3,309,447	991,268
1882	2,607	3,631,717	1,299,504
1883	3,122	4,042,610	1,870,578
1884	4,107	4,808,344	2,316,811
1885	4,860	5,688,087	2,678,018
1886	6,590	6,332,115	2,582,745
1887	7,415	8,229,150	3,732,309

The above statistics refer to the following railroads: Western of Buenos Ayres; Southern; Northern; Ensenada; Andine and Great Western; Buenos Ayres and Rosario; Central Northern; Western of Santa Fé; Central Argentine; East Argentine; Pacific; Santa Fé Colonies; Central of Entrerios; First of Entrerios.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

July 16th.

11370 Friction Gear, E. Jensen, Essex.
11392 Stamping Press, R. Wilson and J. J. Robins, Derby.
11393 Iron and Steel, T. Parker, Manchester.
11395 Petroleum Engines, J. W. Hartley, Birmingham.
11403 Bricks and Brickettes, N. Procter, A. Middleton, C. E. Fraser, and H. M. Carter, London.
11406 Sheet Metal, E. Norton and J. G. Hodgson, London.*
11408 Lubricators, W. F. Mattes, London.
11412 Brakes, H. J. Haddan, London. (J. J. Lappin, Canada)*
11413 Steam Boilers, H. J. Haddan, London. (A. Stirling, United States.)*
11419 Electric Meters, Siemens Brothers and Co., Limited, London. (Siemens and Halske, Berlin.)
11424 Type-writers, J. N. Maskelyne and J. N. Maskelyne, jun., London.
11426 Electric Motors, P. A. Newton, London. (W. Main, United States.)*
11431 Presses, R. W. James, Brockley, Kent.

July 17th.

11432 Gas, C. McKenzie Dowie and A. L. Briggs, London.
11435 Steam Engines, L. St. Lawrence Pendred, Colchester.
11442 Anti-galvanic Bushes, W. Menzies, London.
11447 Flywheels, L. W. Lord, Rochdale.
11466 Indicating Pressures, H. H. Chapman, London. (J. Donaldson, Australia.)*
11472 Rock-drilling Machinery, W. Walker, London.*

July 18th.

11486 Pumping Engines, W. Cameron, Maryport, Cumberland.
11487 Pumping Engines, C. W. Burton, London.
11488 Steam and Water Drums, J. Mills, Prestwich.
11489 Keys, G. Richards, Altrincham, Cheshire.
11490 Piston Rings, W. S. Freeman, Kent.
11497 Cutting Metals, W. W. Hulse, London.
11502 Pumps, A. J. Boult, London. (F. Saurer & Sons, Switzerland.)
11507 Stopping Steam Engines, W. L. Wise, London. (The Lochgau Sohlennägelfabrik, Hold and Braun, Germany.)
11511 Nut Locks, E. Oberwarth, London.
11517 Wood-planing Machines, G. Hopkins, London.
11518 Gases, A. T. Clarksen, London, and J. B. Spurge, Essex.
11522 Indicator, L. Gros, London.
11525 Drying Grain, J. Sleeman, London.

July 19th.

11527 Metal Tubes, R. O. Styles and F. Wheeler-Brown, Dalston.
11530 Water Gas, J. Enwright, London.
11532 Steam Chest, T. C. T. Shaw and J. W. Shaw, Dudley, Worcestershire.
11539 Drain Cock, R. W. Fieldwick, Kilmarnock.
11542 Governors, A. Fletcher, Ashton-under-Lyne.
11545 Cocks and Valves, H. Edwards, London.*
11550 Pistons, W. Lockwood, London.
11560 Steering Gear, W. H. Harfield, London.
11565 Carbonic Acid Gas, J. Childs, London.
11571 Brakes, C. Gordon, Glasgow.
11574 Insulators, W. J. L. Hamilton, London.

July 20th.

11591 Signalling, W. Armstrong, jun., Durham.
11595 Purifying Water, G. W. Allen and H. J. A. Bowers, Manchester.
11599 Firebars, T. F. Passman and J. Taylor, Middlesbrough.
11600 Separating Water from Steam, A. G. Brown, Liverpool.
11601 Steam Generators, A. G. Brown, Liverpool.
11610 Fuel Blocks, W. Hubbard, London.*
11615 Conduits and Rails, F. H. Reed and G. N. McKibbin, London.
11617 Guns, Per Nordenfeldt, London.
11620 Hydraulic Plunger, J. H. Thomas, London.
11621 Railway Rolling Stock, F. H. Addis, London.
11622 Governors, A. Féron, London.
11624 Gas, F. J. Jones, London.

July 22nd.

11637 Signalling, J. Hodgeson, Liverpool.
11638 Nails, H. Peck, London.
11639 Machines, J. M. Black, London.
11646 Steam Engines, W. J. Norris, Leyton.
11647 Air Gun, J. Tourtel, London.
11652 Pneumatic Appliances, R. K. Boyle, London.
11654 Consumption of Smoke, J. Drabble, Edmonton.
11655 Railway Rails and Chairs, Surrey.
11661 Batteries, C. Huelser, London. (H. Mestern, Germany.)
11664 Explosives, Sir F. A. Abel and J. Dewar, London.
11673 Signals, G. Brocklebank, Surrey.

July 23rd.

11687 Drilling Machine, R. Wilson and J. J. Robins, Derby.
11689 Treadle Motion, W. H. Doughty and W. Nagle, London.*
11696 Valves, J. A. Fletcher, S. Fletcher, and J. Fletcher, Ashton-under-Lyne.
11697 Automatic Grip, H. Emanuel, Surbiton.
11706 Feed-water Heater, J. D. Sullivan, London.*
11709 Steam Taps, A. S. Williams, Manchester.
11711 Safety Fuse, J. Altschul and R. H. Punshon, London.
11722 Spanners, J. Woodward, London.
11723 Pneumatic Percussion Tools, T. Thorp and W. J. Crossley, London.
11726 Steam Boilers, D. T. Lawson, London.
11727 Steam Engines, H. Grafton, London.
11731 Metal Pipes, H. H. Lake, London. (O. Knapp, United States.)
11732 Electric Telegraphs, F. Anderson, London.*
11735 Steam Boilers, F. B. King and N. B. Clarke, London.*
11736 Compressing Air, C. A. Jensen, London. (D. Dudley, United States.)*
11748 Explosives, J. H. R. Punshon and F. Parker, London.
11749 Governor, C. T. Guthrie, London.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE

PRACTICAL ENGINEER,

AUGUST 16TH, 1889.

SUBMARINE TELEGRAPHY.

THE development of the art of submarine telegraphy has occupied the attention and energies of some of the most original and distinguished men of all countries during the past forty years, and the combined ingenuity and industry of electricians, mechanics, and engineers have produced the present comparatively perfect system in use throughout the world. To no single person or country can be awarded the whole credit for overcoming the numerous difficulties to be dealt with before success was attained in communicating electrically by cable laid deep in the ocean bed; but of those now living who contributed to the work, it is generally admitted that Sir William Thomson occupies the leading position. So far as the design, construction, and laying machinery for ocean cables are concerned the credit is mainly due to the late Sir Chas. Bright, the late Sir C. W. Siemens, and the late Mr. Newall; but the electrical instruments for sending, receiving, and recording messages, as well as the principal modes of testing cables, are entirely Sir William Thomson's invention.

The first cable of any importance was that laid in 1850, to connect Dover and Calais, which immediately failed from some defect in the insulation. In 1851, however, it was again laid, and operated successfully. The difference between so short a cable and the usual air lines was not sufficiently great to cause any serious trouble in the use of the ordinary telegraphic instruments. It remained for the long cables to prove that the conditions of electric transmission under water were by no means identical with those occurring on land.

The first attempt to stretch across the Atlantic was made in 1857, starting from the Irish coast, but after paying out 350 miles the project was abandoned, as the cable parted in a gale.

In 1858 a cable was laid to Newfoundland, but it was only worked for a few days. In 1865 another attempt was made, this time with the Great Eastern, which was fitted for the purpose with three large cable tanks, carrying in all 2,300 miles of cable; but, after many minor mishaps, the cable parted 1,000 miles on her voyage. During 1866 the attempt was renewed, this time successfully, and a cable was laid from Valencia Bay, Ireland, to Heart's Content, Newfoundland, a distance of 1,670 knots, and in this year the lost cable of the previous year was picked up, spliced, and completed. From that time till now continuous communication has been kept up between Britain and America, and now ten cables cross the Atlantic whose position and actual condition is known with almost perfect accuracy.

A well-known American telegraphic electrician, Mr. P. Bernard Delany, has recently delivered a lecture before the members of the Franklin Institute, in Philadelphia, in which he describes some improvements in the system of working submarine cables which he proposes to introduce; and as the subject is an important one, we think it will interest our readers to describe briefly the principal system at present in use in order to understand Mr. Delany's expected advances.

The main difference between land wires suspended in air and submarine cables lies in the speed of transmission of the impulse. From a number of causes, some of them very abstruse, a current passing through an ordinary wire through air moves much more quickly than one passing through a cable under water. The difference is very considerable, so that an electrical impulse originated here takes about one-tenth of a second to cross the Atlantic. If the same distance be travelled in air it only takes about one-hundredth of a second ($\frac{1}{100}$ sec.). This slowness would not greatly affect the rate of transmission of signals but for the additional fact that the impulse is not sharp, as with land wires, but partakes more of the nature of a wave, rising slowly to a maximum and falling slowly from that maximum, so that a signal made at this end by a rapid contact and break is not so instantaneous at the receiving end, but is to some extent muffled. Two main causes produce this effect: the first is the inductive action of the current upon the iron wire wrapping used to protect the insulating material surrounding the copper core of the cable, and its effect also upon the water surrounding it. A current is thereby induced, tending to resist the movement of that in the core. As the insulation must be very perfect, the cable resembles a Leyden jar, and it has a certain static capacity, just like such a jar, so that a certain time is required for discharge, once the cable is electrically charged. The effect of these causes is to delay and muffle the impulse when transmitted, and to keep up the flow to some extent after the communication with the battery has been cut off at the sending end.

Ordinary telegraphic instruments were found to be much too insensitive to use with the currents possible in cables, and Sir William Thomson designed the first satisfactory instrument to suit the new conditions. It is known as the Thomson reflecting galvanometer. It consists of a very small steel magnet, to which is fastened a very light mirror. The magnet is attached behind the mirror, and both are suspended by a single thread of unspun silk in a space in the interior of a coil of fine insulated copper wire. The magnet is about ¼in. long, and, together with the mirror, which is very thin, weighs only a few grains, sometimes as few as five grains. The magnet naturally tends to take a position due north and south, and the instrument is adjusted so that when out of use the plane in which the wire is wound is parallel to the needle. Any current sent through the wire at once causes the magnet to be deflected, and the direction of the current determines the direction of deflection of the magnet. A beam of light from a fixed lamp is allowed to fall upon the mirror, and it is reflected to a screen, causing a spot of light upon the screen, which is stationary so long as the mirror does not move. This stationary or zero point is the place where the reflected light strikes when no current or signals are sent to the instrument. When a current is sent the light spot moves to one side or the other, as may be determined by the nature of the current. Accordingly, two keys are used by the sending operator, instead of the single key common in land work; one key sends a current from the positive, and the other a current from the negative pole.

This instrument is extremely sensitive, but the work of the receiving operator is exceedingly onerous and tiresome; he must remain in a dark room watching the tell-tale spot of light without removing his eyes from the screen. As no sound gives warning that a message is to follow, and the only indication is the movement of the spot of light to the left or right of the zero point, his attention is always on the strain. Besides, no record is left, and an error once made can only be corrected by repeating the message.

To remedy the defects of this system, Sir Wm. Thomson invented another instrument known as the siphon recorder, which has the great advantage of producing a permanent record upon a strip of paper, like the tape machine on land. The current available is so very feeble that the mechanical power available at the end of the journey across the Atlantic is exceedingly minute, and the knowledge which Sir William has brought to bear upon the solution of the problem is not merely that of an eminent and learned scientific discoverer, but likewise that of the skilled and ingenious mechanic, alive to all the most refined and beautiful mechanical contrivances. His invention is a perfect marvel of mechanism and arrangement. Its leading idea is very simple. If the mirror galvanometer be supposed to exist without the mirror, but with a fine silk filament attached to the magnetic needle at one end, and a pen resting upon a moving strip of paper at the other end, so long as the pen charged with ink rests upon the moving strip under it a straight line is drawn, but if it is drawn to one side or the other, and then returns, a more or less wavy line is produced. The number and relative position of these waves determine the letters signalled. Of course the current is much too feeble to give power sufficient to move any pen, however delicately hung, so this difficulty is met in a most ingenious way. If a glass tube be softened in a blow-pipe flame, and then suddenly drawn out, a very fine filament can be produced, which is really a capillary tube. This tube may be made of any desired fineness, as thin as a hair if necessary. The pen is made from one of those hair tubes, bent to form a siphon. One end of the siphon dips in a vessel filled with ink, and the other end rests upon the moving strip of paper. The fine silk filament connects the siphon to the suspended magnet, and its movement pulls the siphon either to one side of the line or the other, and so the written record is made. The contact of the end of the siphon upon the moving paper would cause too much friction, so this also is met very cleverly. A generator of statical electricity charges the ink continuously, and the end of the siphon is attracted to the paper until it touches it, then repels it, and is attracted again, and so on. In this way it is constantly vibrating just clear of the paper, and it is easily swung to and fro by the current. We have described this machine as a modified mirror galvanometer, in order that it may be readily understood, but it differs from that instrument in reversing matters at another point. The magnet would not give power enough to work the siphon, delicately hung as it is, so it is replaced by a very fine coil of wire hung between the poles of two powerful electro-magnets, and strained slightly by weights to rest in one position. The current from the cable is sent through this coil, and as it is positive or negative in direction, so does the coil move either to one side or the other.

This instrument works admirably at an average speed of a little under fifteen words per minute on long cables, but if this rate be exceeded the tracing, or record of wavy lines, is indistinct and liable to be misunderstood. The difficulty is caused by the interference of the signals one with another. If, for example, three succeeding impulses be sent through the cable of the same polarity, intended to give three movements to one side of the straight line, then the second and third may not appear on the record at all, but only result in keeping the line straight to one side instead of giving three separate waves, because sufficient time has not been given between the succeeding impulses to discharge the cable. When opposing currents succeed each other this difficulty does not exist, because the first work of a current of opposite polarity is to neutralise the static charge and bring the siphon to zero, then to swing it to the other side. If the signals could be so arranged that no two succeeding signals were sent by the same current, but that opposing currents always alternated, then the cable would require no time for discharge, as it would be brought to equilibrium at once. But this cannot be done, because the number of signals to determine all the letters of the alphabet would be unduly multiplied.

Mr. Delany proposes to improve upon Sir William Thomson by neutralising the cable charge after every signal by administering an equal but opposite charge, and so causing the cable to be cleared for the next signal impulse. To accomplish this he arranges a species of revolving commutator, which acts in connection with the signalling key, and sends into the cable from a condenser a measured charge at regular intervals succeeding the signalling impulse, and of opposite polarity. This charge is just sufficient to neutralise the static charge, and no more; if too great, it would be really a signalling charge, and give rise to confusion by signalling at the wrong time. In this fact will be found, we are of opinion, the weak point of the invention. The danger seems to us to lie in the difficulty of adjustment of the neutralising charges. However, with his arrangement, Mr. Delany has succeeded in transmitting thirty words per minute over the Anglo-American cable between Duxbury, Mass., U.S.A., and St. Pierre, Island of Miguelon, a distance of 878 miles, and by a modification he has even succeeded in reading by sound twenty words per minute. These results seem to be greatly in advance of ordinary cable rates of transmission, and are of so encouraging a kind as to justify further effort to overcome the practical difficulties of general application. The improvement of our ocean cable service is of the greatest importance from an engineering and industrial point of view, and we wish Mr. Delany every success in his interesting and valuable work.

A REMARKABLE CHEMICAL DISCOVERY.

Mr. M. Carey Lea has submitted to the Franklin Institute, Philadelphia, samples of a novel form of metallic silver, just discovered by him. In the course of his experiments he has discovered that a modification of metallic silver can be prepared, which is readily and abundantly soluble in pure water. This conclusion, if correct, is a most remarkable and important chemical discovery. We are unaware of any other instance in the whole range of chemical science where a metal in the free state—that is, without being chemically combined with some other substance—can be made to dissolve in water without change. Many metals dissolve in water, but only by decomposing the water and becoming themselves converted into oxides or hydrates, but we are unaware of any metal dissolving freely in water as a metal without chemical change. Ordinary silver, however finely divided, is not soluble in water, and is not at all susceptible of chemical change, so far as oxygen is concerned. It is true that what are called "allotropic" modifications of elements—that is, chemical elements which, while containing nothing else in combination, yet exist in widely varying forms—cannot be identified by physical properties, and generally vary widely in chemical ones. But in this case not only does the new form of silver differ in properties so greatly from the ordinary metal, but it differs from all other known metals. However, the evidence seems strong and convincing. If a solution of silver nitrate be treated with a solution of ferrous citrate, then silver is precipitated in the form of a blue-coloured powder, which may be washed with a solution of nitrate of ammonia, in which it is perfectly insoluble. If the precipitate is now placed in water, it dissolves at once, and forms a solution which is blood red. The substance, when analysed, gives some 98 per cent of silver; the other two per cent is impurity. This property of metallic silver dissolving freely in water without chemical change is most remarkable. Mr. Lea has discovered another form prepared by the reduction of silver tartrate by ferrous tartrate, which ranges from gold yellow to copper-colour. As these modifications of silver deposit in mirror form, they may possibly be applied to some industrial purpose. The stronger acids at once convert any of the modifications into ordinary silver. Mr. Lea's results are important and interesting from a scientific point of view, and may even lead to some valuable industrial use.

RE-USING EXHAUST STEAM.

The persistence with which an exploded error is revived and exploited over and over again is well illustrated by the numerous attempts which have been made to return exhaust steam from an engine to the boiler without condensation, in order to save the heat stored up in it, and to use the steam in the engine again. Attempts of this kind have been very numerous in America, and, according to the *Boston Post*, the great discovery of storing exhaust steam has again been made. We are told "that very little fire is required, as the exhausted steam is saved."

Many of our readers will remember the astonishing fiasco of the "Marchant" engine a few years ago. We well recollect our surprise on visiting the Inventions Exhibition, in 1885, to find a wonderfully complex steam engine at the end of the main gallery, backed up by a prominent announcement, in letters at least one foot high, to the effect that this engine consumed 80 per cent less coal than the best form of modern steam engine; that is, it purported to use only one-fifth of the fuel of our best steam engines. This means, taking even as high as 2lb. of coal per I.H.P. per hour as the best ordinary performance, a consumption of coal of considerably under half a pound per I.H.P. per hour. All practical engineers were, of course, utterly incredulous, knowing well from experience that such economy was simply impossible. The patentee arranged a complex series of pumps, which compressed the exhaust steam, so it was said, up to full boiler pressure, and by other contrivances of a quite unintelligible nature, he stated that he saved the whole or most of the latent heat of the steam, and so economised fuel. No test of the engine was made during the exhibition, but a year or so later an electrical contemporary took an interest in the matter, and published a test made in the presence of one of their representatives, and signed by some twenty engineers of more or less reputation, who were also present. According to this the engine consumed only three-quarters of a pound of fuel per brake horse power per hour. It was only after repeated subsequent discussion that the testing apparatus was thoroughly examined. It was then found that the friction brake was so arranged that it registered two or three times the power developed by the engine, and when all was properly adjusted the consumption was over four pounds instead of under one. During the test the lower part of the brake was in water, in which was immersed a contrivance which relieved the brake of the weight which otherwise appeared to be taken by it.

In face of the warning both of practical failure and theoretical impossibility, it is most foolish that uninformed inventors should waste their energies on the impossible. Clever men, however, have been deluded by this vain hope, as those of our readers who are curious upon the subject can easily discover by referring to Bourne's large work, published a good many years ago, upon steam, air, and gas engines, where experiments of this kind, by an inventor so well known as Robertson, of friction-gear fame, are fully described.

GAS FIRING FOR STEAM BOILERS.

In another column we publish a letter received from Mr. Alfred E. Fletcher, H.M. Chief Inspector under the Alkali, &c., Works Regulation Act, from which we are pleased to find that gas producers are not advocated by him as being economical in themselves. He is in entire agreement with us in the statement that gas producers lose at least 30 per cent of the total heat of the fuel used, which heat is not recovered when the gases are burned under a boiler. Mr. Fletcher looks to Mr. Mond's system, in which a large amount of ammonia is saved, to compensate for this loss of heat, by producing an equivalent worth at least as much, and possibly more, money than the lost coal. By this he hopes that steam users may be able to enjoy the luxury of gas-fired boilers without the heavy additional cost at present involved. In the interests of pure air, we wish Mr. Mond's system every possible success, and hope that it may give substantial aid in solving the difficult but important smoke question. We would point out, however, that Mr. Fletcher's opinion is in distinct opposition to that of most inventors and makers of gas producers. In many circulars and statements published, referring to gas producers as applied to steam boilers, a great economy is invariably claimed. This claim we know from experience is quite contrary to fact, as many steam users who have adopted gas producers have no doubt found to their cost. There are many advantages in gas firing for steam boilers, but with ordinary producers economy is not one of them, and accordingly we agree with Mr. Fletcher in welcoming Mr. Mond's process as avoiding loss.

A NEW MARINE ENGINEERING JOURNAL.

We have before us the second number of a new monthly journal devoted to marine engineering and shipbuilding, published in Leith, and edited by Mr. John Lockie. It is nicely got up, and contains a great deal of interesting as well as a fair amount of original matter. There is room, no doubt, for a monthly journal specially devoted to this branch of engineering, and we wish the new venture every success. The new paper is entitled the *Steamship*.

THE PARIS EXHIBITION.

(*From our own Correspondent.*)

We have now traversed the whole length of that portion of the Quai d'Orsay within the boundaries of the Exhibition, and we now find ourselves at one extreme of the Agricultural Galleries, near the Esplanade des Invalides. But before leaving this part we may mention the English machine bakery, erected by Messrs. J. Baker and Co., engineers, of London. It is in actual operation, and the products—both bread, biscuits, and sweets—are sold to the public. The various machines, and one of the furnaces, are actuated by a six horse power Otto engine, by Messrs. Crossley, of Manchester. We may mention, for the benefit of the English visitor, that the bakery is the only part of the Exhibition we can discover where a good cup of tea can be obtained. The consumption of tea in France is very small compared to what it is with us, and the French consequently do not understand its preparation. If one orders it at any of the numerous cafes here we get very poor tea, for which a high price is demanded. We shall illustrate the more interesting of Messrs. Baker's machines fully on another occasion, but here we may say that a great deal of mechanical ingenuity has been brought to bear upon the perfecting of the various details, so that the art of baking has become quite a branch of engineering science.

Leaving the Agricultural Galleries, we take our seats on the Decauville cars, and soon arrive once more at the Great Machinery Hall or the Palais des Machines. Before leaving the British Section we shall describe several important exhibits which have not been yet mentioned, and first we may state that the Frictionless Engine Packing Company, Manchester, display a very effective assortment of their well-known specialties in engine packing. This packing combines many valuable properties. It is self-lubricating, cannot char or harden, and it stands any steam pressure or degree of heat which can occur in engine work. We propose to refer to this company's exhibit later on.

Messrs. W. and T. Avery's stall should not be overlooked. At it they exhibit several new and most ingenious machines, in addition to examples of their ordinary weighing machine practice. Snelgrove's electrical automatic weighing machine, exhibited for the first time, as constructed by Messrs. Avery, is exceedingly ingenious and beautifully worked out. It is intended for application to weigh bridges or platform weighing machines of any kind using the steelyard, and the main purpose is to make all the actions automatic and at the same time rapid and accurate. To accomplish this the movable poises which are now very commonly used on steelyards are automatically actuated by an electromotor, which is put in motion by a current from a battery. The steelyard is so arranged that when any load is placed upon the platform it at once rises and makes electrical connection with a battery, which starts the electric motor and moves out one of the poises. If, at any position upon the beam, this poise can balance the weight, the steelyard at once falls, and the circuit is interrupted; this causes the poise to stop at once, and its position at once indicates the weight of the load. By most ingenious devices the machine is arranged to bring a second and even a third poise into action, so that it is able to weigh any load from a few pounds up to twenty tons. We have many times watched the operation of this clever machine with great pleasure. It is marvellous to note the rapidity with which its poises move until the weight is balanced and determined. The slow attempts of ordinary hand weighing seem clumsy and inefficient compared with the unerring rapidity with which these weights move at once to the correct place, and settle there with the beam gently in balance. It is almost human in its apparent intelligence. When the weight is removed from the platform the electrical action is reversed, and the sliding weights or poises at once move back to zero. There are two machines at Messrs. Avery's stall, one for English weights and one for French. The former weighs up to ten tons, the latter to 500 kilogrammes. Indicating attachments are provided, which show in clear figures upon dials the weights upon the platform, or rather the weight corresponding to the position in which the poises stop upon the steelyard.

This automatic weigher should be extremely valuable, as it is quite beyond prejudice, and has no bias in either one direction or the other. Another interesting machine shown by Messrs. Avery is their automatic gunpowder-weighing and cartridge-filling and wadding machine. This also is a marvel of mechanical ingenuity. Messrs. Avery hold, and in our opinion with justice, that the only really accurate method of apportioning the gunpowder charge to cartridges is by weight, and that the method of measurement at present used by our arsenal authorities is essentially crude.

The machine shown is capable of charging accurately and wadding 100 cartridges per minute, and it contains six weigh-beams only. As the action of all these beams and connections is the same, it will simplify matters if we describe one set only, which set contains all the essentials of the machine. To begin with, the cartridge-cases are fed into a long tube and rest in a pile one on the other; at one revolution of the machine a slide moves forward, seizes a case, and brings it under a small hopper suspended delicately at the end of a weigh-beam, and a door is opened through which the weighed charge falls into the case; it is then moved on and passes under a punch, which at the proper time cuts out a disc from a strip of wadding, and forces it into the cartridge above the powder. The cartridge is then withdrawn by ingenious mechanism, which arranges the filled cartridges in long trays, each resting in a separate hole or recess, and which causes the machine to be stopped when a tray is filled until a fresh one is put in place for receiving. The gunpowder is fed into a large hopper, and flows from it into the small hopper at the end of the weigh-beam until it is just overbalanced, when the movement closes a door, which prevents any further supply until the beam rises again after emptying into the cartridge. This is a mere outline of the operation of this ingenious machine. Many pretty devices are used in it to save time and secure accuracy in weighing and discharging the powder, and also in cutting the wadding at the proper time and forcing it into the cartridges.

The gunpowder-weighing machine and the automatic weighing machine are beautifully got up in brass, and fitted within glass cases to show the whole action going on.

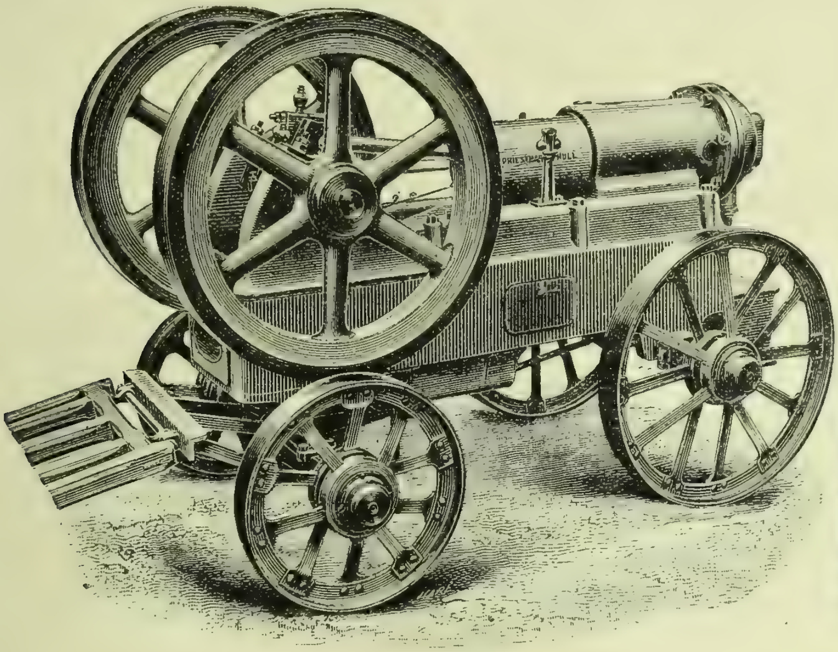
There are many other displays of ingenious machines in the British Section of the Machinery Hall, among them Messrs. Elliot Brothers, of London, show a couple of exceedingly interesting inventions. The first is a novel signalling apparatus for use on shipboard, constructed under Willis's patent. It is intended for use in steering and in the engine-room, and is known as the new electrical signalling apparatus for shipboard. When used for signalling orders from officers to steersman, it consists of the usual signalling lever and dial, one beside the officer and another near the steersman. The lever is put in any desired position, port or starboard, and at once a bell rings, and a finger moves showing the number of degrees port or starboard to which the helm is to be placed. When the order has been complied with a return current, controlled by a connection to the rudder, moves a second finger at the officer's end, so that when he has given an order he can at once see by inspecting his dial that the order has been complied with, and in what time. That is, after giving an order by signal the movement consequent on that order is signalled back, and the indicator informs the officer that the rudder is so many degrees to port or starboard, as the case may be. As applied to engine-room signals the arrangement is very similar, but in this connection another ingenious contrivance is shown, which may prove exceedingly useful on shore as well as at sea.

It is a new speed and direction indicator, which shows the speed at which any shaft may be revolving, and the direction of movement at the same time. It is not of the centrifugal governor kind, but is an electrical machine, which actually counts the number of revolutions when wanted of a shaft revolving at any distance from it. Essentially it consists of an accurate clock, and an electrical make and break arrangement which moves a counter, and indicates the number of breaks in a given time. The instrument we inspected was connected up to the main shaft of the Machinery Hall, and we took the speed of that shaft several times by its means.

To get the speed of the shaft, a button is pressed down to make the electric connection, and the clock measures off one quarter of a minute. The contacts are made four times for every revolution of the shaft, so that in a quarter of a minute the indicator reads four times the revolutions the shaft has made—that is, the number of revolutions per minute. The gear is arranged to run for a quarter of a minute only, so that the counter stops in that time precisely. If the speed is required again, the button must be released, when the counter moves its figures back to zero, and when it is pressed down again the correct last reading again appears. The instrument accomplishes mechanically what one does by hand when counting the revolutions during a given time, as determined by a watch. Its use is most obvious. At any time the captain, in his cabin, can press down a button, and in a quarter of a minute he reads upon a dial the rate at which the engines of his ship have revolved during the past quarter of a minute. In this way he can at once check the engineer in charge, and know independently the revolutions per minute at any time. The same instrument can be applied to mills, and will enable the manager to know from his office the speed of the engine, so that he can detect any extreme variation which may occur. The mechanism is exceedingly simple, and easily applied.

PRIESTMAN'S PORTABLE OIL ENGINE.

The Priestman oil engine is one of the few petroleum engines at present produced which use the common petroleum oil of commerce of the same density, and with as high a flashing point, as that used in mineral oil lamps. Most so-called petroleum engines utilise only petroleum spirit or benzoline, which is easily vaporised, has a low flashing point, and is consequently very dangerous. The general arrangement of the engine is similar to that of a gas engine, and the cycle of operations is the same as that of the Otto. The power is obtained from an explosive mixture produced by vaporising the oil and mixing it with hot air. The mixture so formed is taken into the cylinder and compressed, and then fired by the electric spark. The hot exhaust gases leaving the engine heat up the vaporiser and air heater, and so the application of external heat is avoided after the engine is once started. The engine can be used for any purpose where motive power is required, and is particularly suitable for isolated districts where coal or gas is difficult to get, or where both are moderately expensive. In vol. ii, page 343, we have already illustrated the ordinary form of this engine, and here we show Messrs. Priestman's latest design, as applied for use as a portable engine.



Priestman's Oil Engine.

Such engines have many advantages, such as the entire absence of danger and the capacity to run without attention for long periods. A very important proof of the absence of danger is the fact that the fire insurance companies ask no extra premium where they are used. The cost of working, too, is very low, as the oil consumption is very small. Messrs. Priestman inform us that the engines use as little as 1·2 pints per actual horse power per hour, or less than 1d. for oil per horse power per hour.

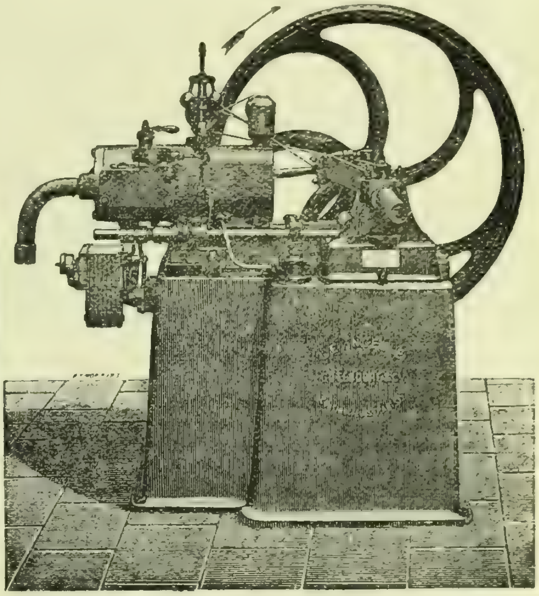
Messrs. Priestman have been awarded two medals by the Royal Agricultural Society, one in 1888, and one this year. The engines are now largely in use, and give great satisfaction. This firm are to be congratulated on their patience and hard work, which have resulted in the production of the first engine capable of using heavy oil.

We are informed that one great though minor improvement has recently been added in a storage cell, which lasts for electric igniting for three months.

THE "L'ETINCELLE" GAS ENGINE AT PARIS.

We recently inspected this gas engine at the Paris Exhibition, and propose to illustrate and describe it here as representing favourably the direction in which French gas-engine designers are moving as distinguished from their English rivals. Like most French gas engines, the cycle is the well-known Otto, and an electrical ignitor is used for firing. The engine is mounted on a hollow cast-iron base, which also serves as a tank. From this tank water is forced by a pump, receiving motion from a cam upon the side shaft, which shaft also carries the cams required for opening the gas and air valves, the exhaust, and the electrical ignitor.

To generate the electric spark a magneto-electric machine is used, which is seen under the engine cylinder in our illustration, bolted to the base. It consists of a series of horseshoe permanent magnets of steel, having between their poles a small armature wound with copper wire. To the spindle of this armature is keyed a pinion gearing into a segment driven by cam and lever from the side shaft, and when the lever is moved it causes the armature to rotate through 90 deg. The cam suddenly releases it, and the armature rapidly flies back, moved by a spring. At the same time a tappet on the lever strikes a pin and breaks the circuit within the cylinder, and so causes a spark, which ignites the explosive mixture.



L'Etincelle Gas Engine.

The engine is constructed by Messrs. Gotendorf and Co., 166, Quai Jemmapes, Paris, and they claim a special compactness and cheapness on account of the absence of a separate water tank.

WATER CONSUMPTION IN STEAM ENGINES.—I.

Steam users, as well as engineers, have been for a long time accustomed to speak of the relative economy of steam engines in terms of the coal consumption. Engines, for example, requiring the consumption of from 1½lb. to 2lb. of coal per indicated horse power per hour would be designated economical, whilst those consuming from 4lb. to 5lb. of coal per I.H.P. per hour would be set down as extravagant. From a manufacturer's or steam user's point of view this mode of comparison may, of course, be all that can be desired, since the magnitude of the coal bill in proportion to the work done by his engines and boilers is what mainly concerns him. It is, however, not so satisfactory from an engineering standpoint, and it is gratifying to note that amongst engineers especially it is becoming more and more the custom, in discussing steam-engine economy, to speak of the weight of steam, or, what is the same thing, the pounds of water evaporated and used as steam for every indicated horse power developed. Thus, whilst a manufacturer might say he was using 3lb. of coal per hour for every indicated horse power his engine developed, an engineer would possibly say, after indicating the engine, that it was using 24lb. of water per indicated horse power per hour. If the boiler which supplied the engine with steam was evaporating 8lb. of water per pound of coal, this would come to the same thing, but very little consideration will show why the latter record of expressing the relative economy of the engine is so much to be preferred. The coal consumed per horse power represents the relative economy of the boiler and engine combined. If an engine is working very economically, and the boiler supplying the steam is doing a high evaporative duty, the coal consumption per I.H.P. per hour will, of course, be very low; and in the same way, if both are working extravagantly, the coal consumption will be high. If, however, an engine is not economical, whilst the boiler is doing good work—or, on the other hand, if the engine is using very little steam per horse power, and the boiler is only performing a low duty—when we express the economy in terms of the coal consumption only we may get a fair average consumption, but this gives no clue as to whether the boiler or engine is working the more economically, or which is at fault.

On this account, in cases where the coal consumption has appeared too high, we have known large sums spent in endeavouring to improve the working of the engine when the fault has really been in the boiler, which has been of poor type, or in defective or dirty condition, and evaporating only a comparatively small quantity of water per pound of coal consumed.

An engine requiring 4lb. of coal per I.H.P. per hour would not be considered to be working very economically at the present time; but until we know what the boiler is doing apart from the engine, or what amount of steam the engine is using irrespective of the boiler, we should not know whether both or which was at fault. The indicator diagrams would no doubt afford some clue to what the engine was doing, but there still might be sources of loss—such as leaky valves or piston, &c.—which might not be indicated by the cards. Given the information, however, that the weight of steam used by the engine was only 17lb. per I.H.P. (which is the amount only required by the most economical compound engines), we find at once, if the coal consumed is 4lb. per hour per I.H.P., that the boiler can only be evaporating 4¼lb. of water per pound of fuel burnt—a most extravagantly low duty. If, now, we can set about improving the performance of our boiler by removing incrustation, for instance, using a better quality of fuel, altering the flues so as to get a better draught, or by putting down a fuel economiser, perhaps (if the feed-water is sent into the boiler cold), and by these means increase the evaporative duty of the boiler up to say 8lb. of water per pound of coal consumed, we should, with an engine requiring 16lb. of water per I.H.P. per hour, only require to burn 2lb. of coal for each horse power developed by the engine. Just in the same way, if we have a good boiler, and we find by actual measurement that it is evaporating 8lb. of water per pound of coal, which is a good average result, and our engine only develops one horse power for every 4lb. of coal used per hour, we find at once that it is using 32lb. of water per I.H.P. per hour, and, according to the type of engine in use, we know in what direction we must look for further improvement.

We have explained this matter thus fully because we consider the expression of engine economy in terms of the water consumed is not yet so well understood as it ought to be, and also because it affords a means of comparing the relative economy of different engines without regard to the coal consumption. The latter is not always readily ascertainable, and even when the gross quantity of coal consumed in the boilers is known, deductions have frequently to be made on account of the quantity used for heating and other purposes, which renders the actual quantity consumed on account of the steam supplied to the engines extremely problematical. Steam also is often used from the same boilers for sizing, mill heating, steaming, and different processes, the amount of which can only be computed very approximately. In large works, where a number of engines of different types are in use, the summing-up of the indicated horse power shown by each, and dividing into the gross coal consumption, gives only the pounds of coal consumed per I.H.P. on the whole, and affords no clue to the relative economy of any particular engine; so that a fair average consumption may be shown in such cases when some of the engines may be working with the very best results, whilst the consumption of steam by others may be very extravagant.

As the water consumption of any particular engine may be obtained approximately from the indicator diagrams, and this affords a valuable means of comparing the economy of different engines without regard to the fuel consumption, we purpose in a subsequent article illustrating how, by means of a table specially computed for the purpose, the pounds of water used per I.H.P. may be computed from the diagrams with almost as little trouble as the power developed.

Although, owing to losses not shown by the indicator, the results can of course be approximate only, yet when the percentage of loss found to exist in ordinary practice is known, the computation of the water consumption affords a means of comparison which will be found extremely valuable in every day use. This is especially the case when from any cause the coal consumption cannot be accurately ascertained, or where, as in large iron and steel making establishments, the waste heat from the heating and blast furnaces, coke ovens, &c., is utilised for producing the steam required.

GERMAN FLOATING EXHIBITION.

Consul-General Oppenheimer, of Frankfort-on-the-Main, in his report just issued, says that the idea of establishing a floating commercial museum of German articles, recently planned by the Association for the Promotion of German Export, has met with general approbation in all industrial circles of Germany. A committee, consisting of the leading manufacturers of Germany, has been constituted to take the matter in hand, and hopes are entertained that the object contemplated will be accomplished. The prospectus points to the fact that exhibitions in their present form have outlived themselves. But in order to maintain the cultivation of international commercial intercourse, it would be necessary to replace the present system of international shows by a more advanced form, namely, to find the purchasers in their own country. For this purpose it is intended to construct a monster steamer, fitted up with all modern improvements and conveniences. This steamer is to contain eight large showrooms, provided with galleries for the reception of the articles to be exhibited. The goods are not to be placed in cases or boxes, but will be arranged in groups properly fastened in order to prevent their being injured by packing and unpacking, so that the exhibition, which is to visit eighty places, may be opened at once on entering at any of the ports. The staff, besides possessing commercial and technical knowledge, must be conversant with the principal modern languages. Like the continental exhibitions, which, in order to insure the success of the undertaking, must make it an object to attract the masses, the floating exhibition is to include entertainments of various kinds, taking on board not only persons sailing with a view to business, but also tourists. There will be concerts, theatres, &c. Restaurants and cafés will also be provided. A panoptical cabinet, a panorama, and similar shows will afford sightseers an opportunity of gratifying their curiosity, and souvenirs may be obtained at the photographer's studio and at the bazaars. The object to be attained by the above arrangements is not only to keep up the interest in the undertaking, but the benefit therefrom will enable the promoters to accommodate passengers and exhibitors on favourable terms. In addition, it is expected that the capital (£250,000) will yield a fair rate of interest, as, judging from estimates, the expenses of a voyage of about two years, calculated at £187,500, are met by gross receipts amounting to £393,650. Thus, the company hope to pay, after having made ample provision for redemption, an annual dividend of about 30 per cent to the shareholders. As regards the dimensions of a steamer containing the above-mentioned eight large showrooms, concert-rooms, restaurants, &c., intended to receive thousands of visitors, and to find accommodation for the crew, staff, and passengers, it is stated that this monster steamer, a floating palace bearing the name The Emperor William, will be the largest vessel crossing the ocean. Her length is to be 570ft. by 70ft., and her height 45ft. The vessel will be constructed of steel, and will be propelled by four-fold compound engines. Ventilators, electric light, refrigerators to reduce the temperature in the hold and engine-rooms, and other arrangements will likewise be introduced. The originators of the scheme think that it will be to the advantage of German industry that the Transatlantic purchasers should thus learn at once the origin of the goods, as they state that German merchandise, representing a value of many millions of marks, is regularly going to foreign markets by way of England, Holland, France, &c., without the consignees having, in most cases, the least idea as to its real origin.

It is estimated that when the Paris Exhibition closes the Eiffel Tower will have been half paid for in charges made for ascending it.

A vegetable cartridge shell has been devised by M. Bieunait, the advantages of which are that it is very light and is consumed in firing.

ON GAS ENGINES, WITH DESCRIPTION OF THE SIMPLEX ENGINE.

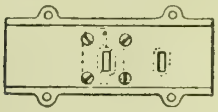
(Continued from page 551.)

The Otto engine is so well known to engineers that any detailed description, beyond the general fact that it is a single-acting motor on the four-cycle principle, would be superfluous; but the method of ignition as described by him in 1877 requires a more careful study; and a critical examination of this, and of the more important of the methods previously used, seems indispensable to the present subject, as the improvements introduced by the author were the direct outcome of a similar study.

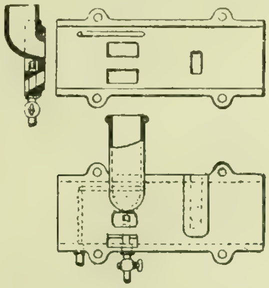
Slide Valve.—The arrangement for ignition in the Otto engine consists of an external flame placed against the cover of the slide, and of a port pierced in the bottom of the cylinder for the admission of the gaseous mixture, and for its ignition; above this (fig. 1) is another small hole by which an equilibrium is maintained between the gases in the cylinder and those in the slide. On one side the slide carries a spreader for effecting the intimate mixing of the gas and air, and in its central part a chamber where ignition takes place. This chamber is filled with a mixture of air and gas in suitable proportions, the slide is moved (figs. 2, 3, 4, 5, and 6), the interior chamber is exposed to the external gas burner, and its charge ignited. As the speed of the slide is suitably proportioned, the flame in its cavity is carried forward and communicated to the compressed mixture in the cylinder. It will of course be understood that by this movement of the slide all communication with the outer air is now cut off, so that the flame in the ignition cavity is protected from any external influence.

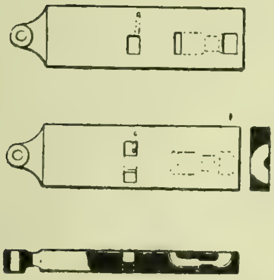
If this momentary flame were at once brought into contact with the compressed mixture, it would be blown out by the violent current set up; but this is avoided by an ingenious arrangement. The small hole previously mentioned, which is situated in the slide face at the bottom of the cylinder, is slightly in advance of the port proper, so that it comes line and line with a similar hole in the valve itself before the port is uncovered. This second hole forms a communication with the interior of the ignition chamber, so that a minute volume of the compressed gases from the cylinder entering thus into an enlarged space is partially expanded, and revives the inner flame when just at the point of extinction. At this instant the port of the slide comes line and line with that of the cylinder, and as the pressure of the ignited mixture in the cavity of the slide has been thus progressively but considerably increased, there is no fear of its extinction, or of its failing to ignite the charge in the cylinder. As an additional precaution, the orifice at the bottom of the cylinder is filled, by a special arrangement, with a mixture richer than gas, and it is by this richer mixture, containing none of the products of combustion of the previous stroke, that the interior flame is reinforced, as has just been described.

Fig. 1.



Figs. 2 and 3.





Figs. 4, 5, 6.

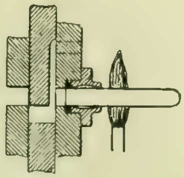


Fig. 7.

This system, however, is very complicated; it depends on numerous orifices, which become rapidly incrusted, owing to the flame which fills them at the moment of ignition; a layer of carbon is deposited on their inner surfaces, and soon attains a considerable thickness. To ensure the equilibrium of pressures with sufficient delicacy, the cut-off edges must be adjusted to a small fraction of a millimetre, and however accurately this may be done at first, it is soon modified by the incrustations above named, which must be frequently removed if the best result is to be obtained. In addition, the slide, reduced as it is in thickness by the interior cavity, is easily buckled by the heat of the flame, and its efficiency impaired. The temperature of the slide, superheated by the interior and exterior flames, is very high, and burns the oil on the slide faces, and the combination of these two defects causes frequent seizing. Bearing in mind what a delicate operation must be the transporting of a flame in so confined a space, it is no matter of surprise that, however accurate the original adjustment may be, miss-fires are of pretty frequent occurrence, arising either from failure to ignite at the outside burner, or from premature extinction of the inside flame, or from absence of perfect balance at any moment—and these miss-fires must detract from the efficiency of the engine. When a rich gas such as is used for domestic purposes is employed, ignition, which depends, as has been shown, upon the equilibrium of pressures, is tolerably regular, because such gas is easy to light; but with a poor gas the problem becomes more difficult, and for this reason its employment has not made much progress. A much stronger flame is required to ensure the ignition of a poor mixture with any degree of certainty. With a large engine, starting becomes an operation of great nicety when the flame has to be conveyed, because if the slide does not travel with sufficient rapidity, the flame is burnt out before reaching the charge in the cylinder; and it is no easy matter to impart sufficient initial velocity to a flywheel of any considerable weight.

An examination of the Lenoir system of 1860, which has since been repeatedly copied, discloses still more serious defects, and these defects were obvious from the first, since all subsequent inventors, including Dr. Otto, have been compelled to adopt an actual flame as more certain and less troublesome.

Lenoir's igniting arrangement was as follows: An insulator containing a platinum wire was fixed at each end of the cylinder, and another platinum wire was fixed inside the cylinder, with its extremity at a short distance from the first. The two wires were respectively connected with the positive and negative poles of a Ruhmkorff coil, through which a battery sent its current, and a spark passed from point to point. At a given moment the circuit was completed by a key, the spark transmitted, and the mixture fired. The circuit was then interrupted, and again made at the next revolution of the engine. At first sight this appears an excellent arrangement, but it was not found to work well in practice. The following is what takes place: At the commencement of each stroke a condensation of aqueous vapour takes place, while the metal is taking up heat; the interior platinum points are covered with moisture, and the spark is transmitted only at intervals, or even not at all, causing difficulty in starting and irregularity in running. Again, the points may become coated with the oil used for lubrication, with an equally objectionable result. Lastly, the points, immersed as they are in the explosive mixture, become incrusted with carbon, and the current is intercepted.

Another cause of irregularity occurs in the interruptor itself, as follows: If it could be arranged that, at the moment the key touched the plate, contact was made and the mixture ignited, and that such contact should only be made at the exact moment required, ignition would be regular; but it is well known that the current through the coil may become so intensified as to pass between the key and the plate at 10, 15, or even 18 millimetres distance, causing ignition at irregular periods. To avoid this as far as possible, interruptors acting suddenly were adopted; but these rapidly wore out, and were inevitably of a complicated nature. At first sight this would seem to be an insignificant objection, as it might be thought that a variation in the moment of ignition corresponding with a variation of only from 10 to 18 millimetres distance between the points of contact would be of no practical account; but a comparison of the diagrams taken with these variations shows a considerable difference. It is surprising to note the difference in the indicated power when the moment of ignition varies by even so little as 1-20th of a second. There is also the liability to an accident which the author has twice met with in his early trials. One pole—say the negative—is in direct communication with the engine itself, so that the whole machine is negatively electrified, and it may happen that at any moment, although the positive current has not been switched on, a spark may pass, and the mixture be ignited prematurely, before the crank has passed the centre.

During a course of experiments on all the systems of ignition known, the paramount importance of a thoroughly good ignition has been conclusively proved. For safe working, it is indispensable to have a perfectly certain ignition, powerful enough to explode a poor gas, and free from the objections above indicated. As a matter of fact, there are only the two principles of an actual flame and of electricity; the choice, therefore, is confined to the various applications of these two methods, and as a powerful ignition is a condition of immense importance, this condition is only fulfilled by the electric spark. All the methods of ignition by flame have proved inferior to it in this respect, including the superheating of a platinum wire by flame, and the expedient of raising a thin tube to a red heat (see fig. 7).

The latter is an old expedient, which was fully described by Mr. Leo Funck in 1879. It gives a regular ignition, but is not free from inconveniences, the chief being that the heat of the tube never equals that of the electric spark, and the plan is consequently not so applicable where poor gases are used, while the tubes themselves deteriorate so rapidly that they are destroyed in the course of a few hours. This is the result of the high pressure produced within the cylinder at the moment of ignition, when the white-hot tube is externally exposed only to atmospheric pressure; the compressed gas is admitted inside the tube, and a still higher pressure, with a tendency to burst the tube, is produced by ignition. If, to avoid this, the tube is made thicker, it does not attain the white heat requisite for good ignition. Lastly, the tube is internally cooled by the partial expansion of the compressed gas admitted to its interior, and this decrease in temperature still further reduces the chances of a good ignition.

If a valve is employed to regulate the moment of ignition within the tube, there is the further risk of a premature explosion, tending to reverse the direction of revolution of the flywheel. This might be caused by the valve not bearing properly on its seat at the required moment, thus allowing the passage of a thin stream of compressed gas, which would be prematurely ignited.

It might appear that the ill effect of the difference between the internal and external pressures could be simply avoided by placing the tube inside the cylinder, but this would entail even greater objections. The tube carrier would require to be removed whenever it required to be freed from the incrustation caused by the products of combustion; it would suffer rapid deterioration from the high internal temperature; there would always be the fear of premature explosions; and with this arrangement, after every stoppage a secondary system of ignition would be necessary, until the internal tube had be brought to a white heat, thus involving two processes instead of one.

The use of platinum wire raised to incandescence by the electric current still remains to be considered. As in the case of the hollow tube just described, there is the disadvantage of the cooling of the wire at the moment of the introduction of the gaseous mixture, and consequent irregularity of ignition. Even without this fault it is easy to see that the heating power of a wire raised to a white heat must be inferior to that of a strong spark which is not affected either by cooling action or by violent currents of air.

The author will now proceed at once to describe the simplex motor, and to point out its distinctive features as compared with its predecessors.

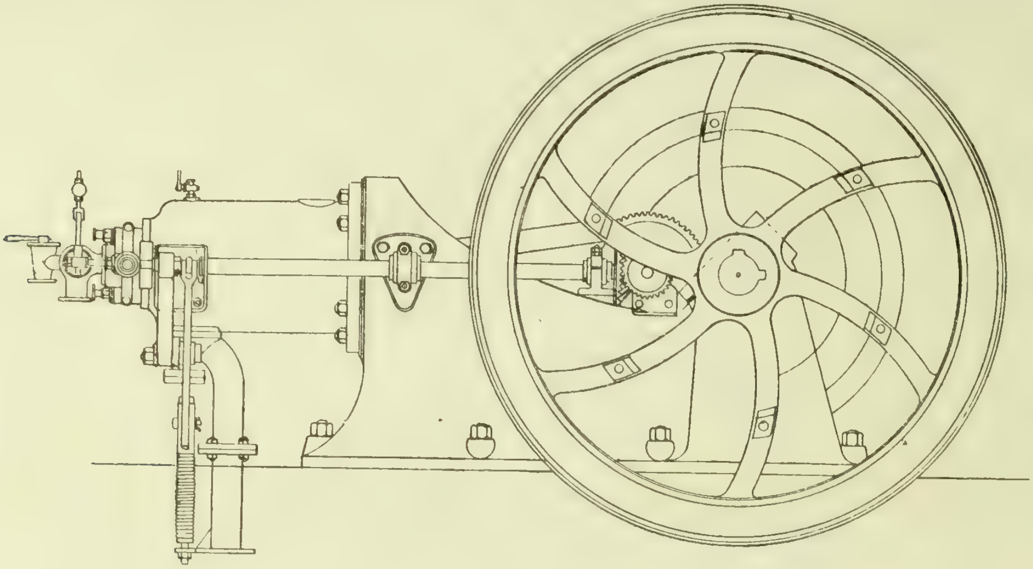


Fig. 8.

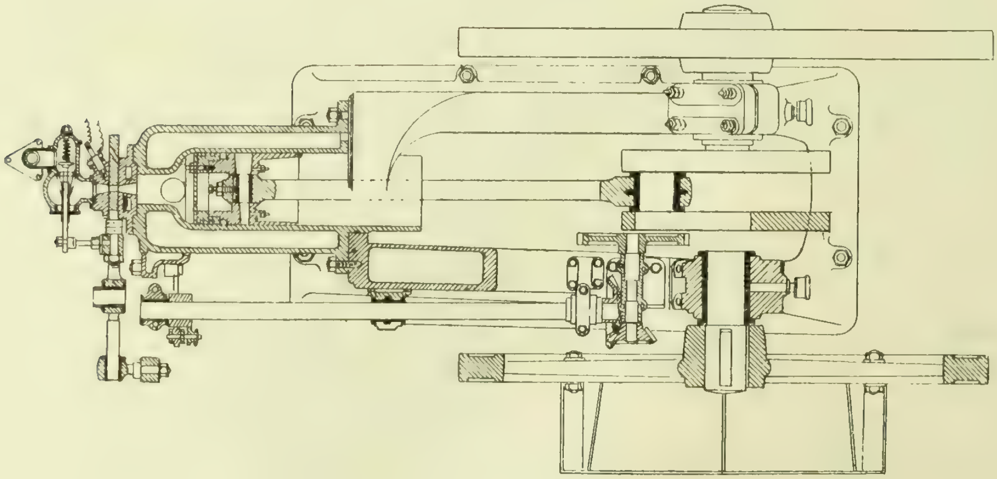


Fig. 9.

The Simplex Engine.

The simplex engine (see figs. 8, 9 and 10), invented by the author and Mr. Léon Malandin, was brought out in 1884. It is on the four-cycle plan of Beau de Rochas, and as its main features are very much the same as the motor described by that inventor, no general description need be given, but it will be sufficient to examine in detail the various novelties and improvements which it offers, as compared with its predecessors, under the various heads of ignition, mixing of gases, governors, starting, working with petroleum vapour, and with gas of poor quality.

Ignition.—During the preliminary studies and trials undertaken to determine the general arrangement of the projected new motor, practical experiments were made on all the known systems of ignition, and the conclusion was soon formed that the electric spark was the only satisfactory and economical method. But as none of the previous arrangements had given thoroughly successful results, the idea was formed of substituting for a single electric spark, produced by contact at a given moment, an uninterrupted stream of sparks, forming practically one continuous spark, produced in the thickness of the slide itself. The great advantage of this arrangement was that the moment of ignition was determined by the edges of the ports, and at first it appeared strange that this device had not been hit upon by previous inventors; but when the practical difficulties of carrying out the new scheme were encountered, this was no longer a subject for wonder. It was found in practice that though the ignition from the sparks between the platinum points was controlled regularly enough so long as the slide was pressed tightly to the face, yet as soon as, from one cause or another, the compression inside forced the sliding surfaces apart, the inflammable mixture found its way to the spark prematurely, and the action of the crank was liable to be reversed. This fault was overcome by placing the porcelain insulator in the cover (fig. 9), which made it impossible for the explosive mixture to reach the sparks before the slide had fairly opened communication with the combustion chamber.

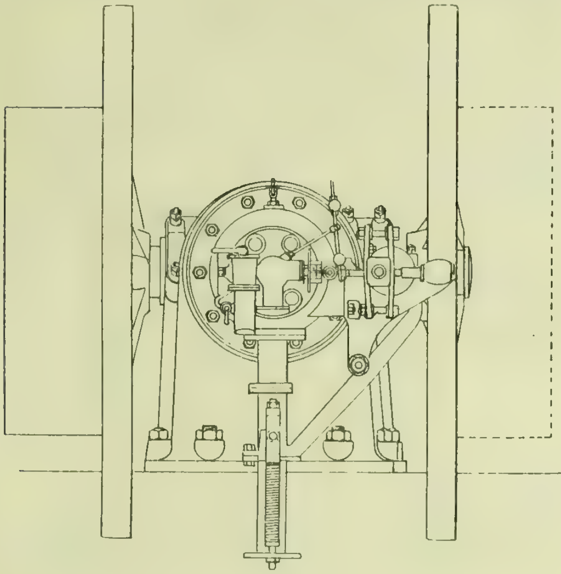


FIG. 9.

One more practical detail still remained to be achieved, namely, after each ignition to clear the oblique opening in the valve and the combustion chamber of the burnt gases, which would otherwise have combined with the fresh charge of explosive mixture, and impaired its deflagation. This difficulty was got over by forming a square hole between the combustion chamber and the slide face, so as to coincide with a horizontal groove in the slide, and thus at the proper moment open up communication with the outer air. This is what happens: At the moment fixed for ignition—that is to say, when the oblique passage in the slide and the admission port of the cylinder come edge to edge—the compressed mixture drives out the burnt gases by the small hole in the combustion chamber, and is at the same instant ignited by the continuous stream of sparks between the platinum points. The time occupied by this expulsion is about 1-150th of a second, but owing to the high compression of the explosive mixture, and its consequent velocity of flow, the clearance is perfect and the instant of ignition mathematically punctual. The advantages of this new mode of ignition are considerable; the slide, which in other gas engines is the part of greatest nicety, becomes as simple as that of a steam engine, being merely a cast-iron plate in one piece without any loose parts, pierced with two holes, one for the admission of the mixture, and the other for its ignition. Its maintenance is easy and cheap, and with ordinary attention it will work for more than a year without any repairs. This is a great improvement over the equilibrium and flame-carrying slides, which require to be frequently faced up.

By getting rid of this conveyed flame and of the gas burner a considerable reduction is effected in the temperature of the valve chest, lubrication is facilitated, and incrustation is done away with. The high igniting power of the spark allows of a much higher initial compression of the explosive mixture, with a corresponding economy in consumption of gas. This certainty of ignition and high igniting power have been of the greatest advantage in the application of the plan to poor gases. Particulars are hereafter given of some of the trials made with the simplex engine, from which an idea can be formed of its economical advantages.

Gas Mixing.—The air and gas are mixed, not in the slide, as in the case with the Otto and other motors, but in an external receptacle fixed on the cover of the slide, the air entering from one side, and the gas from the other, through a valve. After meeting and mixing they are violently sucked in by the action of the slide through a channel at first circular, then conical, then rectangular, and are thus intimately combined into a homogeneous mixture. There is nothing particularly original about this arrangement; but it is simple, and the experience of more than four years has shown that it is completely successful.

Governors.—The two methods of regulating the speed adopted in previous motors were: (1) entire admission or none—that is to say, the supply of gas was totally cut off for one or more strokes whenever any increase of speed occurred; and (2) proportional admission—that is to say, more or less gas, forming a more or less powerful explosive mixture, was admitted accordingly as the engine ran slower or faster. The second method at first sight appears the more rational, but entails certain inconveniences which have led to its rejection. The stronger or weaker mixture resulting from a proportional admission of gas is liable to become non-explosive, at one time because it is too rich, at another time because it is too poor. In either case no ignition takes place, and a charge of gas is expended to no purpose, and under certain conditions this waste may amount to a considerabls proportion of the total consumption. For this reason some different arrangement, based on the principle of entire admission or none, was sought for.

(To be continued.)

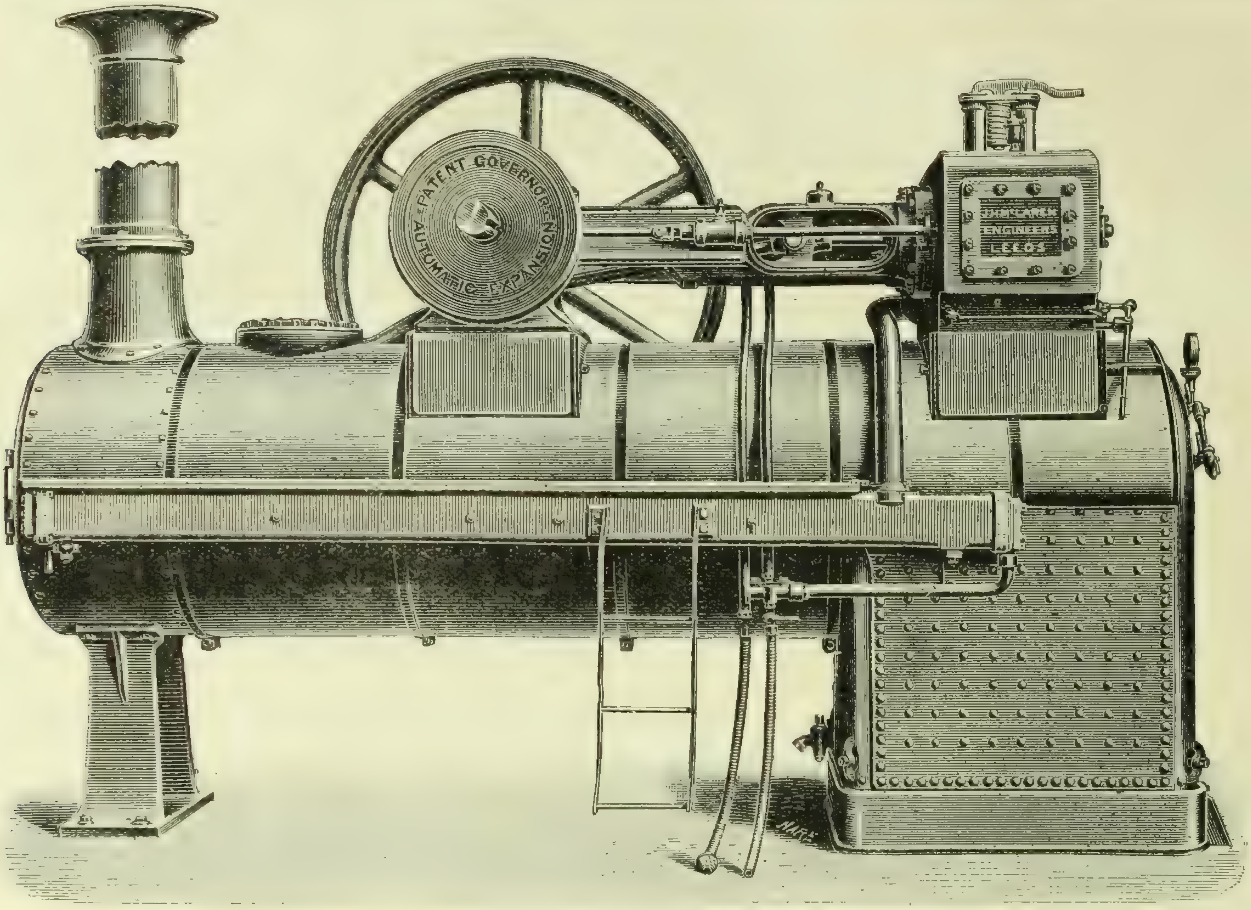
USEFUL TABLE FOR CALCULATING METAL FOR BOILER FURNACES, &c.

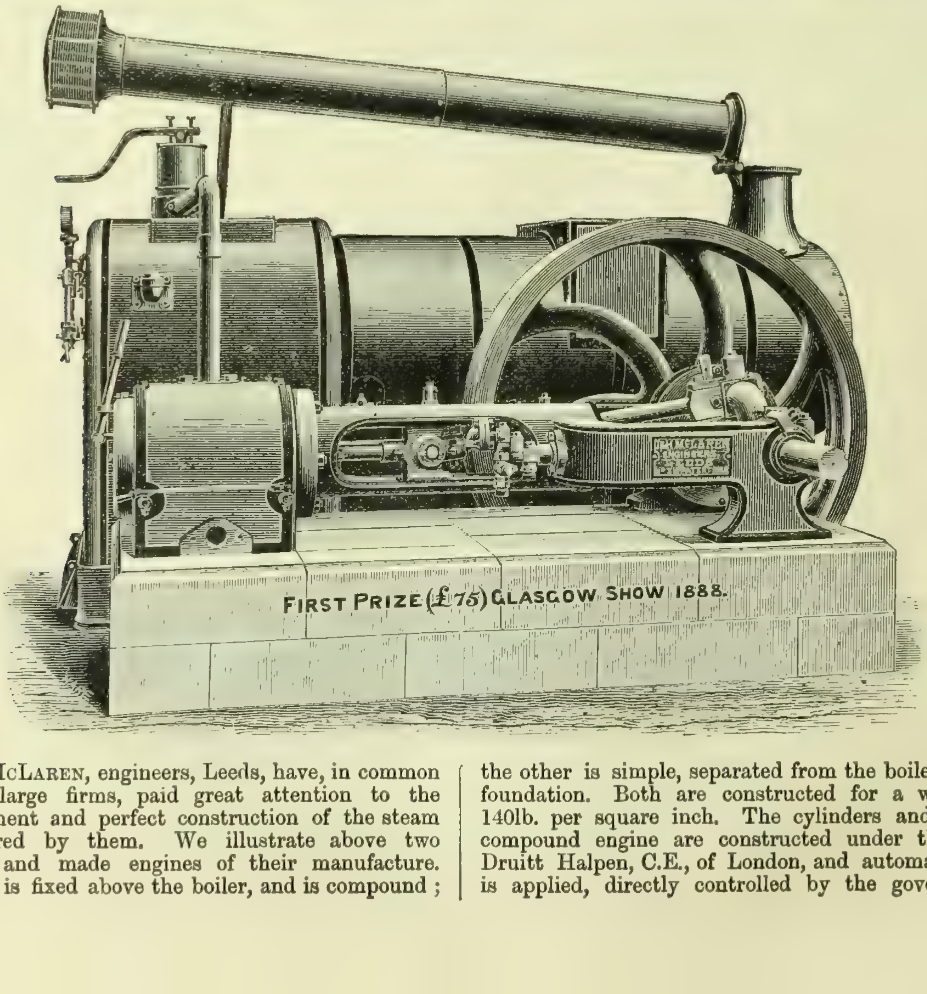
Fraction.	Decimal Equivalent.		
	n	n^2	n^3
$\frac{1}{8}$	·125	·015625	·001953125
$\frac{3}{16}$	·1875	·03515625	·006591796875
$\frac{1}{4}$	·25	·0625	·015625
$\frac{5}{16}$	·3125	·09765625	·030517578125
$\frac{3}{8}$	·375	·140625	·052734375
$\frac{7}{16}$	·4375	·19140625	·083740234375
$\frac{1}{2}$	·5	25	·125
$\frac{9}{16}$	·5625	·31640625	·177978515625
$\frac{5}{8}$	·625	·390625	·244140625
$\frac{11}{16}$	·6875	·47265625	·324951171875
$\frac{3}{4}$	·7	·5625	·421875
$\frac{13}{16}$	·8125	·66015625	·536376953125
$\frac{7}{8}$	·875	·765625	·669921875
$\frac{15}{16}$	·9375	·87890625	·823974609375

The above table will be found useful in connection with the Board of Trade rule for boiler furnaces; also their rule for safety-valve springs, &c.

The column n^3 will be useful also for calculating the moment of resistance to torsion, and bending for round shafts from the formulæ $\frac{\pi}{16} f d^3$ and $\frac{\pi}{32} f d^2$ respectively.

MESSRS. J. & H. McLAREN'S IMPROVED SEMI-FIXED ENGINE AND BOILER.





Messrs. J. and H. McLaren, engineers, Leeds, have, in common with many other large firms, paid great attention to the economical arrangement and perfect construction of the steam engines manufactured by them. We illustrate above two admirably designed and made engines of their manufacture. One, the over-type, is fixed above the boiler, and is compound; the other is simple, separated from the boiler, and is bolted to a foundation. Both are constructed for a working pressure of 140lb. per square inch. The cylinders and valve gear of the compound engine are constructed under the patents of Mr. Druitt Halpen, C.E., of London, and automatic expansion gear is applied, directly controlled by the governor. The steam jackets are effectually drained, and in the case of engines working on the top of the boiler the water is conducted back to the boiler to be re-evaporated. The steam chests are cast on the outsides of the cylinders, and the working parts are arranged for easy accessibility.

The simple engine is of unusually neat design, and was awarded the first prize of £75 at the Glasgow competition of 1888. Engines of this pattern are made in all sizes, from 6 to 20 horse nominal, and can be arranged either on the top of the boiler, or separate.

Messrs. McLaren very rightly insist upon the advantage of economical steam engines over uneconomical, even where the first cost of the former is necessarily higher. There can be no doubt of the saving to the user in purchasing a thoroughly good engine.

ON THE THEORETICAL EFFICIENCY OF VAPOUR ENGINES.[*]

By Professor James E. Denton.

In reference to the discussion of Prof. Wood's paper on "Vapour Engines" at the Erie Meeting of the American Society of Mechanical Engineers, I have prepared the following condensed statement of the possible economy of engines using various substances as a heat medium.

The computation of the table is to be credited to Prof. D. S. Jacobus, of Hoboken.[†]

It applies to engines whose indicator cards would be like the accompanying figure, E A representing clearance volume, the compression line D A being arranged to compress to boiler pressure before the valve opens for admission, and the terminal pressure being that of the atmosphere, with the point of release assumed at exactly the end of the stroke.

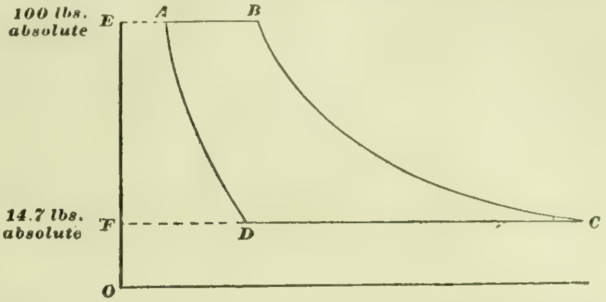
THEORETICAL ECONOMY OF VARIOUS VAPOURS USED AS HEAT MEDIUMS IN A GIVEN ENGINE AT FIXED CUT-OFF, THE EXPANSION BEING SUFFICIENT TO CAUSE A FALL OF PRESSURE FROM 100 TO 14·7 LBS. PER SQUARE INCH. MEAN BACK PRESSURE, 14·7 LBS.

Substance used as a Heat Medium.	Specific Heat in Liquid Condition.	Temperatures in Degrees Fahrenheit at pressures per square inch of		British Thermal Units necessary to be expended in order to generate 1 pound of vapour from "temp. of feed" equal to that given in column 4.	Efficiency or Fraction of Heat Expended, per column 5, which can be realised as useful work in an engine.	Coal per hour per indicated horse power, assuming the boiler to utilise 8,000 heat units per pound of coal. Cylinder condensation neglected—in pounds.	Probable coal per hour per H.P., including allowance of ⅓d. for cylinder condensation for saturated vapours, and zero for superheated vapours—in lbs.
		100lb.	14·7lb.				
1	2	3	4	5	6	7	8
Steam	1·00	328	212	1002	0·14	2·3	3·1
Ammonia, saturated	0·99	56	−27	632	0·15	2·15	2·88
,, superheated.	0·99	282	8	940	0·13	2·48	2·48
Ether	0·55	215	95	195	0·15	2·15	2·88
Carbon bisulphide	0·24	248	115	163	0·17	1·99	2·68
Air—worked as in Joule's Engine. See Rankine's "Steam Engine," p. 373	0·24	607	70	160	0·46	0·70	0·70

Under these conditions, the influence of clearance on economy is entirely eliminated, and if the efficiency be computed without regard to cylinder condensation, we shall obtain the maximum economy that can be expected to be realised between the pressures chosen, and yet we shall have introduced no condition inconsistent with the use[‡] of a vapour in a modern high-pressure engine. Column 6 of the table expresses the fraction of the heat in the vapour (when it enters the working cylinder) which is realised as work, or which is represented by the indicated horse power computed from the diagram A B C D A. It will be seen that these fractions are practically the same for all the vapours. Leaving the air out of consideration for the present, let us consider the reason for this absence of difference of economy of the vapours, notwithstanding that there is so much difference in their boiling points, latent heat, &c.

Thus, steam boils at 212 deg., ammonia at minus 27 deg. Steam requires about twice the heat for the generation of a pound of its vapour than does ammonia. Again, ether, which boils at 95 deg., requires but 0·55 as much heat to change the temperature of its liquid one degree as does liquid water, and but about one-fifth as much heat to generate a pound of its vapour. Evidently there must be some very general neutralising element underlying the effect of such widely differing properties upon the efficiency of a vapour, when used as a medium for the transformation of heat into work of an engine, and my object is to suggest a view of the subject which will bring this element into prominence.

The useful effect or "efficiency of fluid" given in column 6 is simply the quotient of the mean effective pressure of the diagram A B C D A, divided by the heat possessed by as much vapour as will fill the volume A B, or the displacement of the engine piston up to the point of cut-off.



Now, the expansion line B C and the compression line D A differ so little for all these vapours that the mean effective pressure differs no more than is due, say to the variation of expansion lines in indicator cards of various steam engines, from the Mariotte law of expansion or compression.

For practical purposes, therefore, the mean effective pressure, or the numerator of the efficiency value, is the same for all the vapours for equal ratios of expansion. But the heat which must be expended is far less in the cases of some of the vapours than in the case of steam for equal *weights* of substance, such heat being given in column 5 of the table.

If, for example, the space or piston displacement A B, when filled with ether vapour at 100lb. pressure, contained as much *weight* of ether as it would of steam, then the efficiency of ether would be represented by a fraction whose numerator would be the same as that for steam, but whose denominator would be less in the proportion of 195 to 1,002. In other words, the ether would be about five times as economical as steam. But the weight of a cubic foot of ether is nearly as much greater than steam as is 1,002 than 195. That is, to fill the volume A B with vapour of ether would take about as many times more pounds of ether as the heat to vaporise the latter is less than the heat to vaporise water.

Hence, to obtain a *given horse power* from an engine, both the numerator and denominator of the efficiency value are practically equal for steam and ether, and the same principle is the cause of the close identity of the values in column 7 for other vapours, and extends also to air.[*]

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[*] *American Machinist.*

[†] "Efficiency of Vapour Engines," Stevens Indicator, October, 1888.

[‡] The latest application of bisulphide of carbon, ammonia, &c., as a motive fluid do not afford a back pressure practically less than the atmosphere, notwithstanding a condenser is used. For this reason, Prof. Jacobus confines his calculations to the diagram which exhausts against a pressure equal to that of the atmosphere.

[*] The air cycle covered by the table is what is known as Joules' Engine. See Art. 276, Rankine's Steam Engine. The air taken from the atmosphere is compressed along D A to 465 deg. Fah. and 100lb. pressure. It is then passed through the furnace, and heated at constant pressure to 607 deg. Fah., the volume thereby becoming increased by the amount A B. Expansion then occurs along B C, whereby the temperature falls to 160 deg, and at this temperature the air is exhausted to the atmosphere.

As a general principle, therefore, we may say that substances more volatile than water, in the sense of requiring less heat for the vaporisation of a given weight, produce vapours so much more dense than steam, that, to produce equal horse powers in a given engine, as much greater weight must be used of a vapour as is roughly represented by the ratio of the heat of its vaporisation to that of steam; whereby the economy, neglecting differences of cylinder condensation, is practically the same for all common volatile substances as for steam. Experiments with naphtha and ammonia indicate that there may be less cylinder condensation with ammonia and naphtha than with steam, when the former are used so that they expand from a highly superheated condition, and the latter is used without superheating, so that a loss of upwards of 33 per cent of the theoretical consumption of steam takes place through cylinder condensation. Line three of the table applies to the case of ammonia used as a superheated gas, distilled from a aqua ammonia solution. A practical application of ammonia for motive power purposes is being carried out on this principle. The use of ammonia in its saturated condition is, of course, impossible if it is to be condensed, and its waste thereby prevented. No means of condensing it at minus 27 deg. Fah. exists. It was proposed to use ammonia in such a cycle, however, some years since in the Gamgee or zero motor, which offered to boil ammonia by the natural heat of the sea water, and to expand it to 27 deg., and return it to the boiler by some means never clearly defined, and yet unknown.

Experiment also has shown, in a satisfactory manner, that the rate of conduction of heat from the furnace to the liquid in the boiler is greater per square foot of heating surface per hour in the case of highly volatile substances, such as ammonia, naphtha, and bisulphide of carbon, than for steam. This fact makes it possible to produce a given horse power with less boiler capacity or heating surface than with steam; but it should be noted that the total heat expended per hour, or the economy, is not affected by this circumstance. The first cost of boiler plant will be less, but the heat which must be supplied to the vapour per horse power will be practically the same as for steam, as per columns 6 and 7 of the table. Should steam be superheated, so that cylinder condensation may be eliminated, its economy will exceed that of any of the substances in the table, except air.

The difficulties of preventing superheaters for steam from deteriorating, has thus far so offset the extra economy known to result from their use, that no general use of superheated steam is now being attempted. The high temperature involved in the use of air engines (which are known to actually realise most of the high economy promised by theory) has proved an insurmountable obstruction to their competition with steam. The use of volatile vapours, as substitutes for steam, involves objections quite as serious as these. To maintain a back pressure equal to that of the atmosphere requires an amount of water about equal to half that which affords 27in. vacuum, with steam.

Hence, to compete with the non-condensing steam engine in cities where water is worth, say 1 dollar 50 cents per 1,000 cubic feet, the vapour engine will require an expense for water about equal to that of fuel. Besides this fact, the difficulties of controlling the escape of vapour, so that no offensive odours result, and the unknown difficulties due to boiler deposits and corrosion, are such as to make it extremely improbable that the world will ever permit itself to be educated to the use of a substance of this character for its elected favourite, steam.

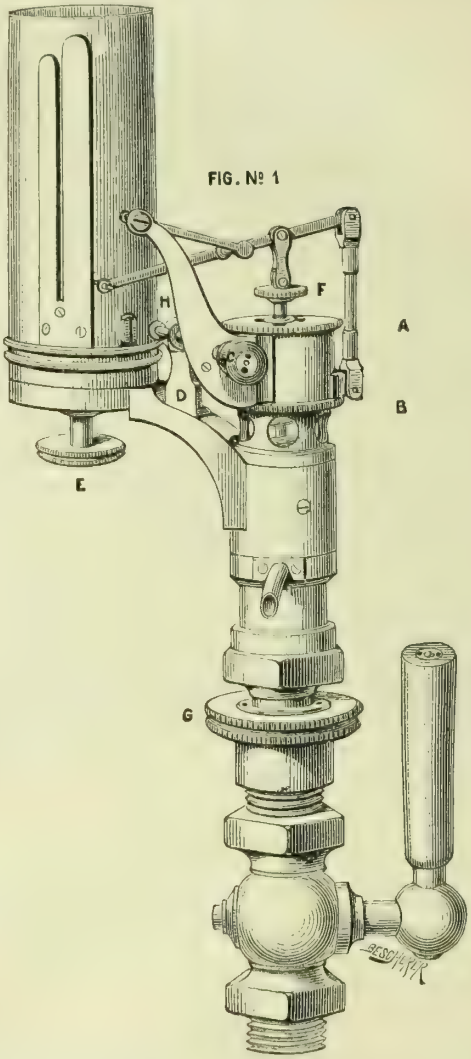
EDISON'S PHONOGRAPH.

Colonel Gouraud informs us that Mr. Edison's private secretary, Mr. Tate, has arrived in London for a conference with him on the policy to be adopted with reference to placing the phonograph on the market. He states that the factory at Orange, New Jersey, is now in full working order, employing over 500 men, with a pay roll of over £1,000 a week, and turning out finished machines at the rate of 15,000 per annum (300 per week). All the parts are machine-made, and interchangeable. The systems of propulsion are applicable to the "Commercial Phonograph" (being the name given to the latest form of machine), viz., battery power, electric light circuit power, and foot power. Over 2,000 machines have now been distributed in America, and are in daily commercial use in business offices exclusively, on rental at £8 per annum. The next thousand machines will be shipped to Europe, the first consignment having left last Saturday. These will be distributed to a thousand different agencies in Europe. Mr. Edison has now entirely recovered from the recent injury to his eyes.—*Electrical Review.*

THE LEFEBVRE INDICATOR.

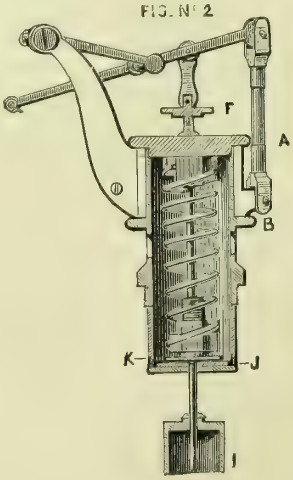
We illustrate here a steam engine indicator of French design and construction. It is designed by M. Victor Lefebvre, and made by him in Paris. Some very well finished examples of it are shown at the Exhibition. From fig. 1, it will be seen that the

FIG. Nº 1



variation from the ordinary Richards type consists mainly in the paralleled motion, which is of the kind known in this country as the Thomson. Fig. 2 shows a section of the spring case, from

FIG. Nº 2



which it will be seen that the piston works at the end of a rod and away from the spring, so that any leakage cannot get at the steel spring. A spout shown in fig. 1 allows free discharge of any steam or vapour passing the indicator piston, and thus prevents access to the spring. This is, in our opinion, a very good feature, as unless great care is taken indicator springs quickly deteriorate from rust. We have known a spring lose five per cent in its strength in a single night through carelessness in allowing rust from a corrosive vapour. The other points of construction are evident and self explanatory.

FATAL EXPLOSION OF WATER GAS IN HULL.

On the morning of Tuesday, August 6th (the opening day of the Yorkshire Agricultural Show, held in Hull this year), a sad and fatal accident occurred in the show ground, at the stand of the British Water-gas Company.

This company had erected a temporary but nevertheless complete plant, consisting of a generator, steam boiler, scrubber, gas holder, and purifier (capable of producing about 30,000 cubic feet of water gas per hour), and had arranged to supply gas to several gas engines of sundry makers, their own exhibits consisting of the illumination of a drawing-room with nine jets, a cooking oven, blow pipe, and smith's forge. The two latter were supplied by unpurified gas direct from the gasometer, the gas supply for the remainder of the exhibits passing through the purifier for purposes of eliminating the sulphur contained in the gas. On the day mentioned, at a little before ten in the morning, the lid of the purifier was suddenly, and without any previous warning, lifted up to a considerable height, and carried some 30ft. away. In its descent it appears to have struck a man named Joseph Cade, belonging to York, the force of the blow causing immediate death.

The lid in question is said to weigh about three hundredweight, and is made up of thin boiler plate about $\frac{3}{16}$in. or $\frac{1}{4}$in. in thickness, its dimensions being, roughly, about 5ft. 6in. by 4ft. by 9in. or 10in. high, the top plate being slightly curved in form.

The force to which the lid has been subjected was sufficient to effect a tearing of the material along the line of angle iron connecting the vertical side with the top for a length of a foot or more. From the evidence given before the coroner, the following particulars are interesting from an engineering point of view, as they give some clue to the cause of the accident:—

The apparatus had been tried on the Saturday and Monday with satisfactory results; but it seems that since then a meter had been connected up in addition to a connection with another gas engine. This necessitated the opening to the air of some pipes connected with the gas apparatus, resulting in a mixture of gas and atmospheric air in the pipes and passages leading from the purifier. This dangerous mixture was being got rid of by the opening of the various taps or cocks, when it is supposed that an attendant connected with one of the gas engines applied a light to the issuing gas, the result being that the sudden pressure lifted the lid of the purifier and projected it into the air as before stated.

The attendant in charge of the gas engine seems to have been misled by the smell of gas remaining in the pipe leading to the engine, as it appears that when he first lighted the Bunsen burner on the engine it burnt for a few seconds, and then went out, and it was when he attempted to relight it that the explosion occurred. Mr. A. E. Seaton, C.E., general manager and director of Earle's Shipbuilding Company, Hull, who was called as an expert witness, with instructions from the deputy-coroner to inspect the plant, has expressed his opinion that the apparatus for the working of the gas as well as purifying it was satisfactory, and neither to it nor to the gas itself was the accident attributable; nor could any fault be found with them, for the supply of gas and the means for burning it were also equally satisfactory, and he gave it as his opinion that the explosion occurred from the application of a light to the issuing gas when there was a mixture of atmospheric air with the gas in the pipe.

The accident created a painful impression in Hull, and more particularly amongst those present at the show, and it was the means of preventing a great many of the visitors from witnessing the exhibition so liberally provided by the Water-gas Company, as the Council of the Agricultural Society would not allow the company to work their plant during the remainder of the show.

Professor James Thomson.—We understand that the Professorship of Civil Engineering and Mechanics in the University of Glasgow is likely to become vacant by the resignation of Professor James Thomson, on account of weak health. The appointment, which is supposed to be worth about £600 a year, is in the gift of the Crown. Professor Thomson is well known as a physicist and investigator of the properties of water under compression. He is Sir W. Thomson's brother.

HEAT ENGINES OTHER THAN STEAM.—I.

(Continued from page 553.)

Having now stated to you pretty fully the nature of the theory of working of the steam engine, and having done this because it is used in my text, I would like to still further clear the ground—although I may be accused of being very elementary—by spending a few minutes on the question of expansion in a heat engine.

In order not to overload more than is necessary the theoretical portion of our subject, I have, up to the present, simply spoken to you of expansion, telling you that expansion is the basis of all economical working of heat engines. I also showed you a diagram, representing the expansion curve of the work done when a big gun is fired—one of the simplest cases of expansive working.

Let us see how expansion operates in a steam engine. You all know that the principal portion of a steam engine consists of the vessel called the cylinder, this being the vessel in which the work is developed; you know also that this is a truly cylindrical vessel of a given length, in which a piston, or disc, is caused to work backwards and forwards by the pressure of the steam which passes alternately into either end of the cylinder, between the covers and the moving piston. From the piston a rod proceeds, working steam-tight through a stuffing box in one of the covers. To this rod a jointed rod is attached, which transposes the reciprocating motion of the piston into the rotary motion of the crank shaft.

Fig. 2 shows by the thick, black lines a section through such a cylinder. At the left-hand end of this you see the piston, with the piston rod proceeding from it, towards and through the cover at the right-hand end; the rod passing through a stuffing box in this cover, to keep it tight against the pressure, and thus to prevent leakage of steam.

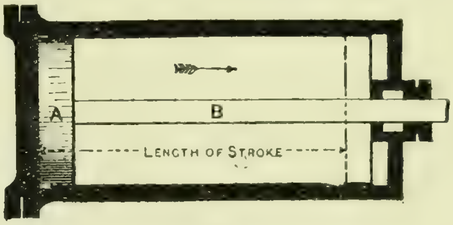
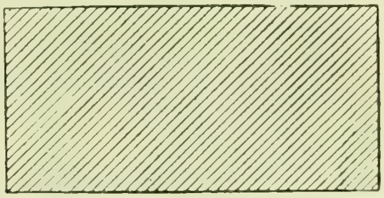


Fig. 2.

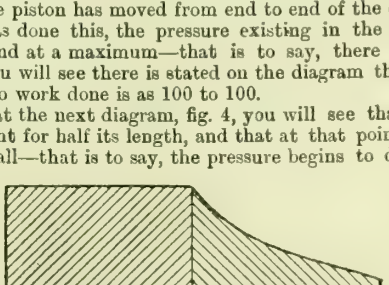
In Fig. 3 you will see a square which is shaded, or hatch-lined. Now this square represents, by its length, the portion of the stroke, or the distance through which the piston has travelled, and by its height above the base line at any point, represents the pressure existing at that point, say in pounds, per square inch. You will remember the diagram of the big gun was shown in a similar way. This square diagram, therefore, tells us that the piston has moved from end to end of the cylinder, and that while it has done this, the pressure existing in the cylinder has been uniform and at a maximum—that is to say, there has been no expansion. You will see there is stated on the diagram that the ratio of steam used to work done is as 100 to 100.



Ratio of steam used to work done, 100 to 100.

Fig. 3.

If you look at the next diagram, fig. 4, you will see that it is only of the full height for half its length, and that at that point the upper line begins to fall—that is to say, the pressure begins to decrease, and goes on decreasing, following a uniform curve until the end of the cylinder is reached, when the pressure is at its lowest. This diagram would tell us that the steam, or other working agent, had been maintained at the pressure at which it was admitted to the cylinder for half the length of the stroke of the piston; that then the inflow of the working agent had been stopped, and that which was in the cylinder

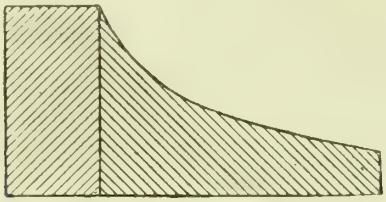


Ratio of steam used to work done, 100 to 169.

Fig. 4.

had been allowed to expand, and had thereby become increased in volume, decreased in pressure, losing some of its heat in the process, because of the work which it had done in expanding and pushing the piston forward, as was done by the powder to the shot. Upon the diagram the advantage to be obtained by this expansion—that is to say, the ratio of steam used to work done—is stated as 100 to 169.

In the next of these diagrams, fig. 5, the same principle has been illustrated, but here it is supposed that the inflow of the working agent at its full pressure has been stopped when the piston has moved through a quarter of its stroke, the remaining three-quarters being done by expansion.



Ratio of steam used to work done, 100 to 238·4.

Fig. 5.

You will see that the right-hand end of this diagram is much lower than the right-hand end of the diagram above it—*i.e.*, the pressure has fallen in this case lower, more work having been done; more heat having been abstracted. And look what has been the result of cutting off the inflow of the working agent as early as one-quarter of the stroke. Here the ratio of steam used to work done is as 100 to 238·4.

Lecture II.

When we left off we had commenced to discuss the question of expansion in a heat engine, and I had shown you how it was possible, by stopping the inflow of the working agent to the cylinder of the engine, at an early part of the stroke of the piston, to obtain an increased useful effect from the steam which was used.

We have now to consider this question of expansion in its application not only to steam, but to other gases, such as are commonly used in heat engines for power purposes.

The diagrams which I showed you last week are the theoretical diagrams for the various points of cut-off which I then stated, these diagrams being calculated out according to one law governing the expansion of gases.

If you will remember, when dealing with the question of the specific heat of gases, I pointed out to you that this specific heat varied according as the pressure or as the volume was kept constant. Of the two laws governing the expansion of gases, the first—propounded in 1662 by Robert Boyle, and commonly known as Boyle's law, or sometimes as Marriott's law—may be briefly stated as follows:—

That the pressure of any given quantity of a gas varies inversely as its volume (in other words, as the space occupied), providing the temperature is kept constant; or put in another way, with any given quantity of a gas the product of the multiplication of volume and of pressure is always the same, for if volume is decreased pressure is increased, or *vice versa*, always providing, as I have already said, the temperature is kept constant.

James Watt was one of the earliest who applied this law to demonstrate the expansion of steam, which may be called the "gas" of water. In the year 1782, Watt took out a patent, No. 1321, for "Certain new improvements upon steam or fire engines for raising water and other mechanical purposes." In this, Watt gave a diagram illustrating the economy to be derived from the use of expansion.

I will ask you to look at fig. 6, which is a copy of this, and it is said to be the first published diagram of the energy developed by a gas in a heat engine.

This diagram is shown inside the steam cylinder, and not outside, as was the case with the diagrams we considered last week. You will see that the length of the stroke of the piston is divided by the horizontal lines or ordinates into twenty equal parts, so that the vertical lines represent movements of the piston, the horizontal lines or ordinates to the expansion curve, representing by their length from the side of the cylinder (which is the base line), the pressures existing at various portions of the stroke. At each of the ordinates there is printed (in the original drawing) the estimated pressures existing at these portions of the stroke, and Watt shows in his patent that, taking the initial pressure as unity, the sum of all these is 11·562, which divided by 20—the number of the ordinates—gives, approximately, ·58 as the mean pressure of the steam during the whole stroke. As you will see, the steam is supposed to be cut off at a quarter of the stroke. Watt's statement of the advantages which are obtained is in these words: "Whereby it appears that only one-fourth of the steam necessary to fill the whole cylinder is employed, and that the effect produced is equal to more than half of the effect which would have been produced by one whole cylinder full of steam, if it had been permitted to enter freely above the piston during the whole length of the descent."

You will, of course, realise that if the steam were cut off earlier in the stroke, say at 1-8th, a greater percentage of effect would be obtained from the same quantity of steam, for the expansion curve would be carried on to a lower point. I have used this diagram to impress upon you that the value of expansion has been understood from the earliest days of the steam engine, and because it serves the purpose of illustrating Boyle's law—to which I have referred—propounded some 120 years before the date of Watt's patent.

I have already stated to you what this law is, and the diagram of Watt is the theoretical diagram for the degree of expansion shown, and in it the pressures at the various ordinates are calculated according to Boyle's law.

Let me restate this law to you in other words, giving your further illustrations. It is "that the pressure of any given quantity of gas varies inversely as its volume, the temperature being kept constant"—that is to say, if you compress a given quantity of gas, so that the space occupied by it is only equal to one-half that which it had occupied before compression, its pressure will be doubled; or if you expand a quantity of gas, so that the space occupied is doubled, then the pressure will be halved, always providing that the temperature is kept constant. Further, please remember that these laws which govern the expansion of gases are similarly operative when a gas is compressed. A curve of expansion, such as that shown in Watt's diagram—calculated, as it is, according to Boyle's law—is called an "isothermal curve," the meaning of the word "isothermal" being "unvarying temperature."

But you will tell me I have already stated, when considering the big gun diagram, that if mechanical work is done by a gas in expanding, some of its heat is transformed into this work, and that, therefore, unless some means are provided for maintaining the temperature of the expanding steam constant in Watt's engine, the curve of pressure could not possibly be one of "unvarying temperature," such as he has shown, but that curve of pressure must be lowered by the amount of heat representing the value of the work done.

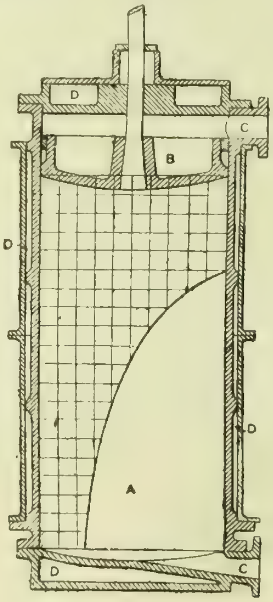


Fig. 6.

If you will again look at the diagram, however, you will see that Watt had realised this, for his cylinder is surrounded by a steam jacket, into which the free steam from the boiler was admitted; by this means he proposed to keep up the heat of the expanding steam in the cylinder, heat being transmitted from the boiler steam in the steam jacket to that which was doing work in the cylinder. Thus, the true isothermal curve which he has shown was theoretically possible.

It is hardly our business to go into the question of the advantages of the steam jacket in a steam engine, but I think, from what I have already told you, and from what I am about to tell you, you will realise that it is an advantage, not because it directly increases the efficiency to be obtained from any given quantity of steam, but because it enables a given quantity of steam to do more work in a smaller apparatus, offering, therefore, less opportunity for loss by radiation, or by contact with the cylinder walls.

But the question of the lessening of the total quantity of heat in an expanding gas, due to its transformation into mechanical work, brings us to the second law governing the expansion of gases—the law propounded by Charles (and practically at about the same time by Gay Lussac and also by Dalton), somewhere about the years 1801 to 1803.

This law of Gay Lussac tells us that the pressure of a gas, occupying a given space, will vary directly as its absolute temperature; and it further tells us (and this is a mere corollary of the other statement) that the volume of a gas which can expand—that is, which is not restrained from expanding—will vary directly as its absolute temperature.

The diagrammatic curve of expansion, which assumes that in an expanding gas no heat can pass away from it through the sides of the vessel in which it is contained, and also that the total quantity of heat contained in the given quantity of gas shall only be lessened by the quantity turned into work due to its expansion, is called the "adiabatic" curve, the meaning of the word adiabatic being "not to pass through." Let me try to illustrate this to you.

Assume that we have a given volume of gas at a given pressure, contained in a vessel absolutely impervious to heat, but whose capacity we can increase at will, and assume that we allow this gas to expand, then, as according to our assumption none of its heat can be lost by radiation, or in any other way except by conversion into work, say in displacing the atmosphere, the curve of pressure will be the "adiabatic" curve.

It was necessary for our purpose that these laws should be stated, and the two curves should be shown, because when we come to consider the diagrams of energy obtained from various forms of heat engines (especially those where some of the work done by the expansion of the gas is absorbed by the subsequent compression of the gas, for the succeeding stroke, previous to its ignition) we must be, to some extent, familiar with these two forms of curves.

Whilst we are upon this question, I will ask you to look at a diagram, where you will see by the dotted line the isothermal curve, and by the full line the adiabatic curve of expansion, and you will remember that, unless the heat is maintained, the adiabatic curve represents the one which would arise if the heat lost by the gas on expanding were all turned into work. (See fig. 7.)

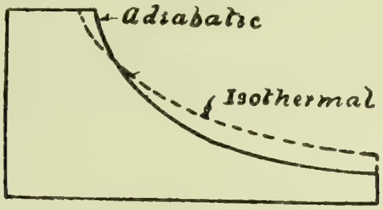


Fig. 7.

To those of you who care to pursue this rather abstruse question farther, I would suggest a full consideration and study of the lectures, and the book based on these lectures, afterwards published by Mr. William Anderson, to which I have already referred.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

GAS FIRING FOR STEAM BOILERS.

To the Editor of "The Practical Engineer."

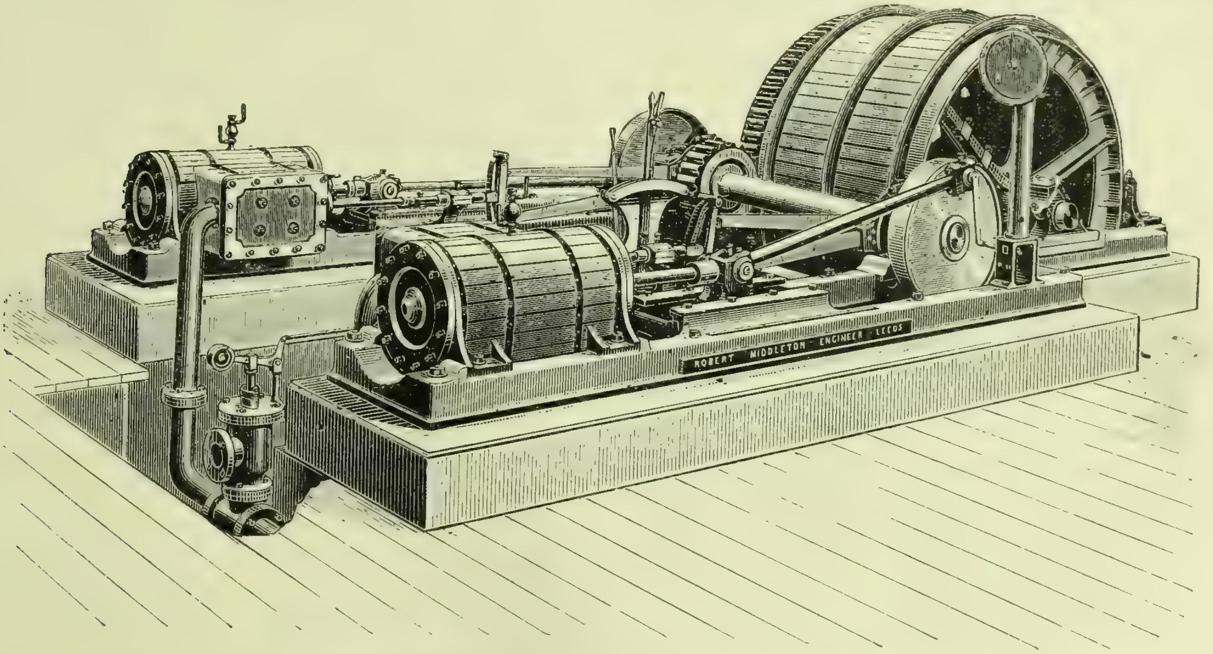
Sir,—In the review you were good enough to give in your issue of the 2nd inst. of my report for 1888, under the Alkali, &c., Works Regulation Act, you refer to the use of gaseous fuel in the furnaces of steam boilers. You are, I think, mistaken in saying that I advocate the gas-firing of steam boilers as being *per se* economical; on the other hand, I quite agree with your statement that "when coal is first converted into gas, and then the gas burned under a boiler, there is a loss of at least 30 per cent of the total heat of the fuel to begin with, and this is not compensated for by any increased economy in the combustion in the boiler flues." I entirely agree with this, and for that reason hail the system of Mr. Mond, in that he, by saving the ammonia of the coal, pays for the loss of heat, and so enables the consumer to enjoy the use of gaseous fuel without extra cost, or even with a possible saving. I think I have been careful to point out in my last and previous reports that it is this gain of ammonia which may make the use of gaseous fuel commercially possible, otherwise its use for steam raising, however desirable, for many reasons cannot be recommended economically.—

Yours &c.,
Alfred E. Fletcher,
H.M. Chief Inspector under the Alkali, &c.,
Works Regulation Act.
Local Government Board, Whitehall, London.

QUERIES AND REPLIES.

63. Screwing Machine Dies.—Can any reader inform me of the best way of advancing and withdrawing dies in a screwing machine, with three die bits? The machine I have at present has four dies and cuts badly, besides making an unequal thread.—D. W.

Answer.—The annexed figures illustrate a good mechanism employed for closing and withdrawing dies. Fig. 1 shows the relative arrangement of the parts when cutting; in fig. 2 the dies are withdrawn. The upper half of the views show the parts in section, the lower in outside elevation. Figs. 3 to 6 show front views of the more important parts, detached from their fittings. In these illustrations A is the mandrel of the machine, a portion of whose headstock is indicated at B. The mandrel is screwed to carry a disc C. This disc is traversed by three radial slots, in which the dies M slide. At the back of the disc there is an annular-turned groove D, within which lies a circular spring E, by the elasticity of which the dies are expanded. G is an annular casting bolted to a disc H, which disc is cast in one with the sliding clutch I, sliding on the mandrel A, but turning with it through the medium of the sunk keys J. In the back of G there is an annular recess of T section, to take four T-headed bolts K, by which G is clamped to H. A portion of the periphery of G and of H is indexed into degrees seen at x, so that on the slackening of the bolts K, G can be swivelled round into any very minutely graduated position in regard to H, and pinched. By this means three cam-like internal edges of the hard steel plate L, which is screwed to the face of G, are brought to bear upon the outer ends of the dies M, coercing them radially to their work in positions nearer to, or further from the centre, anywhere within the extreme positions P and Q in fig. 4. The bolts K being locked, the dies cannot move so long as the ports of the chuck are in the relative positions shown in fig. 1, where G and L are right up in place against the edge of the cap N. But when the sliding clutch I and plate H are drawn back with the



IMPROVED HORIZONTAL WINDING ENGINE.

IMPROVED HORIZONTAL WINDING ENGINE.

Mr. R. Middleton, engineer, of Sheepscar Foundry, Leeds, has recently designed and constructed a pair of horizontal winding engines for the Mieke Imperial Coal Mine, Chicago, Japan, which we illustrate above. They are fitted up in the best manner with double drum on strong steel shaft, strong, gearing and powerful brake. They have strong balanced hand reversing gear and balanced slide valves, and improved equilibrium steam valve. The flywheel shaft is of steel, with strong adjustable bearings, disc crank and best wrought connecting rod, and steel slipper crossheads. The engines are strong and compact, and do a large amount of work with great economy.

lever (not shown) the rings G and L are also drawn back, and the result is that the pressure of L being removed from the outer edges of the dies M, the spring E, coiled as in fig. 6, exerts its outward pressure, and thrusts the dies M outward, and the much-rounded edge seen at the top left-hand corner of the die M in the figures is thrust past the edge of L, throwing the three dies simultaneously free from the screw which is being cut. One of the dies M is shown separately in fig. 6. They are about $\frac{3}{8}$in. or $\frac{7}{16}$in. thick, according to size of machine. There is a slot cut on one side, as shown, into which the spring E fits. The spring is about $\frac{5}{8}$in. wide by $\frac{1}{16}$in. thick. The cap N, being screwed to the plate C by the three screws O, bears against the front edges of the dies, their back edges bearing on the bottom of the grooves cut in C. The spring is prevented from moving backwards from its proper position by means of the annular ring F screwed to the back of C, and covering the groove D. This is taken from a machine which I have seen in constant use for perhaps seven or eight years past.—J. H.

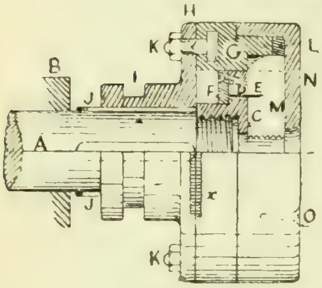


Fig. 1.

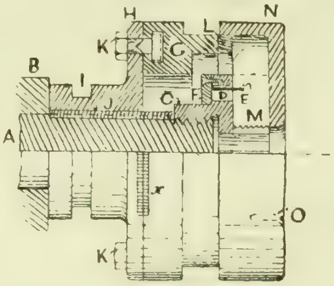


Fig. 2.

Fig. 3.

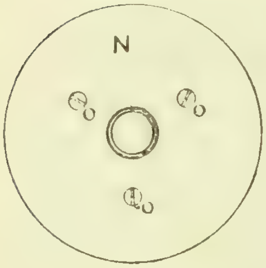
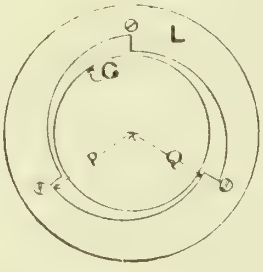


Fig. 4.



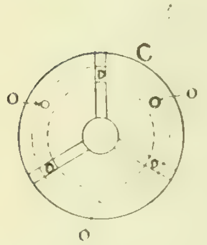


Fig. 5.

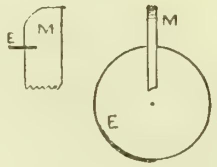
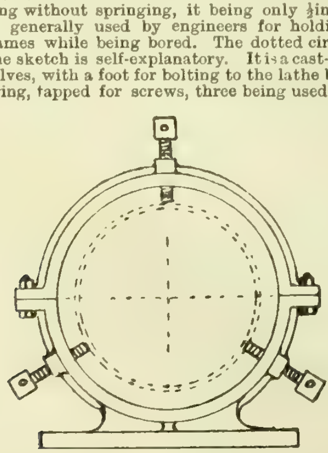


Fig. 6.

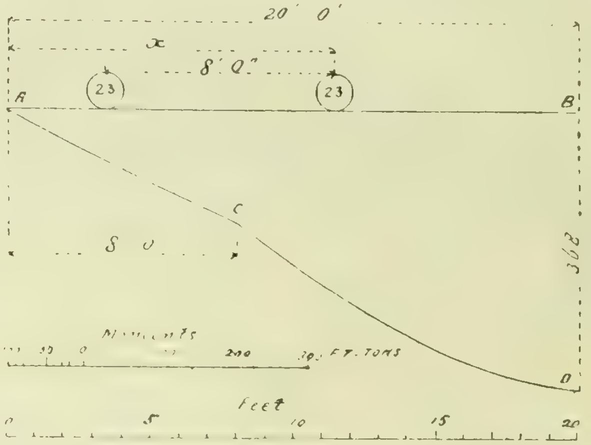
62. Boring Roll Cylinder.—I should feel much obliged for assistance from you, or any of your numerous readers, with the following: I have a cylinder for a roll; its length is 8ft., inside diameter 25in., and its thickness in rough metal about $\frac{1}{2}$in. I wish it bored out at the ends about 5in. or 6in., so as I can fit in arms and shaft, and to run pretty fair for outside turning. Can it be done in the lathe with any arrangement, or how would you advise me for cheapest and best, as my appliances are very limited?—Primrose.

Answer.—The boring of this barrel will be attended with difficulty unless the utmost care is exercised. The chief trouble will be to hold it firmly enough for boring without springing, it being only $\frac{1}{2}$in. thick. Stays like the sketch are generally used by engineers for holding such articles as "Primrose" names while being bored. The dotted circles show the barrel being held. The sketch is self-explanatory. It is a cast-iron ring, preferably made in two halves, with a foot for bolting to the lathe bed, with three deep bosses in the ring, tapped for screws, three being used to reduce the risk from springing the barrel when they are tightened up. Wood blocks, cut V shape, for the barrel to rest in, with a strap over the top, bolted to the lathe bed, would answer the same purpose if "Primrose" does not wish to incur the expense of the strap. The boring must be accomplished with a boring bar at least 6in. diameter, fitted with screw feed and sliding cutter ring; the traverse made self-acting by a star wheel at one end. I will give particulars of the boring bar, if it is required. Simple appliances could be put on the boring bar for turning the barrel up on the outside, if it were necessary.—F.



67. Travelling Crane.—In a travelling crane of 40ft. span, the load is supported on a carriage which runs on two similar girders, the axles of the carriage being 8ft. apart, and a load of 23 tons coming on each wheel. Obtain a diagram to show the maximum bending moment at every section of girder, and give numerical values at 10ft., 15ft., and 20ft. from one end.—J. C. W.

Answer.—The accompanying diagram shows the maximum bending moments due to the rolling load for half the girder, the other half being of course symmetrical with it. It is obtained from the following equations:—



Let M = bending moment in foot tons
l = span in feet
x = distance in feet from A towards B on line AB of section at which maximum moment is required. B is the centre of girder.
R = reaction of support at A in tons
W = load in tons on one wheel

For values of x from 0 to 8ft.

$$M = Rx = W\left\{\frac{l - x}{l}\right\}x = 23\left\{\frac{40 - x}{40}\right\}x = 23x - 0{\cdot}575\,x^2$$

For values of x exceeding 8ft.

$$M = Rx - W \times 8 = 2\,W\left\{\frac{l - x + 4}{l}\right\}x - W \times 8 = 2 \times 23\left\{\frac{40 - x + 4}{40}\right\}x - 23 \times 8 = 50{\cdot}6\,x - 1{\cdot}15\,x^2 - 184.$$

The curve of maximum moments is shown by the line ACD, the ordinates to which are the moments at the different sections. There is a cusp at C, where the distribution of load changes by the back wheel coming upon the girder. At 5ft. the moment is 100·625ft. tons; at 10ft., M = 207ft. tons; at 15ft., M = 316·25ft. tons, and at 20ft. M = 368ft. tons.

In designing the girder, you will of course have to add to these moments those due to the weight of the girder itself.—F. C.

73. Process for Cooling Water at Coates' Mill.—I shall be obliged for any particulars of the process for cooling water to be employed at Messrs. Coates' new mill, at Paisley.—Lever.

74. Flattening Saws and Plates.—Will some reader kindly inform me how to hammer buckles out of saws 4ft. 6in. diameter? Also if the same method does for square plates?—Blacksmith.

77. Air Pipe in Locomotive Funnel.—What effect would an elbow-shaped pipe have which was opened to the atmosphere, in front of a locomotive, at one end, and projected up the funnel at the other?—X. Y. Z.

79. Galloway Boiler.—What is the nominal and actual power of a Galloway boiler, 28ft. long, 7ft. diameter, with 33 conical Galloway tubes, and working at a pressure of 70lb. per square inch?—Boiler.

80. Book on Locomotives.—Can any of your readers inform me of the best book on railway locomotives—chiefly Midland Railway locomotives?—W. B.

81. Bolts for Flange.—In making a flanged joint fluid tight by means of bolts and nuts, what considerations should be taken into account in estimating size, number, and strength of bolts to be used? The fluid pressure being 100lb. per square inch, total amount of separating force due to pressure 10 tons, and length of flange measured along pitch line of bolts being 6ft., what should be the diameter and number of bolts?—C. P. W.

82. Oscillating Engine.—If CP be the crank and PQ the piston rod of an oscillating engine, find the velocity ratio of P to Q, and set out result in diagram. Find also the angular velocity ratio of CP and PQ at any point of stroke.—C. P. W.

83. Stern-tube Bearing.—What should be the diameter of the stern-tube bearing for engine of 4,000 horse power, making 90 revolutions per minute?—C. P. W.

TO CORRESPONDENTS.

C. P. W., London.—Thanks for your letter. All the articles you mention will be continued, but we must necessarily vary our contents to suit all our readers. The articles in the style of "Vacuum Condensers" will also be continued.

W. B., Wigston.—The *Railway Engineer*, London, may suit your purpose. We insert your query on locomotives.

W. J. W., South Wimbledon.—You can purchase vulcanite at the warehouses of any of the large indiarubber companies, which are numerous in London.

MISCELLANEA.

North-Eastern Railway.—The traffic receipts of the North-Eastern Railway continue to increase "by leaps and bounds." Passengers yielded £4,889 more last week than in the corresponding week of last year; merchandise and cattle gave £3,063 more; and minerals £4,474 more. Allowing for a decrease of £9 in dock dues, &c., there was a net increase for the week of £12,417; and for the half-year, so far, a total increase of £49,194 is recorded.

Naval Contracts.—We understand that in addition to the order for the machinery for H.M.S. Pallas, which was recently received by Messrs. R. and W. Hawthorn, Leslie, and Co., Limited, that firm has obtained the contract for the machinery of the second-class cruiser Sybille, to be built for the Admiralty at the shipbuilding yard of Messrs. Robert Stephenson and Co., Limited. The machinery is to develop a power of 7,000 horses with open stokeholds, and over 9,000 horses under forced draught.

Letters by Train. — The Postmaster-General has announced that a departmental committee had reported in favour of an arrangement for the conveyance by train of letters that have not passed through the post. It has taken some time to bring the department to see that the regulation prohibiting railway companies from conveying letters was one that militated very much against the public convenience. It is within the experience of almost everyone that sometimes a message may be conveyed by rail which cannot well be telegraphed, and yet which cannot await the ordinary course of despatch through the post.

Chilled Slide Valves.—*L'Ingenieur-Conseil* states that M. Bollinckx is casting the valves of Rider engines in a mould which chills the faces. The chill penetrates to a depth of $\frac{1}{6}$in. to $\frac{1}{5}$in. As the surface cannot be cut with a tool, it is ground with emery rollers until a perfectly true and polished face is obtained. It is claimed that not only do these surfaces not wear, but that, thanks to their exceeding smoothness, they do not wear the faces on which they work. Further, the co-efficient of friction is naturally very small. The administration of the State railways has sent a representative to examine the application of the mode of construction to the slide valves of locomotives.

The Longest Tram-line in the World.—A tramcar line is being constructed in the Argentine Republic which will connect Buenos Ayres with the outlying towns, and will, when finished, extend over 200 miles. The cars will be drawn by horses, which are amazingly cheap and plentiful in South America. Steam would be a far more costly means of working the trams, for fuel, both wood and coal, is scarce and expensive. The rolling stock consists of five sleeping cars 18ft. long, each with six beds, which in the day time are rolled back to form seats; four two-storeyed carriages, twenty platform carriages, six ice wagons, four cattle trucks, and 200 goods vans.

Argentine Republic.—Figures are published showing that, during the first four months of the present year, 96,200 immigrants landed in the Argentine Republic. There has been nothing approaching this in the corresponding period of any previous year. In 1887 the immigrants from Europe numbered 142,786. In 1888 the number rose to 180,993, being an increase of 38,207 immigrants. By this showing last year's immigration gave a monthly average of 15,082, which is a daily average of 502. At this rate it will not take many years for the Argentine population to double itself, and to outstrip in the process of multiplying the most rapidly growing of the American States.

Glass Pens.—We read in the new issue of the *Moniteur Industriel* of the invention of a glass pen. It is furnished with a helicoid groove which carries the ink. It is described as "delightful to write with;" and, if this be true, we are certain to hear of its making way in the market. The ancients first wrote on their wax-covered tablets with pens of bone. Then came the pen of ivory, and after that came the bronze pen. To write upon the papyrus, when it came into use, the pen was made of a reed dressed as a quill pen now is. Then the goose quill found favour, keeping the field for centuries long, and to this day finding a multitude of hands that prefer it, in driving over foolscap, to the steel pen or any other pen in metal.

The Soda Engine.—This engine, remarks a contemporary, is said to be gaining in favour where steam is not allowed for tramcars; and in the St. Gothard Tunnel, under the Alps, where steam engines cannot be used, the soda engine is worked. The boiler in this engine is filled with a few tons of soda, and when a jet of steam is introduced it produces an intense heat. This gives the motive power, from which there is no exhaust or refuse. In a few hours the soda is thoroughly saturated and the action ceases. A jet of superheated steam from a stationary boiler is then driven through the soda; this drives out the moisture, and it is then ready for use again. To the soda engine there is no visible smoke stack, and there are no fumes, so that it has considerable advantage over a steam engine.

Cockerill's Guns.—That a prophet is without honour in his own country applies to gunmakers among others. We told lately of the disaffection in Belgium because of the determination of the authorities to send their orders for cannons to the German Krupp. The Liege manufacturers offered to do the work at a much lower price, but the inspection generale de l'artillerie laughed to scorn that offer. Perforce of public reclamation, however, Cockerill and Co. have succeeded in getting the authorities to test specimens of steel guns by them. The result is that they are declared to be superior in every respect to Krupp's manufacture, and 62 cannons (12 centimetres) are to be ordered for the defence of the Meuse forts.

The Railway Race.—Mr. William Duncan, of Sunderland, has asked the Chairman of the London and North-Western Railway a very pertinent question. Mr. Duncan wishes to know whether the London and North-Western directorate contemplates embarking in rivalry such as the race of last year?—and unless the reply was satisfactory he proposed to elicit the opinions of his co-shareholders on the matter. Sir R. Moon, in reply, expressed the idea that last year his company's trains simply ran "in the same time as the trains on the East Coast route" to Edinburgh, and now they are running in 8½ hours. Whether Sir Richard supposes that "neck-and-neck" forms no race, or whether he thinks the mad gallop of last year was indefensible, cannot be gathered from his reply.

A Sawdust Filter.—Carbonised sawdust, saturated with chemicals, has been introduced into Germany as a filtering and discolouring material. Sawdust is treated first with alum, then with sodium carbonate, and becomes impregnated with a precipitate of aluminium hydrate, which firmly adheres to it. After being washed with a solution of barium chloride until no precipitate is given, the sodium sulphate simultaneously produced is entirely removed, and the prepared sawdust is ready for use. Coloured liquids filtered with it have their colour entirely removed by the formation of lakes with the aluminium hydrates present in the filtering material. Sawdust saturated in this way with barium chloride is used for filtering liquids from which it is required to remove calcium sulphate, and a sawdust treated with magnesium sulphate and caustic soda is used to remove calcium carbonate from a solution.

The Dangers from Electric Wires.—The New York correspondent of the *Lancet* narrates the following series of accidents which occurred in that city from the breaking of electric wires: The frequent accidents from the breaking of electric wires is exciting much public interest. In several instances horses have been instantly killed by the sudden parting of these wires, the ends of which have fallen upon the animals while passing under. Recently a wire fell, broken, in front of a team. The driver seized the wire to throw it aside, when he was convulsed by the electric current, but could not release his grasp. A gentleman seized him by the arm to pull him away, and was himself instantly prostrated. A second man attempted to push the wire aside with his cane, and was paralysed. A dog approached, and, touching the wire with his nose, instantly fell insensible. At length a workman cut the wire with the stroke of a hatchet, and thus released the first victim, who is slowly recovering. The city authorities will now compel all electric companies to bury their wires in properly enclosed and protected subways.

Well-pumps as Fire Engines.—In many cases, a substantially constructed set of well-pumps, even if fitted down a well 100 or 200ft. from the ground level, may be utilised as a fire engine in large establishments. This is the case with Mr. Blundell Maple's residence at Childwickbury, St. Albans. The pumps are fixed in a well nearly 200ft. deep, and are driven by a gas-engine. The adaptation of the system of fire extinguishing has been planned by Messrs. Merrywether and Sons, of London. On the rising main from the pumps (which supply all the domestic services) a suitable valve, with air vessel, is connected. The former is loaded to the strain the hose will bear, and there is sufficient force to drive one or more streams over the highest points of the building. The main is carried round outside the building, and is fitted with hydrants, hose-pipes, and nozzles, which are kept in suitable boxes. When a test of these fire-extinguishing arrangements was made by Mr. J. Compton Merrywether, a false alarm of fire was given, and in a very short time the engine and pumps were running and delivering two steady jets of water over the highest part of the premises. The men on the estate have been formed into a brigade, and are drilled every quarter.

The Junior Engineering Society.—The summer excursions of the current session, which are now taking place in connection with this society, have, up to the present time, included a visit to the Tower Bridge Works, by the kindness of Mr. Wolfe Barry; an afternoon and an evening visit to the R.M.S. Britannia, of the P. and O. line, the former occasion taking place when the vessel was berthed in the graving dock, and the latter, by the courtesy of the directors, on the eve of its despatch, and consequently at the most favourable time for an inspection. Dulwich Colliery Engineering Laboratory has also been visited, Mr. F. W. Sanderson receiving and showing the party round. A demonstration on the experimental steam engine formed part of the programme. At the Crossness Sewage Pumping Station, visited on 13th ult., the engines, boilers, reservoirs, &c., of the existing works were seen, and the opportunity which was afforded of going over the new extension works now in course of construction was much appreciated, the visitors having the advantage of the company of Mr. F. E. Houghton, resident engineer, who fully explained the many points of interest. The latest visit took place on 1st inst., to Messrs. Brin's Oxygen Works, at Westminster, where the ingenious plant employed by them for the extraction of oxygen from the atmosphere, by means of baryta, was seen in operation.

ILLUSTRATED PATENTS.

3450. **Feed, &c., Pumps**, E. Paul, 83, Newby Street, Liverpool.

Relates to pumps whose office is to preserve a liquid at a constant level, and more especially to boiler feed pumps. As shown in fig. 1, the pump is single acting, and is actuated by the piston B, working in the cylinder A. The rod C is made large, as shown, so as to leave only a small annular space F below the piston. This space is in communication with the boiler by the pipe E and cock G, the latter being placed at the water level. K is a receiver to hold water sufficient to ensure that the space F is always full of the latter. Steam is admitted above the piston by a slide valve, and the upstroke is performed by the steam or water passing through G. If steam passes, the strokes of the pump are rapid; if water, they are slower; and thus the pump automatically preserves the level in the boiler. In the case of a double-acting pump, the piston rod is continued into an extra cylinder and provided with a piston, each side of which is put into communication with the boiler by a separate cock. Instead of a cock at the water level, a valve, as shown in fig. 3, may be employed. This has a free lift in the direction from the boiler to the steam cylinder, but the opening in the reverse direction is adjustable by a collar on the rod *e*. This is for use at the water level in boilers for controlling the lift stroke of an automatic feed pump. It has a free lift in the direction from the boiler to the steam cylinder, but the opening in the reverse direction is adjustable by a collar on the rod *e*.—March 6, 1888. [8½d.]

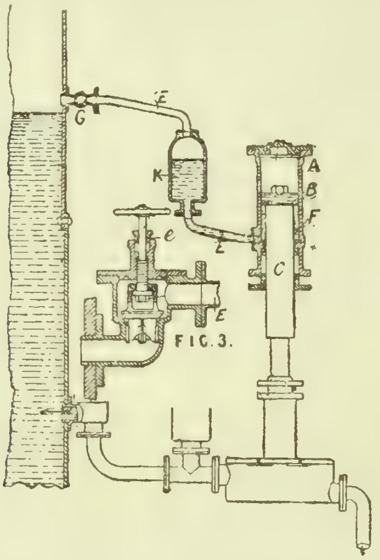
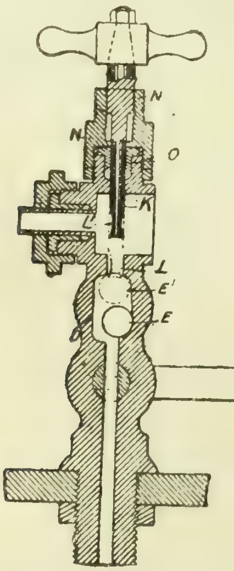


FIG. 3.

3337. **Steam Boilers**, S. Matthews, 13, Noble Street, Hendon, Sunderland.

Gauge Glasses.—The steam and water ways are closed automatically, when the glass breaks, by ball valves, which are held off their seats, when blowing through the glass or connections, by spindles with quick threaded screws. A vertical section of one fitting is shown. The ball E rests in the chamber D, the bottom of which is inclined, and access to which is got by unscrewing a plug, not shown. Should the glass break, the ball is carried by the rush of water into the position E^1, in which it closes the passage L. The ball is held off its seat when blowing through by the spindle K, which is reduced in diameter and fluted at L^1. Where it passes through the nut N, which serves to retain the gland O, it is provided with a quick threaded screw.—March 5, 1888. [6½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

July 24th.

11759 Combination Blast, J. Morrison, Durham.
11763 Lock Nuts, J. C. Bourgeaud, Birmingham.
11766 Water Meter, A. Barclay, Glasgow.
11780 Electric Generators, C. E. Buell, London.*
11784 Water Motor, O. T. Hobday, London.

July 25th.

11803 Hydraulic Motor, J. Graham, E. D. Collicutt, and G. E. Thowburn, Newcastle-upon-Tyne.
11820 Reeling Machines, E. Rushton, Manchester.
11822 Propeller Shafts, J. Taylor, London.
11824 Mules, J. Calderbank and J. Winward, London.
11832 Couplers, E. R. Dolby, London.
11836 Hand Punch, G. S. Brooks, London.
11838 Sleepers, R. D. Ker, Glasgow. (T. Ker, India.)
11841 Coupling, A. W. Johnson, London.
11845 Drying Grain, J. Sleeman, London.
11849 Refrigerators, R. C. A. Banfield, London. (C. Linde, Germany.)
11851 Indicators, H. Lane, London.
11854 Propulsion of Ships, J. W. T. Olan and J. A. Archer, London.
11855 Artificial Fuel, J. Morris, London.
11858 Sprinkler, F. Maynard, Hoxton.
11864 Steam Boilers, J. J. Barclay, London.
11865 Refrigerators, L. Perkins, London.

July 26th.

11867 Removing Scale from Boilers, J. Platt and T. Thorp, Manchester.
11868 Mules, J. Charlesworth, J. Fisher, and R. Yates, Manchester.
11872 Wool Combing Machines, C. Bradley, J. Radford, and J. Richardson, Bradford.
11873 Locking the Nuts of Bolts, T. Lealand, Birmingham.
11875 Furnaces, A. Jackson, West Hartlepool.
11883 Extracting Metals from Ores, S. Trivick, London.
11884 Valves, Sir W. Thomson, Glasgow.
11894 Draught in Furnaces, J. A. Cole, Sheffield.
11900 Conduit, M. Dallas, London.*
11912 Pipe Joints, A. Thomson, London.
11915 Corn-milling Machines, J. E. Evans-Jackson, Middlesex. (J. Pope, Virginia.)*
11917 Spinning Machinery, A. V. Newton, London. (J. Good, United States.)
11919 Pipe Joints, C. A. Gibault, London.
11925 Valves, C. A. Rempen and E. Andre, London.
11926 Gas Engines, J. C. Bull, London.
11927 Covering Electrical Conductors, S. Pitt, London. (J. B. Atherton, United States.)*
11928 Lock Nuts, S. Pitt, London. (A. J. Perry, United States.)*

July 27th.

11929 Springs, W. C. Lockwood, Sheffield.
11931 Governors, W. H. Knowles, London.
11937 Cycle Gearing, D. Jones and C. Wade, Coventry.
11960 Printing Machinery, W. H. Schürmann, London.
11968 Tempering Wire, J. Tetlow and E. Hodgson, Huddersfield.*
11969 Coupling, T. Averell, Belfast.

July 29th,

11997 Electric Meters, W. Emmott and W. Ackroyd, Halifax.
11999 Furnaces, J. Waters, Glasgow.
12008 Breech-loading Guns, W. H. Brighton, Birmingham.
12017 Clocks, D. Sherlock and J. Eshelby, Dublin.
12022 Crushing Mills, C. W. Guy, London.
12029 Driving Gear, F. Rinecker, London.
12030 Brakes, J. Holloway, W. R. Mortimer, and A. D'Romtra, London.
12032 Capsules, P. Bruch, London.
12033 Aluminium, H. Bessemer, jun., London.
12035 Electric Regulators, G. Forbes, London.
12036 Water Meters, W. G. Kent, London.
12038 Construction of Ordnance, L. Gathmann, London.*
12039 Hand Printing, H. S. Burton, London.

July 30th.

12044 Cartridge Extractors, C. H. Maleham, Sheffield.
12045 Gas Engines, H. J. Allison, London. (L. F. McNett, United States.)*
12051 Tension-regulating Devices, W. P. Thompson, Liverpool. (The Ranken and McDonald Spinning Co., United States.
12052 Water-tight Partitions, W. P. Thompson, Liverpool. (W. T. Sylven, United States.)*
12054 Lighting Gas, B. H. Thwaite, Liverpool.
12055 Water-supplying Apparatus, O. Peischer, London.
12059 Brake, R. Clegg, Manchester.
12066 Signalling Lamp, T. W. Watson and A. H. Watson, London.
12068 Lubricators, E. Aldersley, J. Comer, R. Berger, and F. H. Deakin, Glasgow.*
12076 Milling Machines, G. Richards, Altrincham, Cheshire.
12078 Knitting Machines, G. Stibbe, Glasgow. (E. Dubied, Switzerland.)
12079 Looms, J. W. Green, jun., and G. C. Moore, Glasgow.*
12082 Electric Motors, A. J. Jarman, London.*
12086 Railway Signalling, F. N. Kelsey, London.*

Publishers' Announcements.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

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THE

PRACTICAL ENGINEER,

AUGUST 23RD, 1889.

ERRONEOUS SCIENTIFIC THEORY IN PATENT SPECIFICATIONS.

IT is an interesting and remarkable fact that inventors of new machines and appliances have frequently formed entirely erroneous theories of the actions occurring within their own machines, and this notwithstanding their complete practical success and wide usefulness. In the patent specifications dealing with such inventions, false theory or hypothesis has often been embodied in the description necessary for enabling the public to fully understand what is claimed as novel. This has been done by the inventor in all good faith, with the full belief that what he describes actually occurs, and with the honest intention of clearly setting forth what the invention is, how it is to be carried into effect, and what processes or actions proceed in its application to some useful purpose. It is very natural and almost necessary that inventors should form some theory in their minds of the actions and processes proceeding within their inventions; and in some particular point their ideas must have force and truth, otherwise their practical success would be very small. In inventions dealing with mechanism only, and mechanical motions where the novelty consists in a new combination of moving parts, it is rare that any mistake is possible; but when electrical, chemical, or physical considerations come into play, as they necessarily do in a great mass of inventions of the present day, then it is not at all uncommon to find substantial practical improvement associated with entire misstatement of the science of the machine. In questions relating to dynamo machines, for example, an inventor may possibly make great improvements by dint of experiment and trial, and yet be in grave error as to the causes of his improved results. M. Gramme seemed to have essentially misunderstood the theory of his dynamo. When obscure physical relationships occur, as in the action of the Giffard injector, it is very easy to make mistakes, and at one time, but a few years ago, injectors were most imperfectly understood. Many inventors proposed the wildest explanation of their action, and designed appliances based upon these wild conjectures. In furnaces, also, and inventions where combustion of fuel in its solid, liquid, or gaseous form is necessarily considered, mistakes are very common. Patents for new chemical processes are often valueless on account of erroneous descriptions of chemical actions, and misapplication of chemical formulæ.

We have had extended experience of the difficulties and dangers incident to the occurrence of erroneous theories in specifications, and it is our purpose here to point out where the danger is, and how it operates against an inventor when he endeavours to assert his rights and prevent infringement by appeal to the law courts.

Inventors should remember that a patent specification has two main functions; the first is to inform the public the precise nature of the invention claimed by the patentee, in order that people may know what it is that he claims exclusive rights over, and what it is that they must not use without his permission during the term of the patent. In fact, the specification is supposed to be an accurate map, clearly defining the boundary line of the patentee's exclusive property in the realm of nature, so that the public may know the special ground on which they have no right to encroach. The second purpose it must serve is to enable the public, at least those of them skilled in the industry dealt with, to utilise the invention from the description given after the patent has expired and the invention has become public property. The description and drawings must be sufficiently accurate and comprehensive to serve these two main purposes. It is by no means uncommon to find even now inventors who attempt to give a false colour to their inventions as described, in the hope of obtaining the protection which a patent affords, without fully disclosing the nature and extent of their invention. This is a fault upon which patent law is exceedingly severe, and any proved attempt to mislead on any essential point at once makes a patent void and useless. Now, where a false theory of the action of any invention is given by an inventor, even unwittingly, it has often been set up as a defence in cases of action for infringement that an attempt has been made, or that the public has been diverted from the essentials of the invention by such false theory, and that consequently the patent should be held to be bad. This, if proved to be true, would doubtless invalidate the patent, and that is where decision becomes very difficult. In such a case the patentee must show that, even if erroneous in theory, the specification is still sufficiently clear and precise to allow the invention to be carried into useful effect, and that the error in theory does not lead away from the essentials of the invention. It is not by any means absolutely necessary that the patentee's theory should be correct, provided the practical directions are sufficiently clear and explicit, but it is nevertheless exceedingly dangerous if it be incorrect. In the conduct of patent actions this has been abundantly evident, and has caused enormous expense and whole days of argument in court.

In a recent case the patentee was the inventor of an improvement in miners' safety lamps, by which the light given out by these lamps was more than doubled without in any way interfering with the safety in inflammable gases. The invention was exceedingly simple, and consisted only in the insertion of a metallic ring between an outer metal shield and the wire gauze in a particular position. By some means this simple procedure increased the illuminating power very greatly, and in the specification a certain theory was given explaining the increase of illumination. The patentee succeeded in selling a very large number of lamps, which are now extensively used in many mines throughout this country. As usual with a successful invention, many lamp makers sought to share the benefit without arrangement with the inventor, and accordingly he had to take action in order to protect his rights. The infringers, by their counsel, urged as one plea, that the inventor had in his patent enunciated an erroneous theory of the cause of the improvement in light, and had stated that the intervention of his ring produced certain effects which, as a matter of fact, had no real existence. Now, if it could have been shown that the erroneous statement had been wilfully made in order to hide from the public the real nature of the invention, or if it had been proved that although innocently wrong yet it did substantially prevent the mind from understanding the real nature of the invention, then no doubt the patent would have been found to be useless, and the infringers would have escaped. But as neither of these contentions was established the patent was held to be valid.

In a recent compound winding case some interesting points of the same kind came up, and here it was found that although Varley, the original proposer of this system of winding dynamo machines, had not fully understood the nature and consequences of his invention, yet the mere fact of publication, with only such detail as enabled dynamos to be so wound without further explanation or theory, was amply sufficient to bar any subsequent patent.

In drafting specifications, therefore, it is undoubtedly advisable to avoid theory as much as possible, and to confine descriptive details as closely as possible to the matter in hand, and only carry it far enough to make it thoroughly intelligible. If too much theorising be indulged in, then it is apt to cause endless discussion and expense in any legal proceedings which may be taken. Inventors sometimes say to us, "Why take so much trouble? My patent is not likely to be contested." So much the better. But we say it is only in so far as the specification is carefully drawn and obviously good that it is any real protection, and such specifications have a much better chance of protecting the inventor than a loosely and carelessly worded document which obviously affords a weak place for successful attack. In the interests of inventors and manufacturers we think it most desirable that some at least of the principal points of our patent laws should be thoroughly understood, and, accordingly, we intend dealing shortly with interesting points in patent practice in these columns from time to time.

ENGINES FOR ELECTRIC LIGHTING.

In a recent article upon engines for electric lighting, a contemporary refers to the fact of slow-moving engines of the mill type being chosen for the Deptford Central Station, as constructed by Messrs. Hick, Hargreaves, and Co., of Bolton, and seems to consider it almost beyond the engineering resources of the day to construct successful high-speed engines.

Mr. Arthur Rigg, the inventor of the beautiful "Rigg Revolving Engine," writes with some indignation, pointing out that this opinion is an entirely erroneous one. He states his conviction that high-speed engines can be constructed to run with economy and uniformity at all speeds necessary for dynamos, without more attention than that devoted to slow-moving engines.

Mr. Rigg's opinion is entitled to very great respect, as a well-known and successful practical engineer and inventor, as well as the author of an admirable treatise on the steam engine; but we rather favour the use of slow-moving engines for large powers and central stations. Our reasons are obvious. To begin with, there is ample experience in the construction and management of powerful engines of the mill type, and we can be perfectly certain of uniform running, economy, and entire reliability. With high-speed engines, experience is at present limited to comparatively small powers, and with those it is well known that considerable difficulties have to be met. They require more care and more frequent repairs than other engines. Mr. Rigg's revolving engine is admirable in idea, but we doubt if sufficient experience with it exists as yet to make it available for large powers such as, say 1,000 horse, with any approach to economy and certainty. We admired this engine very much when we saw it in action some two years ago, but it seems to us that some points of difficulty still exist, which prevent its successful application for large powers. However, Mr. Rigg may be able to throw some light on this point.

DECLINE OF THE WATER-GAS CRAZE.

The decline and fall of the water-gas craze is now in full swing. As usual in cases where branch companies are promoted, from the funds of which parent companies hope to reap handsome dividends without earning them, the secondary companies are the first to discover faults in the scheme. The British Water-gas Syndicate has three off-shoots, the Nottingham and Derby Water Gas Company, the Yorkshire Water Gas Company, and the North British Company. These companies undertook to pay large sums for rights to work in their respective counties. At recent statutory meetings, the shareholders were informed that negociations were pending for monetary and other concessions from the Syndicate to make the conditions less onerous. We have already pointed out that the field for the profitable employment of water-gas is at present a very limited one, and that so far as we can see, there seems not the smallest hope of it supplanting coal gas for domestic use. We strongly deprecated the raising of large sums of money from the public—but ill informed—on the glowing grounds of the promoters' prospectus, and we are of opinion that legitimate employment for even the capital at present subscribed is very improbable. It is difficult to see where business is to come from to earn a dividend even for the companies in existence.

We cannot see, therefore, even with large concessions from the parent syndicate to the sub-companies, that there is any present hope of sufficient employment. Water-gas can be made by many processes, and there are but few profitable uses failing domestic supply. There is no doubt a fair field for the gradual development of business in applying the gas to industrial purposes, where high temperatures are required, but that will take years to work up, and will necessitate the invention of special means of arranging furnaces to suit varied work.

PHOTOMETRIC TESTING.

The persistence of obsolete methods of estimation and measurement is well illustrated by the continued use of the standard candle as a means of comparison for testing the illuminating power of gas. It has been known for many years that grave difficulties exist in using candles in this way, difficulties so great as to make photometric measurements comparatively inaccurate even in skilled hands. Many excellent standard lamps now exist which secure the almost absolute uniformity of results, yet the old candle still remains the legal unit. We hope, in the interests of accuracy, that a more modern standard may be shortly legalised by act of parliament; meantime we are pleased to see that those prominently associated with gas companies interest themselves in the question. Lately Col. W. T. Makins, M.P., referred to the proposed changes in the law, at the half-yearly meeting of the Gas Light and Coke Company, and stated that a better method should be used.

SUB-MARINE TORPEDO BOATS.

According to a French contemporary a new sub-marine torpedo boat has been tested at Cherbourg harbour recently, and answers its purpose admirably. Its details are kept secret, but it is the invention of M. Goubet, and the boat used in the trials is called the "Goubet." Two men went down in it, and remained below without inconvenience for eight hours, smoking and playing cards. The new boat, it is stated, during the experiments sank to variable depths at command, and was manœuvred quite at will, behaving as much like a fish as possible. The long submersion recalls the tales of Jules Verne, with his caustic potash solution to absorb the carbonic acid generated by breathing, and the chlorate of potash oxygen generator. It only requires the sodium battery and motor to make it complete.

THE INMAN LINER CITY OF PARIS.

Last week the City of Paris made a new record, and for the first time has made the run home from America to this country under six days. In May last she made fast passages both out and home, crossing to New York in 5 days 23 hours and 7 minutes; average speed close on 20 knots per hour, thus beating the best former performance by over two hours. Coming home she crossed in 6 days and 29 minutes. This admirable result fully realises the anticipations of her builders, and justifies the use of twin-screws for the swiftest vessels. It is somewhat remarkable that the sister ship, the City of New York, should have failed to approach this speed. There must be some important difference in detail.

SAMUEL BROWN'S GAS ENGINE, IN 1827.

In a letter to the *Engineer* Colonel Hyde Clarke calls attention to an omission by Mr. H. Graham Harris, in his recent lectures to the Society of Arts. He states that Samuel Brown's gas engine was well known previous to 1835, and excited great interest. He says that in 1826 he understood a launch was driven by screw propeller and gas engine of Brown's construction upon the river Thames, and about 1840 he drained the Croydon Canal with a gas engine for the Croydon Railway. Colonel Clarke states that he knew Brown personally, and that the comparative success of his invention was a matter of public notoriety.

If this statement be correct, then Samuel Brown certainly deserves more credit than he has obtained from those who have written on this subject.

THE PARIS EXHIBITION.

(From Our Own Correspondent.)

It would be quite impossible for us, within the limits of these articles, or even within the limits of our paper, to enumerate, much less to describe, the very numerous and varied steam engines collected together in the vast Machinery Hall at Paris. We propose, therefore, to restrict ourselves almost entirely to the consideration of a very few of the most striking engines; but here we may state that continental makers of engines or machinery are by no means so liberal with information respecting their work as we are here in England. Many of the larger firms seem to consider that their duty to the public ends when they show their engines at work, and they seem to resent, to some extent, any desire to inspect too minutely or to inform ourselves of the internal arrangements of their machines. In our opinion this extreme care is hardly required, at least so far as our country is concerned, because we are happy to state that, notwithstanding great and undeniable advance in continental practice, it is our distinct opinion that our rivals there have still much to learn. And, as of old, they can learn it from ourselves. It is true that we have put in but an insignificant appearance at the Exhibition so far as steam engines are concerned, and so, undoubtedly, appear at a disadvantage to those who form their idea of the engineering position from that display alone; but to those who know the practice in our own country it will be evident that we could bring together, if need be, a much better display of steam engines without difficulty.

Continental engineers still display, as a class, a tendency to undue complication of parts, although there are notable exceptions, and they favour many constructive details which we in Britain try to avoid as much as possible. In Britain a long course of trial and error has eliminated from public use many odd and peculiar forms of engine, but on the Continent, if the Exhibition may be taken as a guide, such types still exist. There are quite a number of beam engines, for example, by Messrs. Weyher and Richemond, in which the central pillar carrying the beam oscillates, and the beam end moves in line with the piston rod. This is a very old plan, and has long been abandoned in Britain. The same firm, however, exhibit several excellent horizontal compound short-stroke engines, in which a strong bed-plate carries two cylinders acting on cranks at right angles, and having overhung flywheels. The valves used are slides, and an expansion slide in the back of the main valve is controlled by a governor.

Perhaps the finest looking and best finished engines in the hall are those by the eminent firm of Messrs. Sulzer Brothers. A triple expansion vertical engine by them is a notable example of good design, finish, and smooth running. The framing is marine in type, and the valves are driven from a special shaft actuated from the main shaft by bevel wheels and a vertical shaft. The governor is carried on this shaft, and the cut-off is varied by the well-known Sulzer trip gear. The steam valves are of the double-beat type, as are also the exhaust valves. They also exhibit horizontal engines of their well-known Corliss type, with Sulzer valve gear, all of admirable construction, and beautifully smooth action. This firm, by the way, force the oil required for the cylinders by means of small pumps on the valve gear shafts.

The largest horizontal engine of the Corliss type in the building seems to be that by M. Farcot. It is a splendid job, but there is nothing specially novel in its design, as the valves and valve gear are of the older Corliss type. The huge flywheel of this engine is built in segments, and during transit one of these was broken; a new one was cast and turned-up after bolting in its place. For a time this work formed a most attractive exhibit in itself, and great numbers of people watched with interest the operation, which was necessarily somewhat prolonged.

The Corliss type of framing seems now almost uniformly adopted among French makers for their horizontal engines, and but few slide valves are to be seen, as we have already remarked in a previous article. The Corliss type of valve, double beat, and piston valves, are widely used. Mahogany lagging has also been replaced almost entirely by Russian iron; but some makers adopt sheet brass, which has an exceedingly brilliant effect. We prefer to use iron, however, and many good firms in Britain now use iron or steel lagging, as our readers are aware.

In the American section there is shown in action a very fine example of Professor Sweet's straight-line engine, in which the leading idea, as the name implies, is the use of the straight line wherever possible in the design. The exterior of the cylinder is finished in rectangular form, and has two opposing valve chests serving for live and exhaust steam. The steam and exhaust ports are straight and short, leading directly to the cylinder ends without contact with the cylinder body, so that the entering steam is cooled by contact as little as possible, while the exit steam cools the cylinder as little as possible.

The connecting rod couples direct to a crank pin passing between two flywheels, which hang inside the bearings. By this device all the motions are direct, and the eccentrics drive straight to the valve spindles. This engine has another interesting peculiarity, which we cannot consider worthy of imitation, nevertheless it proves at least the admirable workmanship of the engine. There are no packing rings or stuffing glands in the whole engine. The piston is simply a long hollow block turned to fit the cylinder very accurately, and having a number of grooves turned in its circumference. The piston and valve rods also pass through long sleeves without packing, but with grooves. When sufficiently accurately made, the oil used in lubrication, or the little steam condensed, provides so great a resistance to the passage of steam that the leakage is practically inappreciable. There does seem, however, to be a very slight leakage in the engine we inspected at work, not more than that due to a slightly imperfectly-screwed-up packing, but still a leakage.

The Straight-Line Engine Company do admirable work, and the extensive use of this engine in America proves that the arrangements answer in practice; but we do not think that the economy, after working for a time, can be equal to our own engines. Cylinders and pistons are sure to wear in time, however well made; and so are piston rods and valve stems, so that after a time leakage must become serious, with the usual result of loss of fuel. We quite believe that our English engineers err on the side of short pistons, and depend perhaps too exclusively upon the piston rings for steam tightness; still it is better than the method of Prof. Sweet. Such an engine is useful as an example of what can be done by accurate work, but is not worthy of imitation. We are much indebted to American engineers for some of our steam-engine practice, especially to the late Mr. Corliss, but the present race of American steam engineers do not seem to offer examples worthy of imitation.

Among the numerous types of horizontal engines suitable for mill purposes, we did not observe any examples of governor regulators so commonly used with us. Are the continental engineers content with less regular turning than we require here, or are their governors so well made and designed that compensation or regulation are not required. In Britain we seem unable to get sufficiently accurate turning without supplementary governors, such as Knowles's, or speed regulators like Wilby's or Higginson's. However that may be, we could not find any equivalent contrivance at the Exhibition. There is no great departure in valve-gear at the Exhibition; perhaps the most striking is that of M. Friker, which seems to be considerably used upon the Continent now.

The Société John Cockerill, of Seraing, have a large vertical compound blowing engine of their well-known type.

Among the leading makers of horizontal mill engines, in addition to Messrs. Sulzer, we may mention Escher, Weysch and Co., Braueur and Co., Joseph Farcot, and Schneider and Co., all of whom are well represented.

WATER CONSUMPTION IN STEAM ENGINES.—II.

After the explanation given in our introductory article of what is meant by the weight of steam or water per indicated horse power consumed by an engine, it will be seen that when we know the pressure at which the steam is released from the cylinder we can, by means of a table of specific volumes and weight of steam, knowing the capacity of the cylinder, the clearance space, and the number of times the steam is discharged per minute, readily arrive at the quantity of water or weight of steam used. Some correction requires to be made for the residual steam left in the cylinder when the exhaust port closes and compression begins, but this can be approximately ascertained from the compression curve when compression is shown on the diagram, and can be allowed for afterwards, as will be shown.

We have said that the results, when the pressures are taken from the indicator diagrams, will be approximate only, and a few words of explanation may be necessary to show why this is so. The weight of water accounted for by the indicator will be always less than that supplied to the boiler from a variety of causes. Sometimes, when boilers show a high evaporative duty, water is carried over to the engine mechanically with the steam, as when priming occurs. A certain amount of steam is condensed by radiation, by contact with the cylinder walls, &c., and by the conversion during expansion of heat into mechanical work; but these sources of loss being known, and duly allowed for, the water consumption found from the diagrams will still prove very useful for purposes of comparison when considering the economy of engines of similar types and construction.

We will take first of all an example showing how the weight of steam is ordinarily ascertained from an indicator diagram, such as shown in fig. 1.

This diagram is from a low-pressure condensing engine, having a cylinder 33in. diameter, 3ft. 4in. stroke, running 32 revolutions per minute, and very lightly loaded. The clearance space or waste room at the ends of the cylinder may be taken at about one-thirtieth of the cylinder capacity, or, say 1,040 cubic inches. We may either take a point on the expansion curve, near the end of the diagram, as at A, where it is certain the exhaust has not yet commenced, and find the cubic inches of steam contained in the cylinder at this point, or we can continue the expansion curve to the end of the stroke, as at T, and measure the pressure at this point, and then take the cubical contents of the whole cylinder, and add the clearance space, &c.

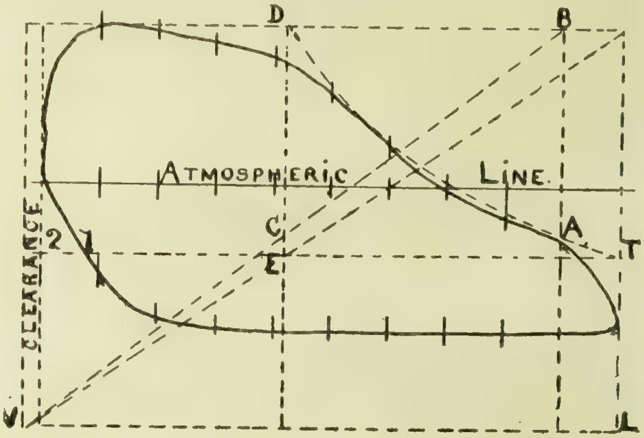


Fig. 1.

Adopting the former course, and fixing upon the point A at a distance of one-tenth of the stroke from the end, equivalent to $\frac{40\text{in.}}{10\text{in.}}$ = 4in. from the end of the cylinder, we have:—

$$\frac{\overset{\text{Area of cylin.}}{(855{\cdot}29} \times \overset{\frac{9}{10}\text{ths. str.}}{36\text{in.})} + \overset{\text{Clearance space.}}{1040\text{in.}}}{1728} = 18{\cdot}4 \text{ cubic feet}$$

of steam discharged each stroke, or 36·8 cubic feet per double stroke or revolution. Measuring from the line of no-pressure VL, we find the pressure at point A is 12lb.; and a table of the properties of saturated steam shows us that the weight of a cubic foot of steam at 12lb. absolute pressure is ·0314lb. Multiplying 36·8 cubic feet by this, we get 1·156 pounds of water in the form of steam accounted for by the indicator for each revolution of this engine. The diagram shows considerable compression, and we must now deduct the amount of steam saved at the return end of the stroke.

Taking a point in the compression curve at 1, at a distance from the end of the stroke equal to three inches in the cylinder (the distance 1 2 on the diagram bearing the same proportion to the total length of the diagram T 2 that three inches bears to the total length of stroke), and measuring the pressure here we find it to be 12lb. Then $\frac{(855{\cdot}29 \times 3) + 1040}{1728} = 2{\cdot}87$ cubic feet of steam saved per stroke, or 5·74 cubic feet per revolution by compression. The weight of a cubic foot of steam at 11lb. pressure we find to be from the table ·0289lb., which gives us $5{\cdot}74 \times {\cdot}0289 = {\cdot}1659$lb. of water saved per revolution. Deducting this from the amount previously found we get $1{\cdot}156 - {\cdot}1659 = 0{\cdot}990$lb. as the weight of steam accounted for by the indicator for each revolution of this engine. As the engine makes 32 revolutions per minute, or 1,920 per hour, we find 0·9901lb. × 32 × 60 = 1900·8lb. of water consumed per hour.

On measuring up the diagrams, the mean effective or average pressure is found to be 12lb., and the indicated horse power 65, so that if we divide the total quantity of water used per hour by 65 we have $\frac{1900 \cdot 8}{65} = 30 \cdot 01$lb. of water per indicated horse power per hour as the net amount of water consumed by this engine accounted for by the indicator. The actual water used per indicated horse power will probably be from 16 to 20 per cent in excess of that shown by the indicator, so that, taking the latter amount and adding one-fifth of the quantity found as above, we arrive at a total actual consumption of 30·01 + 6·0 = 36·01lb. of water per indicated horse power per hour. If this engine were supplied from a boiler evaporating say 7½lb. of water per pound of coal, we should have the coal consumed $\frac{36 \cdot 01}{7 \cdot 5} =$ 4·08lb. per indicated horse power per hour, a rate of coal consumption something like what we should expect to find from a condensing engine working at such a low pressure and with a load so light as this.

We have assumed the waste room or clearance space to be about 1-30th the capacity of the cylinder, but this will vary somewhat with different engines. Where it is desirable to determine it accurately this may be readily done by placing the engine on the dead centre, so as to have the piston at the extreme end of the stroke, and pouring water down the port until the whole space is filled, when from the number of pints of water used the cubic inches of space may be computed.

Now, instead of measuring the pressure of steam in the cylinder at the point A on the diagram before release takes place, as is commonly done, we might have produced the expansion curve DAT to the end of the diagram at T, and measured the extreme terminal pressure LT, which we find is 11lb. instead of 12lb. as at A, and we should have obtained practically the same result. We shall show in a subsequent article how the isothermal curve DAT, which proves extremely useful as a standard of comparison, may be very readily constructed.

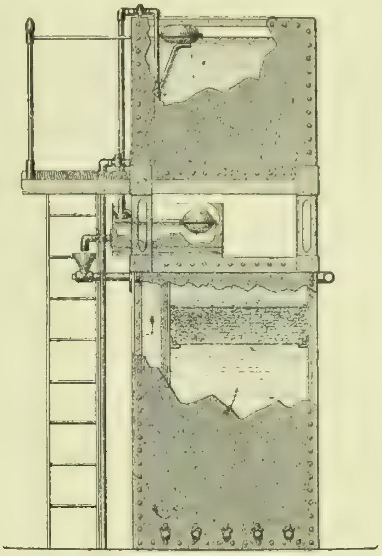
It will be seen, however, that either of the above modes of determining the approximate water consumption from the indicator diagram, is a somewhat long and tedious process, and hence is not likely to be used except in special cases.

It will be necessary, if the water consumption is to be regularly computed with the horse power, to employ a much more expeditious method, and the mode of calculation last referred to, which takes in the whole capacity of cylinder, *i.e.*—diameter, total length of stroke, number of revolutions per minute, &c., suggests a means by which constants may be found from the known volumes of steam at different pressures, and a table of these constants constructed which will render the determination of the weight of steam from the diagrams a comparatively simple matter, or in the foregoing determination of the water consumption, after calculating the total weight of steam discharged from the cylinder, we divided by the indicated horse power, and this requires for its determination many of the factors which we used in calculating the weight of water, such as diameter of cylinder, length of stroke, number of revolutions, &c., many of which may be cancelled out. In our next article we propose to show how such cancelment or elimination of factors may be made, and by taking the well-known volumes of steam at different pressures we can find constant numbers which, arranged in tabular form, will enable the pounds of water per indicated horse power to be approximately ascertained, even without taking the trouble to ascertain what the horse power of the engine actually is.

SOFTENING AND PURIFYING HARD WATER.

There can be no doubt whatever of the great importance of pure, soft water to the steam user, as in any water containing solid matter in solution the act of evaporation within the boiler deposits the solids in various ways—part deposits as mud, part as scale, which forms and adheres to the hottest portions when the heat flows through the plates to the water within. It is generally known that the most complete purification of water can only be effected by treatment of the supply before it enters the boiler at all, and many modes of attacking the problem have been proposed. Of course the only way of entirely eliminating solids in solution is by distillation, and this is done to a very large extent on board ships by well-known forms of feed make-up apparatus. On shore the chemical method, to some extent proposed by the late Dr. Clark, has been much used, and perhaps most widely in a development of that process, the invention of Mr. Howatson. The "Howatson" patent water purifier and softener is designed to separate the solid impurities from water or other liquid, but its principal application is for the softening and purification of water. The great majority of well, river, canal, and town supply waters contain sulphate of lime, bicarbonate of lime, and carbonate of magnesia, and these, with organic impurities, are the principal ingredients that cause the greatest amount of trouble, not only in steam boilers, but for bleaching, dyeing, and washing of every description, as well as for culinary and domestic purposes. All these impurities can be removed by passing the water through this apparatus, and a continuous stream of water of the softest and purest kind is obtained.

The apparatus, as shown in the illustration, is fitted to purify water by what is known as the "lime" process; it is, however, as perfect in its action for any other treatment of the water. The lower portion of the apparatus is what may be termed one large tank divided into two compartments; the one on the left, into which the water and reagent are first introduced, is made large enough to allow the complete chemical action to take place; the water then passes at the bottom into the right-hand tank, which is constructed as a subsidence filter, and is shown in section. The lime, soda, or other solution is contained in the two top tanks (working alternately), and flows into the small left-hand regulating tank underneath; the water to be purified flows into the other small tank, both of these being fitted with floats to maintain the levels and cocks, with nozzles of requisite sizes, so that with equal pressures the flow of water to be purified, and the reagent for the purification, can be regulated to the nicest accuracy. For instance: If the apparatus is to purify 500 gallons an hour, and 5 per cent of the reagent is required for the purification, the nozzle which runs 475 gallons an hour is put on the water cock, and the one to run 25 gallons an hour on the reagent cock; by this simple arrangement the apparatus can be set to work by the most unpractised hand, and a perfect result guaranteed. The water and reagent are well mixed by flowing through a funnel into the left-hand large tank, where the chemical action is completed; the water then passes in a milky-white state into the right-hand tank, and, passing through the subsidence filter, gets rid of all solid impurities, and passes off at the top soft, pure, clear, and ready for use.



The apparatus is now in extensive use, and the business is in the hands of The Water Softening Company Limited, 4, Westminster Chambers, London, for whom Mr. Howatson acts as managing director. The company is well represented at Paris, and examples of both large and small purifiers are shown. We examined a large one in action on the Quai d'Orsay supplying a range of Babcox and Wilcox boilers, and other water-tube boilers. It occupies little space and does its work with the slightest attention and expense.

The railway companies in England, France, Belgium, Italy, and the Argentine Republic use it largely, and these governments have also adopted it.

At Roubaix, in France, it is even used to purify sewage, and there it deals with 72,000 gallons per day perfectly successfully.

For boiler purposes on land it has a wide field of usefulness, and its extended introduction will not only cause greater economy in the use of fuel, but will much increase the life and safety of boilers which at present use hard water. We observe from the statements of many users that they have saved largely, and have been able to steam continuously without opening the boilers for cleaning, where cleaning at very short intervals was previously required.

ENGINE PATTERNS.—VI.

FIGS. 40–43 illustrate the casting of a horizontal cylinder, which was used for driving the gear of a set of deep-well pumps. The principal feature about it is that the cylinder, the cylindrical guide for the crosshead, and the foot, are in one casting. In these figures A is the cylinder body, B the guide, with openings O, C the foot, D one-half the steam-chest recess, the other half being contained in the cover. The facing E, for the gland of the stuffing box F, is placed diagonally, so that one stud goes into the main casting, and the other into the steam-chest casting. G is the steam inlet, H the exhaust outlet (the curves of each being similar), I are bosses by which the foot is bolted down, J waste oil cup at end of guide, K lubricating cup with syphon for guide.

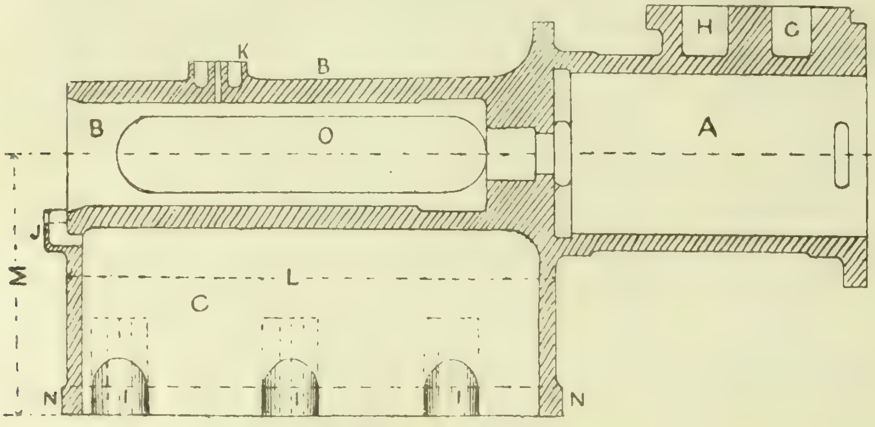


Fig. 40.—Sectional Elevation.

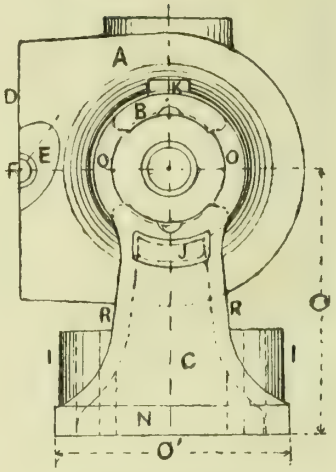


Fig. 42.—Front View.

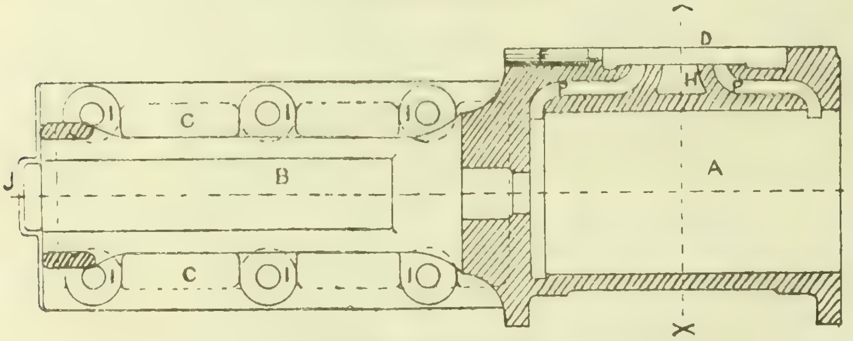


Fig. 41.—Sectional Plan.

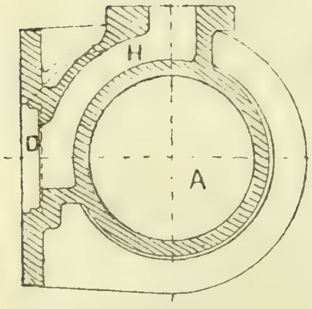


Fig. 43.—Section on X X.

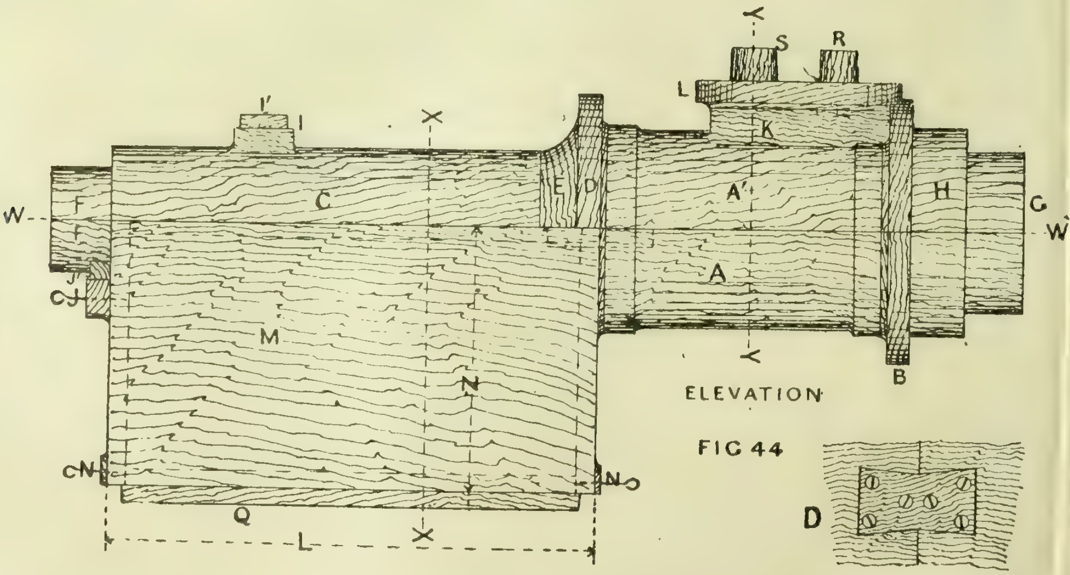


Fig. 44 —Elevation

Figs. 44 to 47 illustrate the construction of the patterns, which do not bear very much similitude to the casting. The whole of the foot, with the exception of the plain ends and faces, is formed with cores; hence the purpose of the rectangular boxed-up portion M, which occupies the place of the foot. The interior of the steam chest is cored, and the entire length of the guide and cylinder is taken out with a single core. When constructing the pattern the rectangular portion M is boxed up, as shown in figs. 44, 45, 46, with rebated joints and sides passing right down from top to bottom. The length L^1 of this portion is equal to the length L in fig. 40, and its depth Z equal to the depth M in the same figure. Its width is arbitrary, the only point necessary to observe being that there is sufficient sand to support the cores by which the outer flanks of the foot are formed. The amount of width given is apparent on a comparison of the fillet N on the casting, in figs. 40 and 42, with that on figs. 44 and 45. In fig. 45 the length O of fillet corresponds with the length O^1 in fig. 42, and the widths P P in fig. 45 are the widths of prints, but the width P represents the narrowest portion of the core. The print Q, in figs. 44, 45, 46, carries the core made for recessing out the interior or hollow portion of the foot.

In figs. 44 and 47 the cylinder body AA^1 is turned, as in previous examples, and recessed at one end for the flange B. The lower half of the body A is attached to the print M with a dovetail, a common mode of union in pipe work. The thickness of this is seen dotted, and the form of such a dovetail is shown in plan at D, in fig. 44. This is a substantial and simple method of uniting abutting parts.

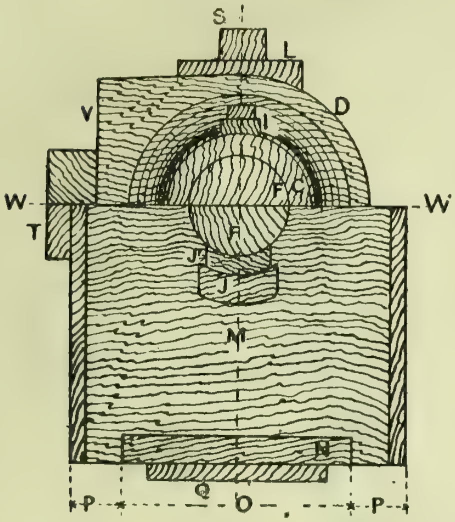


Fig. 45.—End View.

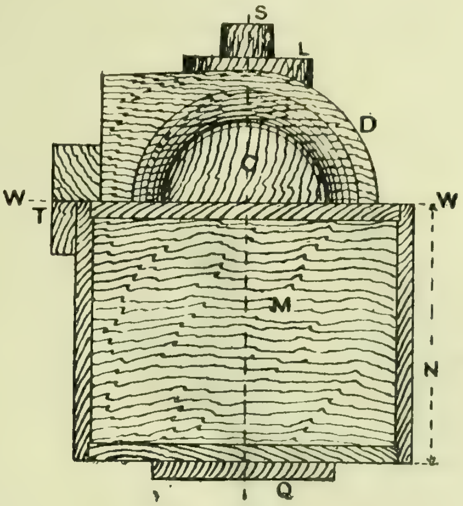


Fig. 46.—Section through X X, fig. 44.

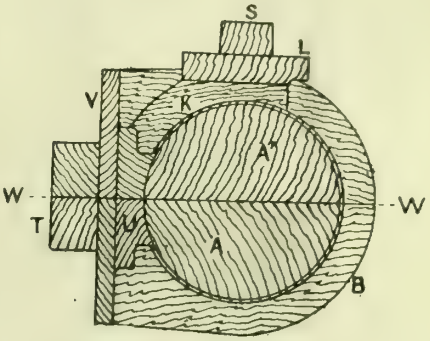


Fig. 47.—Section through Y Y, fig. 44.

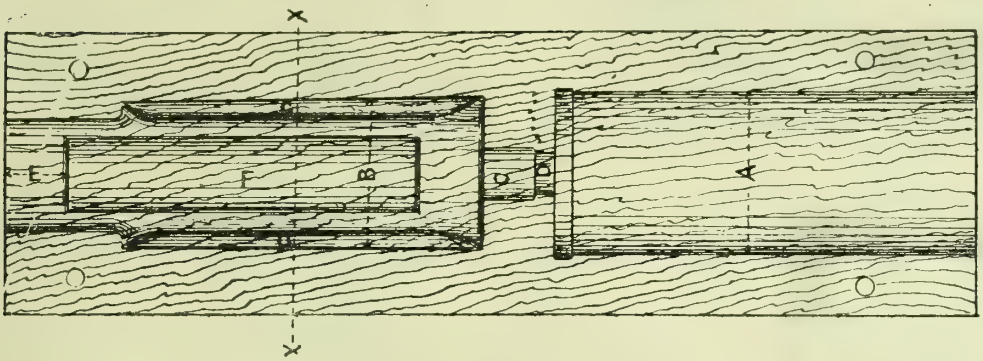


Fig. 48.—Plan.

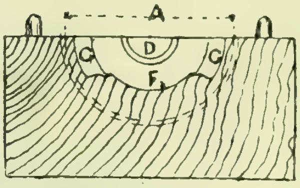


Fig. 48.—Section on X X.

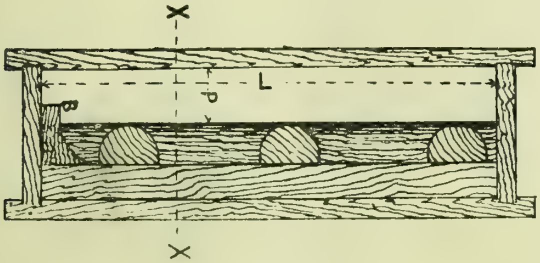


Fig. 49.—Plan.

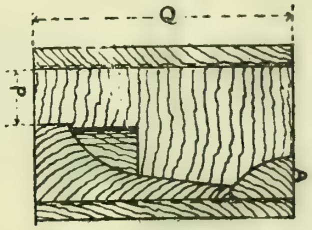


Fig. 49.—Section on X X.

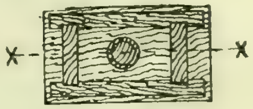


Fig. 52.—Plan.

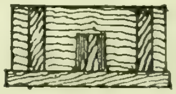


Fig. 52.—Section on X X.

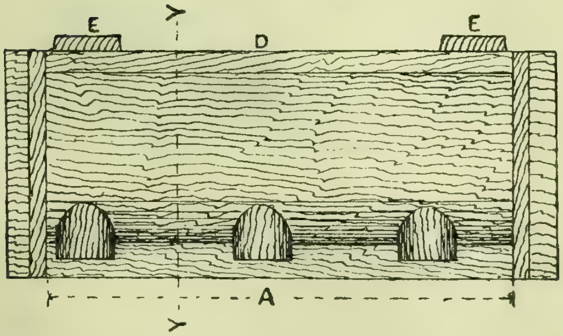


Fig. 50.—Section on X X.

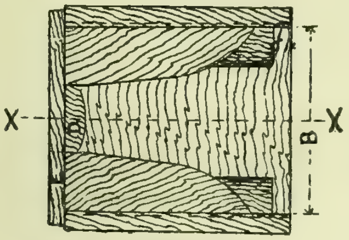


Fig. 50.—Section on Y Y.

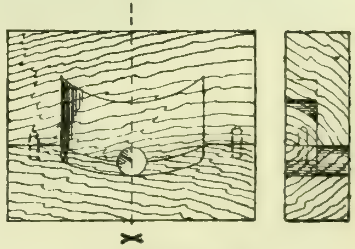


Fig. 51.—Plan.

The upper portion A^1 of the cylinder body should properly be turned in one with the half of the guide C, which is formed in the pattern. The flange D, with its hollow E, is let into a suitable recess turned for its reception. The hollow E is made

MESSRS. WERNER AND PFLEIDERER'S EXHIBIT AT PARIS.

(*For description see page 585.*)

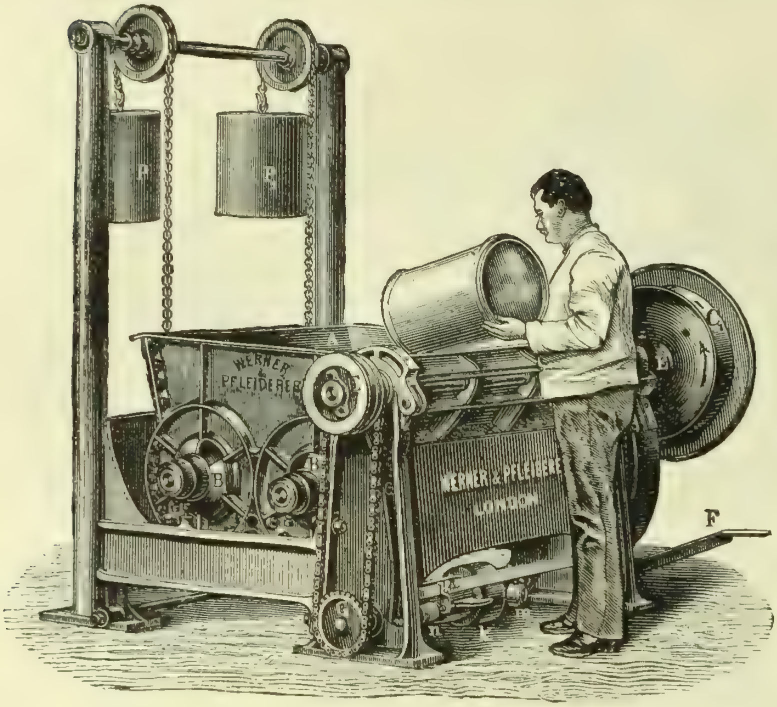


Fig. 1.

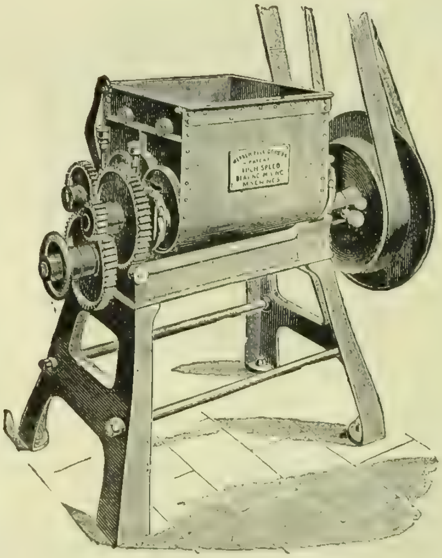


Fig. 2

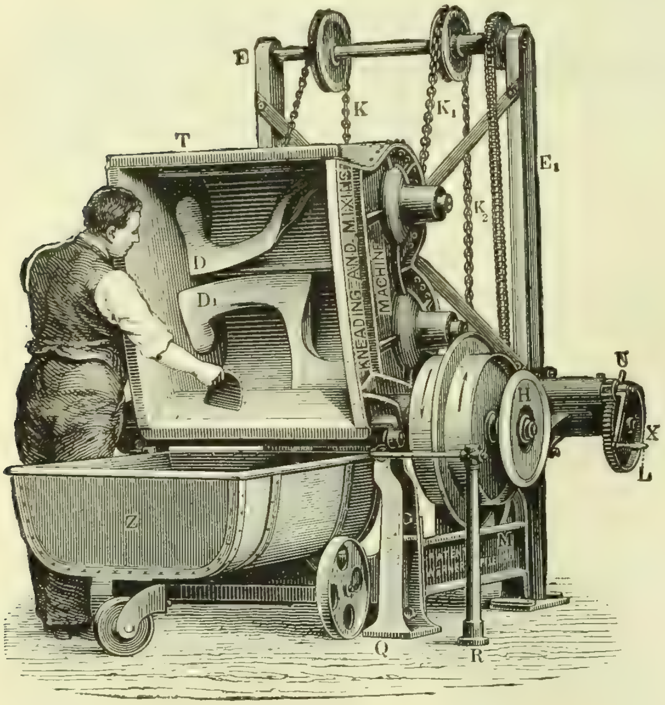


Fig. 3.

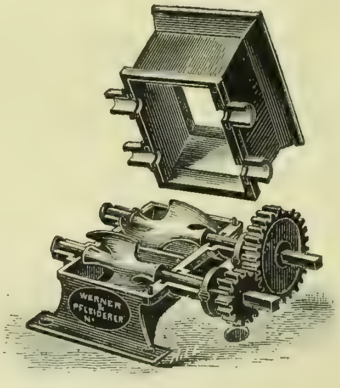


Fig. 4

large to compensate by its strength for the overhang of the cylinder. F and G are the prints for the guide and cylinder core, and H is the head metal. I and J are the oil cups, with their prints I¹ and J¹. J is skewered on, and N are the fillets, also skewered on.

The fittings for the passage block, and flanges and steam chest are as follow: K, figs. 44 and 47, is the block through which the steam and exhaust passages pass. L is the flange, dowelled to the block K, to which the flanges of the inlet and exhaust pipes are bolted. R is the print for the steam inlet core, S that for the exhaust core. I, figs. 45, 46, and 47, is the print for the steam chest recess. U is the body of the chest, V its flange. The pattern is jointed and dowelled along the line W W, and after the cores are all in place the mould is turned up, with the head metal H upwards, and so cast.

The core boxes are shown in succeeding figures. Fig. 48 is the box for the cylinder body and for the guide. Comparing it with figs. 41 and 44, there need be no difficulty in identifying similar portions. In fig. 48, A is the cylinder core, B the guide core, C the stuffing box, D the hole for the gun-metal bush, through which the piston rod passes. E represents the length of print F, in fig. 44. F, in fig. 48, is the facing for the circular crosshead.

G G are the portions of the core which cut through the sides of the guide to form the open spaces O, in figs. 40 and 42.

It may occur to some that to make a box instead of using a striking board for such a core as this is unnecessary work. It is, however, chiefly a question of the number of castings required. But it may be pointed out that it is not a simple case of striking up, as it would be if the cylinder bore A only were concerned, because if a core were struck up, then the facings F would have to be cut into it, and the projecting thicknesses G, which form the openings O, in figs. 40 and 42, would have to be put on it. And further, the core would be apt to bend at the centre D, where it is very small, because the core bar would need to be somewhat smaller than the hole to carry the loam. Using a core box, a stiff cast-iron grid can be used, and little or no sagging will occur. It is not necessary, either, to make an entire box, because both halves are precisely alike; therefore a half box will suffice. I have, according to circumstances, made this class of core by both methods.

Fig. 49 represents the box used for forming the outside R of the foot, in fig. 42. The depth Q in fig. 49 coincides with the depth Q in fig. 42, and Z in fig. 44, while the length L of the box equals the length L in fig. 40 and L¹ in fig. 44. The coincidence of the curved interior of the box and of the lugs therein, with the curved outside RR and lugs II in figs. 41 and 42, is clear. The block A in fig. 49 forms a portion of the outside of the guides. The piece B in the core box forms that portion of the flange D, in fig. 44, whose place is occupied by the print M in that figure. This and the arrangement of the hold-down bosses necessitate the use of two core boxes, right and left handed, or else a reversal of one, if only one be used.

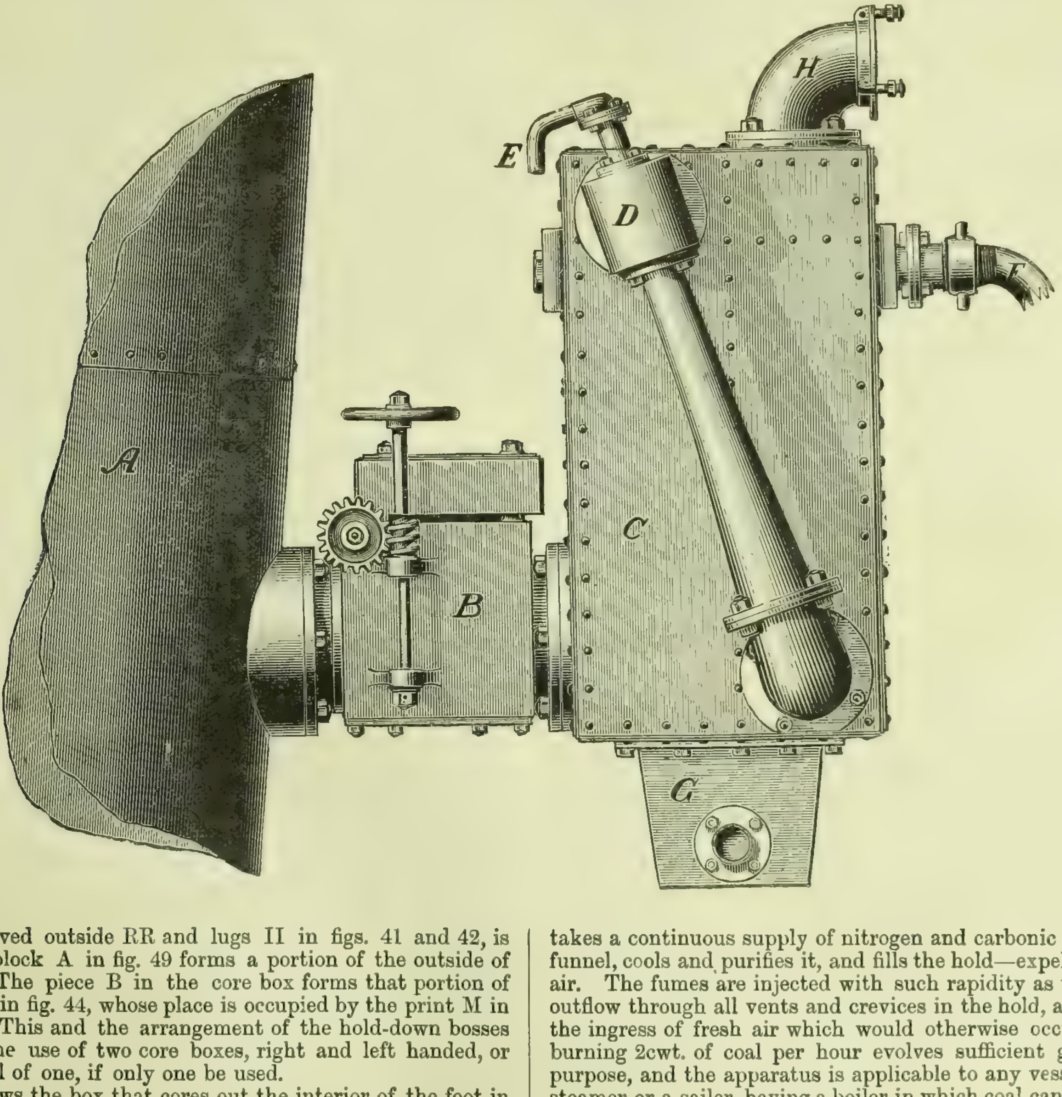
Fig. 50 shows the box that cores out the interior of the foot in figs. 40 and 42. In this the length A, and width B, and thickness C correspond with the length, width, and thickness of the print Q in figs. 44, 45, 46, while the coincidence of the shape of the interior with that of the interior of the foot, figs. 40 and 42, is apparent. The piece D is that which forms the lower portion of the guide, and E E are the battens by which it is held up in place. Fig. 51 shows the box for coring out the waste oil cup in figs. 40 and 45, and fig. 52 that for the oil cup K in figs. 40 and 42. The oil drips into J from the guide, and runs away through the hole beneath. The oil in K is syphoned through the boss, for which a hole is drilled in the casting.

The core boxes for the steam chest D, in figs. 41 and 53, and for the steam and exhaust passages, are like similar boxes already illustrated, and I do not, therefore, draw them here. The print T, in figs. 45, 46, and 47, carries the steam chest core, which in turn carries the passage cores PP, in fig. 41, and one end of the exhaust core H, whose opposite end is carried by the print S, in fig. 44. The steam inlet core is carried at one end by the print R, in fig. 44, and rests at the other upon the steam chest core, entering the chest at the termination of the slide valve facing.

J. H.

CARVER'S FIRE EXTINGUISHING APPARATUS.

Mr. Carver, of Messrs. Coates and Carver, Cross Street, Manchester, has designed a most ingenious apparatus which his firm have now introduced for extinguishing fire on board ship. The central idea is to fill the hold with a gas, or mixture of gases, incapable of supporting combustion, and so stop the fire by preventing access of the necessary oxygen. The gases leaving the vessel's furnaces by the funnel have had most of their oxygen burned out, so that they furnish a copious supply of the required nature. The apparatus consists essentially of an ejector which takes a continuous supply of nitrogen and carbonic acid from the funnel, cools and purifies it, and fills the hold—expelling the fresh air. The fumes are injected with such rapidity as to produce an outflow through all vents and crevices in the hold, and so prevent the ingress of fresh air which would otherwise occur. A boiler burning 2cwt. of coal per hour evolves sufficient gases for this purpose, and the apparatus is applicable to any vessel, whether a steamer or a sailer, having a boiler in which coal can be consumed at this rate. Vessels fitted with the apparatus can extinguish fires in, and also ventilate, other vessels.



Referring to our illustration of the apparatus, A is a part of a boiler funnel; B a valve box, having a valve which can be set so as to admit to the apparatus either fumes from the funnel or fresh air, as may be required; C a galvanised iron chamber, divided into two compartments by a vertical partition; D a steam jet blower, which sucks from one compartment of the chamber C, and delivers into the other; E the end of a pipe supplying steam to the blower from the boiler; F the end of a hose pipe supplying water for producing a shower in each compartment of the chamber C;

G a trap through which the waste water flows out of the two compartments of the chamber—a pipe is connected to this trap for leading the waste water away; H an outlet for the fumes from the delivery compartment of the chamber C (delivery pipes are connected to this outlet for conveying the fumes to any required hold).

So effectually are the furnace gases cooled that the temperature is reduced to about 80 deg. Fahr. on leaving the apparatus. After the fire has been extinguished, and sufficient time has elapsed for its heat to be conducted away, the valve B is shut off to the funnel gases, and opened to fresh air, which is so forced into the hold, and displaces the nitrogen and carbonic acid, so that the men may enter with safety. Numerous and satisfactory trials have been made, which demonstrate the efficiency and safety of the apparatus. To set it to work, water and steam are turned on. The steam, in passing through the blower, draws into the suction compartment of the chamber C, through the valve box B, either fumes from the funnel, or fresh air (according to the position of the valve), and then forces the current into the delivery compartment of the chamber, and through the outlet H, into the delivery pipes, under a pressure which does not exceed 2lb. per square inch. The current flows through both compartments of the chamber in an upward direction, and in each becomes intermingled with a descending shower of cold water. The shower in the suction compartment cools the funnel fumes before they reach the blower, and that in the delivery compartment cools and dries the current (whether of fumes or of air), after it has been warmed and moistened by admixture with the steam used in the blower.

Great care has been taken so to design and construct the apparatus that it shall not be liable to get out of order through disuse, and that easy means of access are afforded to all parts of it, in the event of any unforeseen difficulty arising.

In our opinion Mr. Carver is to be congratulated for introducing a simple and effective safeguard against the fearful peril of fire at sea. The apparatus is especially useful for coal laden or cotton laden vessels, and the owners of passenger steamers will, no doubt, soon see the advisability of fitting it to their ships.

INSTITUTE OF MARINE ENGINEERS.

As will be seen from an advertisement in this week's issue, a certificate of incorporation has, on the recommendation of the Board of Trade, been granted to the above Institute. The next session for the reading of papers commences on Monday, Sept. 2, when a paper, specially written for junior members, will be read by Mr. W. J. Craig on "Scientific Trinities." Papers will be read at subsequent meetings by Mr. R. Bruce on "Radial Valve Gear;" by Mr. Joseph Williams on "Forced Draught;" and by Mr. A. Beldam on "The Progress and Development of the Marine Engine."

THE "AMINES" PROCESS OF SEWAGE PURIFICATION.

When the late Royal Commission on Metropolitan Sewage Discharge (Lord Bramwell's) finished its exhaustive inquiry, the Commissioners summarily recorded their deliberate opinion by stating that "no known process of precipitation purifies sufficiently," &c. This report was published in 1884, and since that year various efforts have been made to discover an efficient process; but it seems to have been reserved for Mr. H. Wollheim, of 101, Leadenhall Street, London, to elaborate such a process, which he has named the "Amines" process, because it utilises certain organic bases belonging to the chemical group of the Amines (ammonia compounds). This process, while it completely sterilises the effluent—the great object aimed at by all investigators—is as near commercial success as any sewage treatment can ever be. The working of the process, as experimentally carried on at Wimbledon Sewage Farm, was recently witnessed by Lord Rosebery, and a number of gentlemen interested in the subject have also inspected it, amongst them being members of the Main Drainage Committee of the London County Council and other members of the Council, as well as Professor R. Fletcher, of Dartmouth College, United States, Mr. E. B. Ellice-Clark, M.I.C.E., Dr. T. Dudfield, Professor C. E. Cassals, public analyst for Deptford, and others. The process as carried on at Wimbledon may be briefly described as follows:—The Amines, either pure or in the form of Amine salts, are used in combination with lime, preferably milk of lime, the proportions varying in accordance with the nature of the sewage and attending conditions. At Wimbledon herring-brine is used and is introduced into freshly-made milk of lime. It is immediately decomposed, and a very soluble, gaseous reagent is evolved, to which the inventor has given the name of "Amminol." This reagent announces its presence by a peculiar briny odour, similar to that of the seabreeze. Amminol is a very powerful disinfectant, and when introduced into sewage rapidly extirpates all micro-organisms capable of causing putrefaction or disease. The disinfectant mixture is added to the sewage as it issues from the sewers, and is thoroughly intermixed with it by mechanical means. The effect is almost instantaneous. By the action of the lime violent flocculation is set up, and the suspended matters tend to subside. Simultaneously the putrid smell of the sewage is replaced by the peculiar briny odour of the reagent. In this state the sewage flows into settling tanks. There the subsidence of the solids takes place at a rapid rate. When it is complete (in a depth of 6ft. it is stated to take only half an hour) the clear supernatant effluent, completely deodorised and disinfected, may be discharged with perfect safety. How completely the purification has been effected we learn from reports made by Dr. Klein, F.R.S. Dr. Klein found that whilst a sample of sewage examined by him contained 2,400,000 organisms in the cubic centimètre, the resultant effluent, after treatment by the "Amines" process, was absolutely free from all or any organisms. In another report Dr. Klein pronounces the effluent as sterile. He also suggests that the effect of the treatment on specific micro-organisms—such as bacillus anthracis, the cholera comma bacillus, the typhoid bacillus, the pneumonia bacillus—should be ascertained. As to the economical aspect of the question, Mr. Wollheim states that the cost of the process, while it varies with existing conditions, may be given in round numbers as ranging from ½d. to ¾d. per 1,000 gallons of sewage treated. In the case of the London sewage (taking the daily flow at 130,000,000 gallons) the cost need not exceed £330 daily, equal to about £125,000 per annum, which means 7½d. per head of the population, or a rate below 1d. in the pound. It may be remembered that Lord Bramwell's Committee stated that "the cost of treating the sewage of London by a good and efficient chemical precipitation process would entail an expenditure of not less than £200,000 a year." It should be added that in his estimate of cost the inventor does not take into account the possible revenue to be derived from utilising the sludge. The latter may be reduced in filter presses to solid cake, or subsequently, if required, to powder by further air drying for manurial purposes; or, partly deprived of its moisture, it may be used for filling up low-lying lands.

MR. EDISON IN PARIS.

"The great Edison is within our walls," is the chorus of Parisian journalists, glad to seek momentary relief from the disagreeables of the Boulanger trial. The *Figaro* (says a Paris correspondent) went down in the person of its triumvirate to Havre to welcome the inventor of the phonograph, and to offer him a reception of which the American inventor recks little. He has come over to Europe to enjoy himself, to "have a good time," and does not care to be troubled with deputations whose compliments he cannot understand or even hear—for Edison is very deaf, or pretends to be, which is one way of getting rid of importunate admirers.

Thomas Alva Edison was born, so one of his biographies states, on February 10, 1847, in the State of Ohio, and brought up in Michigan. Being forced at an early age to earn his living, the lad chose the occupation of a train-boy, *i.e.* a seller of newspapers, refreshments, cigars, &c., on the railroads. During the intervals of travel the youth managed to pick up a quantity of miscellaneous knowledge, which he turned to account in starting a newspaper of his own. The success attained by the *Grand Trunk Herald*, which was brought out "on board the train," induced the ambitious youngster to found another journal, called *Paul Pry*, at Port Huron, which set respectable folk by the ears, but which had the credit of first publishing the news of the battle of Pittsburg. It was not in journalism, however, that Edison was destined to win his laurels. On a fortunate day for the train-boy a stationmaster initiated him into the mysteries of telegraphy. Discerning his aptitude for the wires, the Michigan Railway gave him a post as telegraphist. But he was not regarded as a model employé, being too prone to peer into the mysteries of the craft rather than to transmit the messages confided to him. After stages at Cincinnati, Memphis, and Stratford, Edison set up a laboratory of his own, where he devoted himself to experiments. The Western Union Company purchased one of his inventions, which is said to yield to the discoverer $6,000,000 a year.

Edison's subsequent career is writ large in his numerous inventions, and more recently is associated with the phonograph, which forms one of the wonders of the Exhibition, and the great attraction of the American section. Several members of the

Press have waylaid the distinguished scientist, if the term may be applied to one who candidly confesses that the scientific world does not seem to make much account of him. To his own countrymen he cried off, begging for at least one day's grace before being paralysed by the interviewer. A writer to *Le Temps* seems to have been somewhat taken aback by so much simplicity and unpretentious manners. The great man is surrounded by a band of disciples who have the look of junior clerks in warehouses or banks out for a holiday, more bent apparently on amusing themselves than on playing at budding *savants*. These apprentices are part of the staff of the Menlo Park establishment, who are charged with the task of adding to their sufficiently copious stock of Yankee notions when abroad, keeping their eyes open to anything that may spell dollars.

Edison himself is described as "not so much an inventor as the manager of a scientific and financial syndicate." To M. Gaston Calmette, of *Le Figaro*, who made the journey to Havre to present the collective homage of "the best informed journal in France," Mr. Edison said that his work on the telephote was well advanced, and that before a year had elapsed he would make known his results. In the meantime he may possibly bring out a phonograph company, with private subscriptions, after the fashion of the Telephone Company.

LEEDS ASSOCIATION OF FOREMEN ENGINEERS AND DRAUGHTSMEN.

The annual excursion of the Leeds Association of Foremen Engineers and Draughtsmen, which took the form of a visit to the Britannia Iron Works, Gainsborough, the property of Messrs. Marshall, Sons, and Company, Limited, was held on Wednesday last, when about forty honorary and ordinary members, including Mr. J. C. Moorhouse, president, Mr. T. Craister, vice-president, and Mr. J. Yates, ex-president, left Leeds by saloon attached to the 10 a.m. Great Northern Railway Company's south express, arriving at Gainsborough at 11-23, where they were met by Messrs. Irons, Cribb, &c., and driven to the Britannia works, which were formed by the late Mr. William Marshall, the father of the present managing directors, Mr. James Marshall, and Mr. Henry D. Marshall, in 1848. The total area of these works is upwards of 16 acres, of which the shops cover an area of about 14 acres, and, judging by appearances, the remaining yard-room is rapidly being converted into shops. About ten per cent of the inhabitants of the place are engaged at the works, 2,350 hands being employed in the manufacture of portable engines, compound engines, stationary engines of various types, vertical engines, electric light engines, traction engines, boilers of every description, thrashing machines, corn-grinding mills, circular saw benches, and complete outfits of tea and coffee machinery. Arriving at the works the party were conducted to the general offices, where they were received by Mr. James Marshall, and joined by Messrs. Herbert and William Marshall, sons of the managing directors. These offices are well equipped by an efficient system of telephones. They are in connection with the whole of the shops, giving direct communication between the offices and the various heads of departments. Passing from the general offices, the drawing offices were next visited, then the engineers' stores, where various parts of the standard engines, for which the firm are world-famed, are kept until required for erection, or to replace a similar part in some distant place. The party then passed through the boiler yard, in which were stored a very large number of boilers of various types, on their way to the engineers' department, where the tools specially adapted to the work were very closely inspected by the members, who showed great interest in the various tools, many of which were at one and the same time doing three or four operations which ordinarily would be done on as many machines. This department, as are all the others, is well supplied with power and hand cranes, these, owing to the general light character of the work, being mostly of a lighter class than one is accustomed to in Leeds. Afterwards the galleries were taken *en route*. Here the lighter machinery, screwing, &c., is carried on, the copy milling machines attracting special attention. The heavy tool bay was then visited, this being devoted to the heavier stationary engines, &c., several of which were in course of erection. Passing through the casting store, where the several castings are kept prior to issue to the shops, the foundry was next visited. This is a fine building, and in this, as in all the shops, every man seemed to have ample room to get round his work without the crowding one is accustomed to see. Hydraulic, pneumatic, power, and hand cranes, travelling and stationary, abound, and two pneumatic moulding machines, one of which is capable of turning out eighty complete boxes per hour, were very freely discussed. Proceeding through model store and over model store, at last the cupola stage was reached, and here a grand economical feature was noticed. The works are built on a hill side, and the coals and coke, pig and other metal are delivered direct from the railway on to the cupola stage level, the foundry floor being some 25ft. lower. The boiler shop was next visited. This is divided into six large bays, in which boilers of all descriptions were being built up. Special multiple drilling machines, rivetting machines, &c., in large numbers were carefully examined. Hitherto the party had kept on the north side of the railway, but now, passing by means of a tunnel under the rails, the south side was reached, and the brass foundry first visited; then the electric-light shed, where three dynamos by Siemens and Compton were being driven by engines constructed by the firm. The smithy was specially noticeable for the neat stamping turned out. In the wheel shop, the wheels for traction and portable engines were being put together in an incredibly short time. Passing through the bolt and nut shop, the engine store rooms were reached, where a number of finished engines were to be seen; but considering the great activity in the several departments visited, the stock was small, the output evidently not much more than keeping pace with the demands. In the next bay were a large number of engines and machines packed ready for shipment, and further on in the same block of buildings was another large machine shop, which like the others contained much interesting novel machinery, a large portion being specially adapted to requirements of the branches of engineering in which the firm have made themselves so renowned. In the machine-fitting shop and in the frame shop much interest was taken in the tea and coffee plants which were in course of construction. In the rapid extensions which are continuously being carried on, it is necessary to cut away large portions of the hill side, which is composed of marl and gypsum, the latter being reduced to a fine powder in a disintegrator, and sold in the neighbourhood; while the marl is converted into bricks on the premises, the brick yard being fitted up with the latest machinery for the purpose. From the brick yard the visitors proceeded to the engine, paint, and packing shops; the machine erecting shop, general wood-working department, and the log saw mills; thence back to the general office. At 3 p.m., the party were entertained by Messrs. Marshall to luncheon, at the Sun Hotel. Mr. Jas. Marshall, supported by Messrs. Moorhouse, Craister, and Yates, occupied the chair; and Mr. Herbert Marshall, supported by Messrs. W. Marshall and Tempest, Hon. Sec., Leeds Association, the vice-chair. The chairman gave a most cordial welcome to the association, and Messrs. Moorhouse and Craister responded, and expressed the great pleasure and interest experienced by one and all. A most enjoyable and well-spent day was ended by the announcement of the arrival of the conveyances to carry the party back to the station, where the saloon was attached to the 5-53 train, arriving in Leeds about 7-30 p.m.

MESSRS. WERNER AND PFLEIDERER'S EXHIBIT AT PARIS.

The exhibit of Messrs. Werner and Pfleiderer, of 86, Upper Ground Street, London, S.E., consists entirely of various specimens of the different sizes and types of their well-known "universal" kneading and mixing machine. We have carefully examined these machines, and are much struck with their good workmanship and design. There are many purposes for which they can be advantageously applied, as in every case where kneading, mixing, stirring, beating, masticating, or incorporating of any material is required, the "universal" can readily be adapted. The "universal" has been introduced successfully, we are informed, for materials of a specially difficult nature after all previous attempts to employ machinery on the work had failed. Naturally one of the trades in which this machine forms a most important item is that of the bread and biscuit baker and confectioner.

In the movement which has in the last few years sprung up, and is now rapidly spreading, favouring the use of machinery in the making of dough in place of the old objectionable methods, the "universal" has had to face very energetic competition, and has held its own well, and has in fact a large share of all those qualities which go to make a desirable machine. It is to be found in a large number of the most advanced and perfect of the model bakeries of this and other countries both for large and small installations, and has been adopted by many of the European governments for their military and other bakeries. So much is it favoured by the German and Austrian commissariat departments that it is included in nearly sixty complete bread and biscuit plants, which Messrs. Werner and Pfleiderer have recently supplied to them, besides a large number of separate orders which they have received for this machine alone. Above all, however, the makers claim that in each instance it has given thorough and complete satisfaction.

Among other articles for which the machine is adapted, may be mentioned as examples cake mixtures, macaroni, vermicelli, chocolate, grains, flours, horse and cattle foods ; for pharmaceutical preparations, pill masses, tooth pastes, ointment, snuff, opium, quinine ; for paint, putty, white and red lead, aniline, alizarine, ultramarine, polishing pastes, indiarubber, guttapercha, linoleum, lincrusta, emery wheels, electric carbons, gunpowder, dynamite, bitumen, crucible clays, artificial manures, starch, soap, lubricant, mortar, cements, artificial stones, boiler and pipe compositions, washing powders, oils, fats, &c., &c.

It will be readily supposed that to suit the above list of manufactures, the machine is necessarily made in various sizes, types, and classes of strength.

The specimens exhibited are six in number, comprising one of each of several varieties. We illustrate on page 582, at fig. 1 a mixing machine, at fig. 2 a machine for special substances ; fig. 3 a kneading machine, and at fig. 4 a small kneader also for special work.

Those of our readers who are interested in this class of machinery, and are visiting the Paris Exhibition, should not fail to see Messrs. Werner and Pfleiderer's interesting exhibit.

HEAT ENGINES OTHER THAN STEAM.—II.

(*Continued from page 571.*)

But now, having spent all this time in dealing with the theoretical curves of expansion, I am going to tell you that, in a real heat engine, these theoretical curves are neither of them practically realised. The curves really obtained, although they may approximate to these, do so for reasons with which time will not allow me now to trouble you, and the curves obtained in practice vary, as we shall see, in accordance with the construction of the engine, with the nature of the working agent employed, and with the work really done by it.

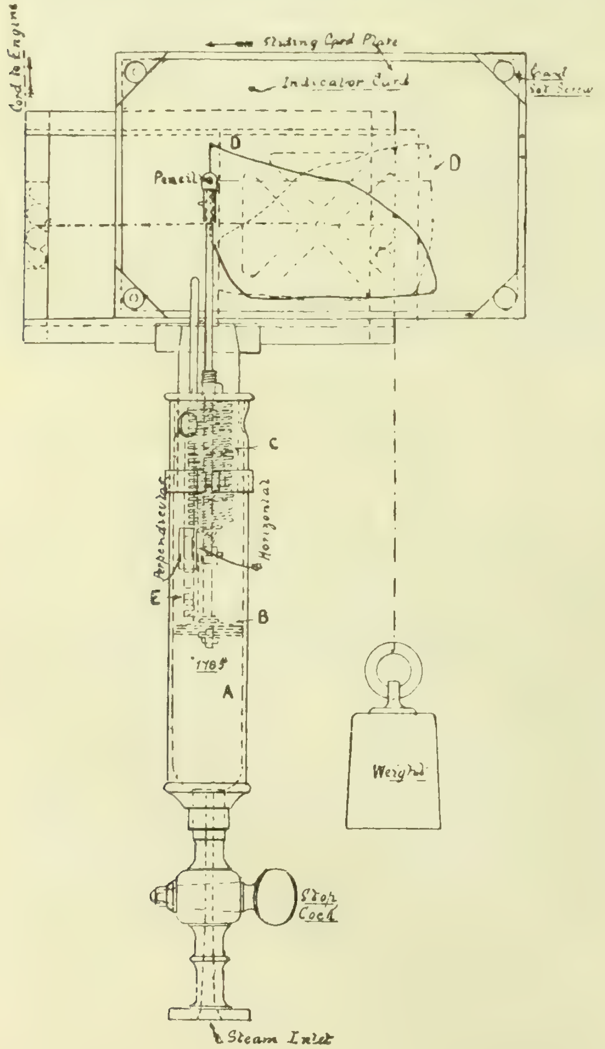


FIG. 8.

Still, it was necessary that we should briefly consider these laws with the theoretical expressions of them in the diagrams, because when we come to compare the actual diagrams obtained from the various sorts of heat engine, we shall find that the rudimentary knowledge which our brief consideration of these laws has given us, will enable us more fully to estimate the value of the results which are achieved in practice.

Now, the engineer, although he can construct by calculation the theoretical diagram, which should be obtained in any given engine, when he knows the initial pressure and the point in the stroke where the inflow of the working agent at full pressure ceases, yet he has had—from the very earliest days of the steam engine, and due to the genius of James Watt—an apparatus which he can attach to any engine, and which will enable him to tell that which is occurring in the cylinder.

Through the kindness of Mr. Wollaston Blake, of Messrs. James Watt and Co., the successors of the original firm of Boulton and Watt, I have here for you to see the actual instrument made and used 104 or 105 years ago (judging from the date upon it) by James Watt, and fig. 8 gives you a diagram showing a section through the instrument.

Let me explain this apparatus to you. All of you can realise that if a pipe were connected to the space between one side of the piston and the cylinder cover of any engine, and that if in that pipe there was another smaller cylinder, having a piston in it capable of movement, that smaller piston would be subjected, during the whole length of the stroke of the main piston—both away from, and back again towards, the cylinder cover—to the same pressure as existed in the main cylinder.

Now, if to the small piston you attach a rod, capable of moving as the piston moves, and if to that rod you fasten a pencil, so that it will make a record on a piece of paper, the small piston being normally kept in position by a spring, and only being moved when the pressure existing in the main cylinder comes upon it and against the resistance of the spring, the position to which the small piston moves at any portion of the stroke of the main piston will, if the strength of the spring is known, give us exactly the pressure existing in the main cylinder at any time.

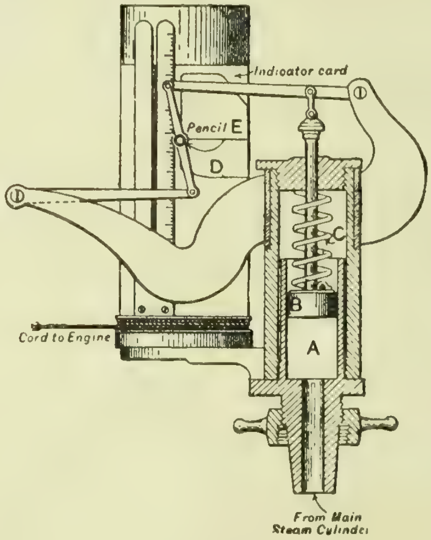


FIG. 9.

Now, if we cause the piece of paper on which the pencil makes its record to move backwards and forwards in accord with the movement of the main piston, and if we put the pencil in contact with the paper, we shall have a diagram produced, the length of which will bear a relation to the stroke of the main piston, and the height of which will show exactly the pressure existing at any portion of that stroke ; in fact, it will tell us what the pressure is which exists at any moment in that end of the main cylinder of the engine to which it is attached. And this is exactly what the indicator does for us. You will see in fig. 8 the sliding card plate moved in one direction by means of the cord which is attached to some reciprocating part of the engine, and moves with it, care being taken that the part to which it is attached makes its reciprocations in exact relation to those of the piston of the main cylinder. The reverse movement is made by means of the weight, which is lifted when the engine draws the card plate in one direction, and falling as the engine travels in the other direction, pulls the plate back with it. The lower portion of the indicator cylinder is attached by a pipe to the main cylinder, and in it there is a piston kept in its normal position by a a spring. By means of the stop cock at the bottom the indicator cylinder can, at will, be put into communication with the main cylinder. The pencil is attached to the top of the piston rod of the piston of the indicator cylinder, and you see the sort of diagram which is made ; the diagram giving, as I have said, an exact record of the pressure existing in the main cylinder at any part of the movement of the main piston.

The principle underlying the Watt indicator is the one which governs the various indicators now in use. The most important improvements which have been effected consist in making the piston of the small cylinder of a definite area for all indicators, in only allowing this piston to have a slight movement for a large variation in pressure, and in making the various moving portions of the apparatus as light as possible, so as to eliminate the evil effects of momentum. The small movement of the piston is multiplied by means of some kind of parallel motion to something largely in excess of the movement of the piston itself.

Here is one of the most commonly used forms of indicator—that known as the "Richards"; and here is a more recent form, known as the "Crosby."

You have a lithograph of the Richards indicator among those which have been handed to you (fig. 9). In this the piston is marked B, the small cylinder A, the spring C, the pencil E, and the indicator card D. The principle upon which both these indicators work is, as I have said, absolutely similar to that of the Watt indicator, and they are improved only in the minor details—the "next-to-nothings" of working and manufacture.

Having shown you some of the theoretical diagrams and also the instruments which produce the diagrams obtained in practice from real engines, let me ask you to look at some of these latter diagrams (see fig. 10). In each case the horizontal line is the line of atmospheric pressure, and the left-hand bottom corner of the diagram is the point of the commencement of the stroke of the main piston, which is supposed to be moving from left to right and back again.

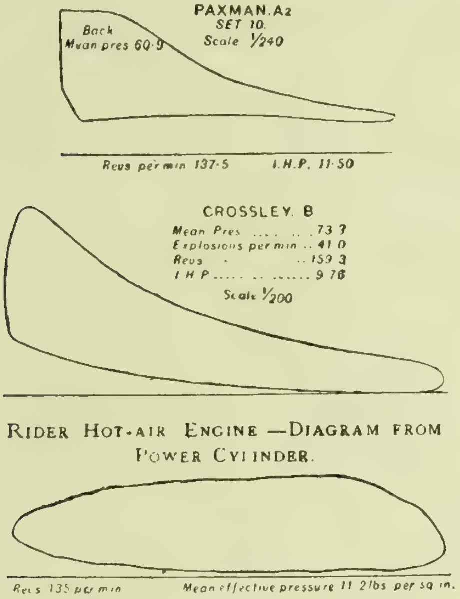


Fig. 10.

You will see at the bottom a diagram obtained from the power cylinder of a hot-air engine, and you will see that in this the pressure rises, not very rapidly, at the commencement of the stroke, which is to the left of the diagram, that it is slightly increased for a large portion of the stroke; and that it then falls, not with a hollow curve, but with a rounded curve, till the end of the stroke is reached; and you will see that neither the isothermal nor the adiabatic curve is even approached in such a diagram.

I shall have to deal very fully with similar diagrams to these three when I come to consider the various engines from which they are obtained, and I will not, therefore, delay about them now. I will, however, just ask you to look at the indicator diagram from the steam engine which is at the top of fig. 10, and the gas engine in the middle of fig. 10, and you will see that, although the curves in these approximate to one of the theoretical curves, yet it is only an approximation.

The diagram obtained from petroleum engines is practically similar to these two.

In order to obtain motive power from any working agent, you will realise from that which I have told you, that it is necessary there should be a lessening of the heat existing in that working agent; that is to say, the temperature of the working agent at the time when it enters the engine must, if work is to be obtained from it, be in excess of its temperature when it leaves the engine. From this we gather that in order to transform the heat in a working agent into mechanical work, it is a necessity that a series of changes or operations should be gone through; and it follows, if the transformation is to be continued, that this series of operations must be repeated.

(To be continued.)

THE Electro-Automatic Rapid Transit Company, of Baltimore, on a two-mile experimental track, near Laurel, Md., U.S.A. has, it is stated, recently attained a speed of two miles per minute with the motor and car. The object of this method of rapid transit is for the transportation of mails and light express matter between large cities, and the automatic control of the speed and stops from a central or terminal station without travelling attendants.

BOILER EXPLOSION AT CARDIFF.

A SERIOUS boiler explosion occurred last week at the Roath Brickyard, Cardiff, by which a man and a boy, the son of the manager of the brickyard, were killed. Two other men were also so seriously scalded and injured as to necessitate their removal to the infirmary.

The boiler, which was housed in a wooden shed, was of the ordinary vertical type, about 6½ft. in diameter, and 13½ft. high. It appears to have been of strong construction, double riveted at the longitudinal and transverse seams, and is stated to have been made at the Globe Foundry, Cardiff, only a few years ago, and to have been in good condition at the time of the explosion.

The firebox, which was about 4½ft. in diameter, was stiffened in the upper part by four cross water tubes, or "Galloway" tubes, and light longitudinal tie rods stayed the firebox crown to shell crown. The working pressure is stated to have been 80lb. per square inch, at which the boiler is supposed to have been working at the time of explosion. For so large a firebox this would appear to be a high pressure, and as the firebox portion of the boiler failed by collapse, and ruptured along its whole length, in all probability the explosion was due to over-pressure. The bottom part of firebox appears to have been previously repaired at some time by a large patch, and these repairs may have had some effect in altering the shape of the tube from the true circular form, and thus reducing its strength to resist collapse. No satisfactory information respecting these points, however, can be ascertained until after the Board of Trade examination, but from the particulars we have been able to obtain we think it may be assumed that attention will be drawn in the surveyor's report to the great risk which is too often run in working boilers of this type with fireboxes of large diameter unstrengthened by hoops, &c., such as are almost invariably used for the furnace tubes of horizontal boilers, even for comparatively low pressures, and with diameters very much less than the one which failed in the above instance.

At the inquest, which was held at Cardiff on the 13th inst., the usual stereotyped verdict of "accidental death" was returned, the jury considering that no blame was attached to anyone.

STATE OF THE SKILLED LABOUR MARKET.

THE following memorandum has been prepared for the *Board of Trade Journal* by the labour correspondent to the Board of Trade:—

Reports as to the condition of their several labour markets have this month been received from 19 trade unions. From the returns thus furnished it appears that during July the demand for labour has in no way fallen off, although there has been but little improvement upon the remarkable figures of the previous month. Practically, therefore, the market has been stationary and continues so, while at the same time it is characterised by great steadiness, and there is an absence of serious disturbance of any kind. In fact the only really important disputes now pending are those of the lace makers at Nottingham, and of some of the card-room hands in the Oldham cotton trade.

The cotton trade generally is not well employed at present, as much short time is being worked as a means of counteracting the operations of the cotton corner, which seems now to be a regular annual institution. With this exception all the great industries are well employed, and work is plentiful.

Of the 19 societies reporting, 10 state trade to be "very good," seven "good," and two "moderate." The total membership represented by the societies reporting is 191,023, of which only 3,302 are out of work, being a proportion of 1·7 per cent, as against 1·8 per cent for last month, and 4·6 per cent for the corresponding month of 1888.

PROPOSED CANAL IN SWEDEN.—The *Bulletin du Musée Commercial* for 1st June last contains the following note: The question is mooted of constructing in Sweden a canal for the purpose of joining the Kattegat with the large lake of Venern. This canal will join the towns of Uddevalla and Genersborg; it will be eminently useful for a portion of the interior of Sweden, where there are numerous iron and steel works. Its length will be 25 kilometres; it will traverse lakes for an extent of about 8 kilometres. Its depth will be 7 metres, allowing of the entrance of vessels of 3,000 tons. It will have, moreover, locks 116 metres in length by 15 metres wide. An extensive transit trade in wood for building purposes is reckoned on, as well as 100,000 tons, at least, of iron.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

THE NATIONAL COLLECTION OF SCIENTIFIC APPARATUS.

To the Editor of "The Practical Engineer."

Sir,—In view of the timely inquiries which are to be instituted by Sir Henry Roscoe respecting the collections of scientific apparatus at present placed in the western galleries of the South Kensington Museum, one or two remarks may not be out of place. The arrangement of the collection, it is to be presumed, is as yet only in embryo, unless it is taken for granted that it is always to be rather an interesting assortment of relics than an actually practical means of facilitating science teaching. While many of the appliances shown in the departments relating to physical and mechanical science are such as have a certain fascinating influence upon the minds of junior students, they are decidedly not what science teachers and practical men require for reference or use, being in some cases obsolete, and in others constructed upon principles other than the standard ones recognised by the printed syllabus in the Directory of the Science and Art Department.

It is surely quite time that every point in that syllabus should have its corresponding practical illustration in a national science collection, and that every item in such a collection should be located with respect to those surrounding it, so that reasonable comparisons and analogies may most easily be made by students. Some of the shortcomings and faults in the existing state of affairs, so far as the classification is concerned, are in all probability due to the fact that some of the presiding officials, as in other Government departments, are unable to move with the rapidity of the times. In scientific research this is very naturally the case now, seeing that we have really been advancing with leaps and bounds—in electricity, for example. If a few of the leading investigators in such a subject as the last mentioned were properly rewarded by the Government, and allowed (with a properly high remuneration) to take the reins, in place of some of the old hands, we should soon see a brighter side to the picture.

I write this as a practical science teacher, and, as I consider, from the teacher's point of view, believing that in the future experimental scientific research will necessarily occupy a far higher position in relation to our principal industries than it does even now.—Yours, &c.,

Wm. Hillier.

2, Great George Street, Westminster, S.W.

QUERIES AND REPLIES.

77. **Air Pipe in Locomotive Funnel.**—What effect would an elbow-shaped pipe have which was opened to the atmosphere, in front of a locomotive, at one end, and projected up the funnel at the other?—X. Y. Z.

Answer.—The effect of such a pipe being inserted would be to produce a blast, the power of which would vary with the velocity at which the engine travels; it would be very weak in proportion to the blast produced by the exhaust steam.—F. C.

74. **Flattening Saws and Plates.**—Will some reader kindly inform me how to hammer buckles out of saws 4ft. 6in. diameter? Also if the same method does for square plates?—Blacksmith.

Answer.—Your correspondent, "Blacksmith," will find a good deal of information on flattening and hammering saws in "Saw Mills, their arrangement and management," by M. Powis Bale. The operation cannot well be described without illustrations.—A. O.

81. **Bolts for Flange.**—In making a flanged joint fluid tight by means of bolts and nuts, what considerations should be taken into account in estimating size, number, and strength of bolts to be used? The fluid pressure being 100lb. per square inch, total amount of separating force due to pressure 10 tons, and length of flange measured along pitch line of bolts being 6ft., what should be the diameter and number of bolts?—C. P. W.

Answer.—The diameter of both should bear some proportion to the thickness of flange—the diameter of the bolt should not be less than the thickness. The working tensile strain in the bolts may be taken at three tons per sectional square inch on the least section, which is that at the bottom of the thread. In this case the number of square inches required will be $\frac{10}{3} = 3{\cdot}3\dot{3}$. Suppose bolts ¾in. diameter to be used, the diameter at the bottom of the threads will be very little over half an inch, and the area of a circle ½in. diameter is 0·196 square inch; the number of bolts required will therefore be $\frac{3{\cdot}3\dot{3}}{0{\cdot}196} = 17$.—F. C.

Answer.—The principal considerations to be taken into account when dealing with a joint to be made fluid-tight under pressure are the pitch of the bolts connecting the flanges, the initial tension on the bolts, due to screwing up, and the material with which we make the joint. "C. P. W." will find this matter very clearly set out in an article "Hydraulic Machinery employed in the concentration and transmission of Power (VII.)," under the heading of Pipe Joints, &c., which appeared in the *Practical Engineer* of May 24, 1889, in which it is stated that it may be taken as a good empirical rule that the pressure on the joint surfaces due to the screwing up of the bolts should be at least equal in intensity per square inch of joint surface to the hydraulic pressure under which the joint is required to be water-tight. In practice this initial tension on the bolts is allowed for in the factor of safety used, the bolts being of such a size and diameter that the stress per square inch of area at the bottom of the thread does not exceed 2,500lb., taking for the load on the bolts, the hydraulic pressure, plus area exposed, and to make a good joint the pitch of the bolts should not exceed five times their diameter. Then in the case given by "C. P. W." the total load 10 tons × 2,240=22,400lb., and $\frac{22{,}400\text{lb.}}{2{,}500\text{lb, working load per square inch on bolts}} = 9$ square inches total effective bolt area required, and taking one-inch bolts as a suitable size, giving ·55 of a square inch at the bottom of thread, then number of bolts required $= \frac{9 \text{ total area required}}{{\cdot}55 \text{ area of bolt}} = 16$, and 6ft. = 72in. = total length measured along pitch line of bolts, therefore pitch of bolts $= \frac{72}{16} = 4{\cdot}5$in., which is within the limit and should make a very good joint; the width of flange may be three times diameter of bolt, and thickness 1¾ times dameter of bolt.—Tubo.

83. **Stern-tube Bearing.**—What should be the diameter of the stern-tube bearing for engine of 4,000 horse power, making 90 revolutions per minute?—C. P. W.

Answer.—This question is somewhat ambiguous as given, as a great deal depends upon circumstances, which may vary considerably with the particular class of engine used, as the ratio of the maximum to the mean twisting moment depends entirely upon the number and the relative positions of the cranks as well as upon the degree of expansion in the cylinders. However, as the question is probably one set at an examination, and therefore requiring a more or less general answer, the following will no doubt suit "C. P. W.," if not, I shall be pleased to make the matter more explicit if he wishes it: The diameter of propeller shaft necessary for an engine of 4,000 indicated horse-power, when making 90 revolutions per minute, may be estimated with approximate precision by the formula:—

$$\text{Diameter of shaft} = 4{\cdot}25 \sqrt[3]{\frac{\text{I.H.P.}}{\text{R}}} \qquad \text{where}$$

I.H.P. = the indicated horse-power transmitted R = the revolutions per minute and 4·3 = a constant which depends for its value on the intensity of stress allowed on the material of the shaft. Substituting the values given, we obtain

$$\text{Diameter of shaft} = 4{\cdot}25 \sqrt[3]{\frac{4{,}000}{90}} = 15\text{in.}$$

If the shaft is fitted with brass liners, the diameter of stern tube bearing will be larger than the above by twice the thickness of the liners. This size of shaft would pass Lloyds' survey for a triple expansion engine, having cylinders, say 35in.-56in.-90in. by 48in. stroke for a working pressure of 149lb., which engine would, at a referred pressure of about 29lb. on the low-pressure cylinder, and at 90 revolutions, develop somewhere about 4,000 indicated horse-power.

Note.—When the twisting moment is uniform, and the shaft is subjected to torsion alone, then this constant is found from the formula—

$$c = \sqrt[3]{\frac{5{\cdot}1 \times 33000 \times 12}{2 \times \pi \times \text{stress}}}.$$

Omricon.

79. **Galloway Boiler.**—What is the nominal and actual power of a Galloway boiler, 28ft. long, 7ft. diameter, with 33 conical Galloway tubes, and working at a pressure of 70lb. per square inch?—Boiler.

Answer.—A Galloway boiler 28ft. by 7ft. would be considered as equal to 280 horse power indicated. The actual power is influenced by so many separate items and conditions that horse power, nominal or indicated, is quite a misnomer. The boiler does not do the work, it only provides the steam which is supplied to an engine more or less efficient, therefore the same evaporation might give widely different results in two different engines. A good way to ascertain the capacity of a boiler is to get out the heating surface and grate area, and then allow a consumption of coal per square foot of grate according to draught, if good, say 20lb. to 22lb. per square foot per hour, and if sluggish allow less. Then allow, say 8lb. of water per pound of fuel, and you have evaporative capacity, and if there is any excessive waste, you can at once tell whether it is in engine or boiler. The ratio of heating surface to grate area in a boiler 28 × 7, Lancashire or Galloway, would be about 25 to 1; this would give about 36 square feet of grate, and with fair draught, 20lb. of coal should be consumed per square foot of grate, giving an evaporation of 8lb. of water per pound of coal, therefore 38 × 20 × 8 = 5760lb. of water per hour, and if the steam was used for driving a fairly good compound condensing engine using about 20lb. of steam per I.H.P. per hour, we should have 288 I.H.P. as work actually done by engine with steam supplied. Good or bad draught, or engine in good or bad trim, would greatly influence the results. I am glad to see two or three good makers now speak of the capacity of their boilers, having dropped the misnomer "horse-power." Hoping this may tend to enlighten "Boiler."—Chalkline.

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73. **Process for Cooling Water at Coates' Mill.**—I shall be obliged for any particulars of the process for cooling water to be employed at Messrs. Coates' new mill, at Paisley.—Lever.

80. **Book on Locomotives.**—Can any of your readers inform me of the best book on railway locomotives—chiefly Midland Railway locomotives?—W. B.

82. **Oscillating Engine.**—If CP be the crank and PQ the piston rod of an oscillating engine, find the velocity ratio of P to Q, and set out result in diagram. Find also the angular velocity ratio of CP and PQ at any point of stroke.—C. P. W.

84. **Brake Straps on Cranes.**—What is the usual method of calculating the breadth of brake straps on ordinary cranes?—W. R.

85. **Morton's Ejector Condenser.**—Can any of your readers give me a description of Morton's Ejector Condenser, with a sketch, if possible?—Crankum.

86. **Working Drawing of Crane.**—Will you kindly permit me to ask any of your readers if they could give me information as to where I could get a working drawing of a crane; also, if there is a book published on shading?—J. H.

87. **Diameter of Piston Rings Before Cutting.**—In the case of cast-iron piston rings of equal thickness, *i.e.*, where the inside and outside circumferences are concentric, could you give me the diameter of the ring before being split, in terms of the diameter of the cylinder? Also, where the ring is ½in. thicker in the middle than at the split ends, what would be the diameter of the ring before being split? A text-book I have says $\frac{1}{10}$ larger diameter than the cylinder, but this seems to me excessive.—H. V.

TO CORRESPONDENTS.

H. E. T., Birmingham.—Your query is hardly suitable for our columns.

W. R., Middlesbro.—Your query is rather vague. The pressure required to move a hydraulic ram against 700lb. per square inch is obtained by multiplying the pressure per square inch by the area, and allowing an additional amount for friction of leathers, &c. You can readily find the usual allowances for friction by reading our articles on "Hydraulic Machinery."

MISCELLANEA.

The steel pen trade at Birmingham is buoyant. The weekly average production exceeds 160,000 gross. This production absorbs 16 to 18 tons of steel, of which only eight tons appear in the article, the rest being loss or waste.

Priestman's Petroleum Engine.—The Northern Lighthouse Board has adopted Priestman's oil engines for blowing fog signals in preference to steam or gas engines, effecting a great saving in first cost, no chimney being required, as in the case of a steam engine, or gasworks, which would be needful if a gas engine were adopted.

Science in Japan.—It is astonishing to find the Japanese in so great a hurry to follow the ways of the West. There is announced the publication of a dictionary containing the Japanese equivalents of the principal scientific words and phrases in English, German, and French. As evidence of assiduity, it is said that 36 Japanese scholars have been working at this vocabulary during six years.

Novel Water Engineering Works at New Mills.—There has just been completed for Mr. F. J. Sumner, owner of the New Mills (Ollersett) Waterworks, some novel engineering works to increase the supply of the district. A turbine has been fixed on the banks of the River Goyt, from which the motive power is obtained, and this drives a motor which again forces water up pipes for an enormous distance upwards to a reservoir. The water is in the first instance obtained from a spring in a coal mine at Furnace Vale, to which service pipes have been laid, and down to the water motor. The work has proved a great success.

The Congo Railway Company.—The Brussels correspondent of a contemporary says that the Congo Railway Company has been recently constituted in Brussels, with a capital of 25,000,000f. The railway will run from Lower Congo along the river up to Stanley Pool, a distance of 435 kilometres, and will connect Matadi, which can be reached by large vessels, with the present centre of African trade in the Congo territory. It is stated that at least 2,500,000f. are at present expended yearly in transporting goods by porters in the neighbourhood of the cataracts, and this sum alone would be sufficient soon to pay off the cost of the line.

The Iron Trade in Austria.—The Vienna correspondent of the *Economist* says: Our iron and steel works are prosperous. Those which are united in a trust—the Bohemian and Alpine works—have organised a common office, in which every transaction is to be notified and communicated every month to the members. The first abstract for the six months up to last June records sales—exclusive of rails—to the amount of 1,335,000 double cwts., or 116,000 double cwts. more than during the same period of last year. Some of our steelworks are preparing to produce bigger rails, named Goliath rails, for the large lines, which are running a good many express trains.

New Weldless Steel Tire Mill.—A new railway weldless steel tire mill has been opened at the works of Messrs. Steel, Peech, and Tozer. Many years ago the weldless tire was made in Rotherham, and the erection of this mill will be the revival of a heavy trade which had been practically lost to the district. The building, which is a spacious one, is fitted with all the latest improvements in tire making. There are two 6-ton steam hammers and tire-rolling machinery, which will be driven by a pair of powerful engines supplied by five large boilers. The new mill will afford employment for about 100 extra men, making the total roll 1,000 hands, and will be capable of increasing the weekly tonnage by 150 tons.

Allen's Patent Pneumatic Riveters.—The new pneumatic riveters—Allen's patent—which were some time back introduced to this country by Messrs. De Bergue and Co., of Manchester, are being adopted in several important works. The whole of the riveting on the new girder bridge which is being built by Messrs. Handyside and Co. over the Trent at Newark, for carrying the Great Northern Railway, is being done by one of these riveters, and the firm have now ordered a plant for their own yard at Derby. The Grangemount Dockyard Company, who adopted this system of rivetting soon after it was first introduced, have now ordered a further plant of these pneumatic riveters for their new yard at Alloa, and we understand that where they have been introduced this system of riveting is giving every satisfaction.

A Canal between India and Ceylon.—Navigators frequenting the seas of southern Asia have for a long time felt the necessity of a passage being opened between the Gulfs of Manaar and Bengal. The Palk Straits, which divide Ceylon from the Indian continent, are strewn with sandbanks, and towards the south there is a chain coral known as Adam's Bridge, which is dreaded by seafaring men. Mr. Ramat, the agent of the French Steamship Company, has initiated a project for cutting a wide canal, two kilometres long, across the western point of the island of Ramesurum, in Palk Straits. By this canal the ocean steamers would be able to go from Colombo to Pondicherry, and other ports on the Coromandel coast, without going round Point de Galle and Trincomali, thus shortening the distance by about 300 miles, and avoiding the dangerous navigation.

Petroleum in Australia.—The Central News says: It has been known for some years past that there exists on the banks of the river Boorong, South Australia, an oxidised petroleum in the form of an elastic bitumen. A company has been formed to bore for the liquid petroleum, and great confidence is expressed by experts that the south-eastern parts of South Australia will ultimately become the largest petroleum field in the world. Skilled drillers from Canada and Galicia have been engaged, and already engineers and drillers are on the way out to South Australia.

Fast Passage of the City of Paris.—The Inman and International Company's steamer City of Paris arrived at Liverpool on Wednesday morning, August 14th, after completing the fastest passage on record from New York. The actual time occupied by the City of Paris in her voyage from New York to Queenstown was five days, 23 hours, and 38 minutes. She has previously performed the distance under six days, but the present voyage is faster than the former one by a few minutes. The City of Paris is so far the only steamer that has completed the trip from New York to Queenstown under the six days. The log of the steamer shows a remarkable conformity in the daily runs. From 4-31 p.m. on the 7th inst. to noon on the 8th she made 340 knots; to noon on the 9th, 446; 10th, 447; 11th, 460; 12th, 462; 13th, 463; and until the arrival at Queenstown at 8-13 p.m. on the 13th, 174 knots. When it is remembered that a knot is about 1⅛mile, it can be understood how great the daily runs are, as on five consecutive days she made considerably over 500 miles per day. The City of Paris had about 1,000 passengers on board, amongst whom there was naturally much enthusiasm at breaking all previous records.

The New Bridge over the Dee.—The new railway bridge which spans the river Dee at Queen's Ferry, and completes the direct route of the Manchester, Sheffield, and Lincolnshire Railway Company to North and South Wales, was opened by Mrs. Gladstone on Saturday, the 27th ult. The proceedings began by a presentation to Mrs. Gladstone of a gold casket by Sir Edward Watkin, on behalf of the railway company, and thereafter the swinging girder of the bridge was rotated by hydraulic power and set in motion by an electric ball pressed by Mrs. Gladstone. She then declared the bridge open, and named it the Hawarden Bridge, amid cheers. Mr. Gladstone, who delivered two short speeches during the ceremony, paid a glowing tribute to the splendid energy and enterprise of Sir Edward Watkin, who, he said, had rendered a more substantial service than any other man to his fatherland of Wales by promoting the erection of that bridge. Subsequently luncheon was served, and, the usual toasts having been drunk, Mr. and Mrs. Gladstone were presented with an address congratulating them on their golden wedding. Mr. Gladstone responded, pointing out the benefits of the new undertaking.

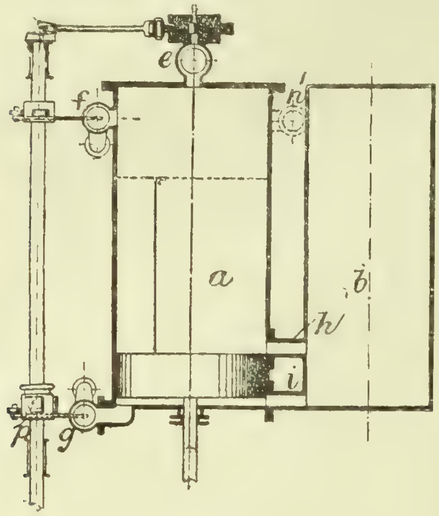
Arts and Crafts Exhibition.—The Society of Arts offers the sum of £150 in money prizes, as well as twenty of the society's bronze medals, for objects in the Arts and Crafts Exhibition which is to be held at the New Gallery, Regent Street, London, in October next. The awards will be made for designs and cartoons for decoration of all kinds, a decorative painting, or more particularly in association with architecture or cabinet work, textiles, tapestry, needlework, woven and printed patterned fabrics, lace, painted glass, pottery, tiles, majolica, painted china, table glass, metal work, wrought iron, brass, and copper, repoussé, gold and silversmiths' work, chasing wood and stone, carving in ivory and other materials, cabinet work inlaid and painted, and carved furniture, decorative sculpture, and modelled work, friezes, architectural enrichments, relievos, plaster and gesso work, printing, book decoration, printers' ornaments, illuminations and decorative MSS., wood and metal engraving, bookbinding, and cloth cases, wall papers, stencilling, and leather wook.

The Suram Tunnel.—The Russian *Official Messenger* states that the works on the Suram Tunnel advance very rapidly. Last spring the bad weather caused a serious interruption, the peasants of the neighbourhood refusing to carry by the damaged roads the stones extracted from the quarries. The want of stones has been supplied, and the works have followed their natural course. From the side of Tsipa the tunnel has been opened to the required extent for a distance of 750 sajenes, and the stonework lining completed for 640 sajenes. There remain to be opened 270 sajenes, and lining for a length of 380 sajenes. From the side of Beglety the lining has been completed for more than 400 sajenes, and the required dimensions have been given to the tunnel for 500 sajenes. On this side there still remain 350 sajenes to bore and 350 to fix the interior revetment. All the works will be definitively closed from the Tsipa side about next February, and from Beglety side in April or May, 1890. In the Tsipa section 1,300 workmen are employed in the interior of the tunnel, and about 1,000 outside. The progress of the works is considerably hindered by the numerous infiltrations of subterranean springs, which eject the enormous quantity of about 860,000 vedros a day. Some springs spout out with such force that they upset the workmen. There are others which contain mineral water. One spring is composed of more salts of iodide than any other of the same kind in the whole world. In order to arrest these infiltrations trenches have had to be constructed. The friability of the soil causes frequent earthslips. The dimensions of the Suram Tunnel surpass those of all the other tunnels of Europe. The St. Gothard Tunnel has only 60 square metres of excavation, while the Suram has 90.

ILLUSTRATED PATENTS.

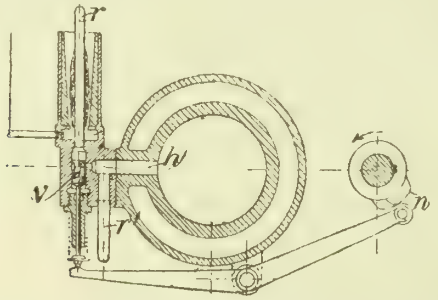
3020. Gas Engines. C. D. Abel, London.—(*The Gas Moteren Fabrik Deutz; Deutz-on-the-Rhine.*

In four-stroke cycle engines the products escape on the end of the power outstroke to a reservoir, and with compressed air are further expanded in the front of the cylinder, on the end of the suction outstroke they are again admitted to the cylinder with compressed air. In the drawing *a* is the motor cylinder and *b* the reservoir, *e* the admission valve, and *f* the exhaust valve; *g* is a valve actuated by an adjustable cam *p* for admitting air to the front of the cylinder, and for the emission of products therefrom. The products escape from *a* into *b* through the port *h* on the end of the power outstroke and enter the front of the cylinder through *i* during the exhausting instroke; on the suction outstroke the products are returned to *b* through *i*, and enter *a* through *h* at the end of the stroke; on the compressing instroke, the valve *g* is opened to admit air to the front of the cylinder and remains open during a part of the working outstroke for the escape of the mixed air and products. The port *h* may be in any other position as h^1 and controlled by a valve. February 28, 1888. [8½d.]



3095. Gas Engines. C. D. Abel, London.—(*The Gas Motoren Fabrik Deutz; Deutz-on-the-Rhine.*

Relates to a hot tube igniter and consists in providing a chamber opening to the passage between the cylinder and the igniting valve. The valve *v* is held open by a spring during the suction, working, and exhaust strokes but is closed during the compression stroke by a cam *n*. During the compression the products remaining in the passage *h* are forced into the chamber r^1 and the passage *h* is filled with combustible, which, when the valve opens, enters the tube *r* and ensures ignition. The valve has a conical face formed on its end which bears on a seating when it is open and prevents leakage round its spindle. The cam *n* is adjustable in order to regulate the period of opening the ignition valve to the speed of the engine.—February 29, 1888. [8½d.]



3238. Stop Cocks, J. A. and J. Hopkinson, Huddersfield.

Relates to a mode of packing the plugs of cocks. Fig. 1 is an elevation of the plug of a cock, and fig. 2 a section of the whole cock. The packing B^1, which may be of any suitable substance, such as vulcanite or vulcanised fibre, is disposed in grooves in the plug B and forms the bearing surface of the plug. A mould, which is a copy of the inside of the shell, is used for fitting the packing. Various standard sizes of cocks may be made, and thus a perfect fit is secured, and also the plugs are interchangeable. The plug is held in its place with just sufficient pressure to ensure a good fit, either by a nut or by a cover *a* bearing on a shoulder or flange on the plug. In the latter case packing *c* is preferably introduced between the cover and the flange. The cover may have a stuffing box and gland.—March 2, 1888. [8½.]

FIG.1.

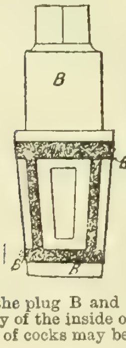
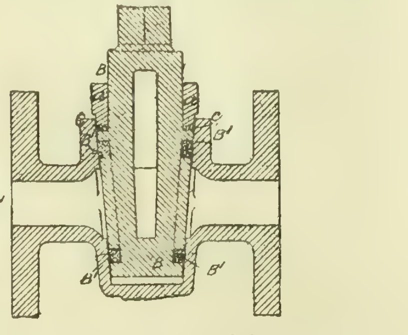
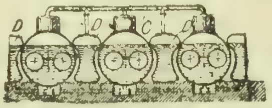


FIG.2.



3216. Steam Boilers. J. W. Oldroyd, London.

In the place of the usual brickwork enclosing the side flues auxiliary steam generators or fuel economisers for heating feed water are used. They may be of any convenient shape according to circumstances, and fitted with the usual mountings. One form is shown in connection with a battery of boilers, in which the auxiliary generators represented at D, D, are connected to the main steam pipe C. March 2, 1888. [6½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

July 30th.

12089 Cartridges, P. Giffard, London.*
12090 Pulleys, M. Couchman, London.*
12091 Gas Burners, C. Clamond, London.
12092 Furnaces, A. Weber, London.*
12094 Coupling Railway Carriages, J. E. Davis, jun., London.*
12095 Paper Bags, C. B. Stilwell, London.
12096 Boiler Tubes, S. E. Condon, London.*
12100 Moulding Fuel, L. Furrell, London.
12105 Sectional Boilers, J. Bond, London.*
12109 Weldless Chains, H. Rongier, London.*
12113 Copper Ingots, C. L. Bath, London.
12115 Bending Pipes, H. H. Lake, London. (H. E. Fowler, United States.)*
12121 Air Motors, F. Hoffmann, London.
12123 Navigable Vessels, J. F. Flannery, London.
12124 Motor, J, B. Denis, London.

July 31st.

12145 Generating Electricity, P. M. Justice, London. (E. G. Acheson, United States.)*
12149 Gases, B. H. Thwaite, Liverpool.
12164 Shells, Shots, &c., W. Ambler, London.
12165 Wheel Tires, W. Ambler, London.
12170 Type-writers, J. Turner, London.
12182 Printing Presses, H. F. Wyatt, London.*
12185 Distributing Electricity, A. H. Howard, London.
12188 Electric Currents, H. H. Lake, London. (F. V. Maquaire, France.)

August 1st.

12190 Twisted Wire, J. Patchett and Patchett, Birmingham.
12198 Lifting Machinery, D. T. Young, H. W. Young, and E. P. Wright, Birmingham.
12210 Brake Power, S. Miller, R. C. Steed, and F. Gooch, London.
12216 Steel Alloy, J. P. E. C. Stromeyer, London.
12236 Electric Currents, J. Swinburne, Wimbledon.
12237 Electric Transformers, J. Swinburne, Wimbledon.
12238 Hot-air Motors, C. Wells and D. A. Bamford, Middlesex.
12239 Steam Engines, C. Wells, Middlesex.
12245 Driving Shafts, J. S. Campbell, London.*
12248 Coil Springs, W. Blakely, London.*
12250 Power Hammers, W. Honneknövel and E. Hönneknövel, Barmen.

August 2nd.

12251 Electric Couplers, I. A. Timmis, London.
12254 Valves, G. Richards, , Altrincham, Cheshire. (D. W. Payne, United States.)*
12258 Steam Engines, A. F. Stott, Bradford, Yorkshire.
12266 Water Gas, B. H. Thwaite, Liverpool.
12273 Lubricators, W. E. Heys, Manchester. (Messrs. Schäffer and Büdenberg, Germany.)
12278 Motor Engines, J. Heaton and G. H. Holden, Manchester.
12287 Steam Engines, T. Laker and J. Clark, London.
12308 Carriages, T. Nordenfeldt, London.
12312 Pulleys, H. Lea, Middlesex.
12313 Electric Conductors, H. Lea, Middlesex.
12314 Breech-loading Guns, T. Southgate, London.
12315 Refining Gold, G. Kamensky, London.
12318 Metallic Nuts, S. F. Ibbotson, A. B. Ibbotson, and W. Clarke, London.

August 3rd.

12325 Lathes, W. H. Price, Liverpool.
12337 Gas Engines, R. Haddan, London. (A. J. Mirre, France.)
12369 Fire Bricks, A. Brand, London.

August 6th.

12374 Magnets, J. F. Bennett, Sheffield, Yorkshire.
12378 Drills, I. E. Storey, Manchester.*
12379 Shafting, J. E. Whiting, Bombay, East Indies.
12382 Cleaning Boiler Tubes, J. Platt and T. Thorp, Manchester.
12385 Separating Wheat, W. T. Bates, Liverpool.
12388 Current Reverser, E. J. Haughton, Dulwich.
12390 Electric Motors, S. C. C. Currie, Birmingham.*
12401 Propellers, G. Chupman, Glasgow.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

CHEAP PREPAID RATES FOR ADVERTISEMENTS OF

MACHINERY, ENGINES, BOILERS, &c., WANTED OR FOR SALE, SITUATIONS VACANT OR WANTED, &c.

One line (seven words) 6d.; and each Additional Line of seven words, or less, 4d.

Initials and Figures counted as words. Remittances may be made in halfpenny stamps.

THE PRACTICAL ENGINEER,

AUGUST 30TH, 1889.

INITIAL STRAIN.

THERE are many engineers who are under the impression that the more tightly a thing is screwed up the safer it is, and it is, therefore, desirable to point out that this is not necessarily, nor indeed generally, the case, and often the over-tightening of connections may be a source of danger. The danger is caused by screwing up work to such a degree that the breaking point of the connections is approached. In some cases a certain amount of initial strain is necessary to prevent rattling, but the requirements of different classes of work should be carefully considered, and no haphazard method of tightening everything up adopted. It is highly important that this matter should be thoroughly understood by the general run of artisans, for it is not to be supposed that overseers can watch every detail of tightening a nut or cottar, nor should it be necessary for them to do so.

If the pull upon a bolt is at right angles to its length, there is not the slightest use in initial strain, and it merely needs to be screwed up sufficiently to keep the parts it connects in close contact, there being no tendency to displace the bolt or nut longitudinally; but if the pull upon the bolt is longitudinal, some normal stress is necessary to prevent knocking, and the amount of this can easily be determined in each particular case. Let us consider for a moment the action of initial stress upon a bolt longitudinally strained, such as the bolt holding the bearing cap of a steam engine. If in such a case the nut were only screwed up to touch the metal, then, when tension comes upon the bolt, it is slightly, but still to some degree, elongated, thus removing the parts joined from actual contact; on the cessation of the tension these parts will fly together again, and this action being constantly repeated, knocking will be set up, causing injury and destruction to the parts concerned.

If the amount of initial tension upon the bolt is equal to that which can be brought upon it in the course of work, it is evident that in that case the parts held by it will not be separated, as the bolt will be no further extended unless the working stress exceeds the initial stress already upon the bolt. The amount of tension that can be put upon a bolt with an ordinary spanner is very great. Suppose that an inch nut, well oiled so as to move freely, is being tightened up with a fifteen-inch spanner, then the pitch of the thread being one-eighth inch, and the circle described by the end of the spanner 47 inches, the force applied to it is multiplied by 376, so 24lb. pressure on the end of the spanner would put 4 tons tension on the bolt, which is more than it should be subjected to when forming part of a machine. At a strain of about eight tons per sectional square inch, the elastic limit of wrought iron is reached, and it begins to stretch permanently; hence if this point is approached by the initial tension, the bolts will gradually yield and want constant tightening up, whereas, if the initial force is kept well within the elastic limit, they will remain in adjustment for an indefinite time. The stress calculated above would be equal to five tons per sectional square inch of the metal; therefore, if the force on the end of the spanner were raised to 40lb., the elastic limit of the iron would be reached. When locking nuts are used on the top of the ordinary ones, the initial force on the former should be considerably less than on the latter, otherwise they will take up the stress from the ordinary nuts, which, as they are usually much the thinner of the two, they are quite unfitted to bear, and, moreover, they would thus put an excessive strain on the bolt threads, which might lead to stripping.

We may mention here that we have known bolts to break from over tightening, such a case having occurred on an iron arched bridge during the time it was being tested. Prior to the test the nuts were tightened up by an ignorant inspector, unknown to the engineer, and so nearly to the breaking point were they strained, that the vibration caused by running a string of heavy locomotives on to the bridge broke the bolts in all directions.

It is, however, not only bolts that are concerned in the matter of initial strain; its use or otherwise in iron bracing may be discussed. If we have a cross or counter-brace steadying the framework of a structure, there is a sort of feeling that if the tie bars have a pull upon them in their normal condition, they have a better hold of the frame than if unstrained; but this is not really the case, for whatever help the initial stress on one bar gives it to resist further extension is counteracted by that of its companion bar. In this case it is necessary that the ties should be tightened up sufficiently to take a firm bearing, and ensure their resistance being called into action on the slightest disturbance of form taking place. In point of fact, if two ties are pulling against each other, the initial tension, if there is any, is a gratuitous waste of strength, for it will only be the difference of stress that will tend to restore the work distorted by an external force, and therefore the initial stress is so much more unnecessarily put upon the work.

Initial strain appears in another and a useful form in cylinders for hydraulic presses when iron or steel rings are shrunk on to them, the same method being also used for some kinds of large guns. In thick cylinders exposed to internal pressure the circumferential stress decreases from the inner to the exterior surface, and thus the thicker the cylinder the less proportionately is its average strength to resist bursting. This is due to the fact that radial compression of the component material must occur, and the proportional circumferential extension is at a maximum in the interior layer, and therefore at that place fracture will commence long before the breaking stress has been reached by the layers more distant from the centre. From this we find that there is spare tensile strength in the exterior part of the cylinder, and if this can be brought into action there will be a corresponding increase of general strength. The effect of shrinking a strong ring on to a cylinder will be to put its material into compression; then, when no internal pressure is acting on it, we have a cylinder of which the internal layers are in compression and the external in tension, to an extent regulated by the relative diameters of the cylinder and its encircling ring or rings, for more than one may be used if required. If the cylinder so composed be now subjected to an increasing internal pressure, it will first reduce and ultimately eliminate the compressive stress in the interior layers of metal, and then throw them into tension, but all the while, though in a much smaller degree, increasing the tension in the shrunk rings. Now, with this arrangement, if the shrinkages are properly arranged, we may arrive at a condition when there is a tolerably uniform amount of compression throughout the whole thickness of the metal, and thus with a thinner cylinder a much greater strength is obtained than the ordinary method of manufacture would afford.

THE EIFFEL TOWER STRUCK BY LIGHTNING.

According to the *Times* correspondent, the Eiffel Tower was struck by lightning very heavily on Monday night of last week. All who were upon the structure at the time heard a tremendous explosion, twice repeated, but they suffered no injury. It is reported that some molten metal fell from the lightning conductors, and a portion of the upper metal work has been damaged. The fact that those on the tower escaped corroborates the belief of electricians that a position within an iron structure is exceedingly safe under such circumstances.

THE SPEED OF SHIPS IN CANALS.

A French engineer, M. Saint-Yves, has recently conducted a series of experiments upon the laws governing the resistance to the movement of vessels in canals. It has long been known that a great increase of resistance is experienced in narrow channels to that encountered in the open seas. From M. Saint-Yves' experiments, made upon a model canal and model ships, he finds that when the midship section is about two-fifths of the canal section a speed of 18 knots at sea would be reduced to nearly 9 in the canal with equal expenditure of propelling power. With a section of about one-fourth, a sea speed of 14 knots corresponded to a canal speed of about 9·4 knots. From experiments upon the Ormuz, passing through the Suez Canal, it appears that while a sea speed of $10\frac{1}{2}$ knots is attained with 40 revolutions per minute, only $4\frac{1}{3}$ knots is made in the canal, or less than one half of the sea speed. These facts are most interesting and important, but considerable further investigation seems necessary for the complete understanding of the whole problem.

LOSS OF LIFE ON RAILWAYS.

From the returns just issued of the accidents on British railways during the past year, it appears that the number of lives lost is being steadily reduced from year to year. The average number of passengers killed per annum for the past five years is just over sixteen, while in the previous five years it was over eighteen. Last year only eleven were so killed, or one life lost for every sixty-seven million passengers carried; but one person was injured for every one and a quarter million carried. Our railway system is evidently exceedingly safe, but still leaves room for improvement in the reduction of injuries inflicted. The largest number of train accidents resulting in injuries was on the Great Western system, and the least on the London and North-Western.

THE BRITISH ASSOCIATION.

At the forthcoming meeting of the British Association in Newcastle, Mr. E. Muybridge will give demonstrations of his discoveries relating to animal locomotion. It will be remembered that this gentleman photographed instantaneously a series of positions at minute intervals of time of animals in the act of walking, running, and flying. The pictures revealed facts previously unsuspected of the modes of action and the sequence of movements of the limbs and wings of animals and birds. The photographs have caused much interest in the scientific world of England and America, and when the series is combined by means of a rotating mirror arrangement, the animals can be shown upon the screen in apparent motion. Edison's perfected phonograph will also be shown. In an interview Professor Merivale had with Mr. Edison's representative, Col. Guiroud, he was informed that a new instrument had arrived from America which was to be sent to the meeting. Mr. Edison himself, however, will be unable to be present.

TANK STEAMERS AND LIQUID FUEL.

In an interesting but somewhat over-enthusiastic article, communicated by Mr. Charles Marvin to the *Newcastle Daily Chronicle*, he predicts the speedy competition of refuse oil with coal for furnace work and steam-raising in Britain; and he points to the great development of the ocean-going tank oil steamers. It is stated that in 1883 forty tank vessels were running from Baku, and that now over one hundred are placed upon the Caspian Sea, while fifty tank steamers are running freely on the Atlantic and European seas. The first European-built tank steamer, the Iviet, commenced work in the Black Sea in 1885. It came to London in 1886, and in that year the second tank steamer, the Glückauf, constructed by Messrs. Armstrong, Mitchell, and Co., successfully crossed the Atlantic. During the first six months of the year 371,603 barrels of Russian oil came into the United Kingdom, all carried in tanks; while 76,754 barrels came from America in tanks, and 285,155 barrels of oil in barrels. At present nearly the whole of the oil so transported is intended for use in lamps, but as new fields become opened up a greater proportion of the heavy oil will be produced, which can only be useful for fuel. Mr. Marvin states that petroleum from Lima, Ohio, is carried to Chicago for fuel purposes, in an 8in. pipe line of 210 miles in length, and that hundreds of manufactories are now using oil exclusively instead of coal. The Standard Oil Company, who own this line, are putting down piping to the Atlantic Coast to despatch a cheap fuel oil to this country. Other supplies may be expected from Russia and Burmah, when we may expect a large influx of fuel oil into England. English coal will then have to contend with a strong competition in the home market. We fear that Mr. Marvin's predictions will fail to be verified on this occasion.

It is quite true that oil is largely used in Russia for steam-raising, both on steamers and locomotives; but Mr. Marvin appears to overlook the fact that even in Russia, where petroleum refuse is so plentiful, the cost in money for a given power is considerably in excess of the cost for the same power here. That is, although petroleum refuse is cheaper for fuel and steam-raising there, yet the expense of a horse power for one hour exceeds that in this country using coal. No doubt there are many uses to which a cheap fuel oil could be applied here, both for the production of power and light; but meantime, so long as present prices exist in Russia, there is no chance of competition with coal here.

WATER GAS FOR DOMESTIC USE.

OUR contemporary the *Financial Guardian* is not prepared to believe, with us, that water gas cannot possibly supplant coal gas for household purposes in this country, and in proof points to America, where it is largely used in dwellings. The conditions in America, it should be remembered, are very different from those existing in the United Kingdom. Coal and labour are both dear, while crude petroleum is cheap. It therefore pays to make non-illuminating water gas, which is carburetted with hydrocarbon, and thereby made luminous on burning. But even in America the luminous water gas is sold at about 10s. per 1,000 cubic feet, just about the average price of coal gas in the States. It would be hardly possible, with the waste oils at command here, to sell a carburetted water gas of sixteen candle power at 3s. per thousand, a price higher, we need not say, than that ruling in many of our large towns.

The success of cheap water gas as an illuminant depends upon the usefulness and reliability of the magnesia comb, and we have yet to learn that the practical difficulties have been overcome more completely than in the case of the Welsbach light, which so far has failed to win an extended public confidence. Water gas, in its many forms, is best suited for the production of high temperatures and motive power, and there lies its future, but not by any means an immediate or extensive one. The applications will extend slowly and laboriously, not rapidly.

WE understand that the gun factory part of the Woolwich Arsenal is being considerably increased to cope with the growing demand for guns of all calibres. Notwithstanding the increasing ability of private firms to take large orders for guns, the national gun factories are more necessary than ever, for the manufacturers are anxious to get as big a price as possible for their wares, and their charges are only kept down by the knowledge that if they ask too much the orders will go to Woolwich. Great things are hoped from the new Director of Ordnance Factories, Mr. Anderson. This gentleman has not the unique reputation as an artillerist that General Maitland (his predecessor) enjoyed, but as a maker of gun mountings and hydraulic machinery he has been famous for many years, and it is hoped that he will be able to vastly improve the machinery employed.

THE VACUUM AUTOMATIC BRAKE.

AN exceedingly interesting and important exhibit at Paris is that of the Vacuum Brake Company, of London, who show novelties in the means of rapidly applying their automatic brake where very long trains are required, as for military purposes. After inspecting the stall at Paris, we considered the system so interesting and important, that we recently visited the works of Messrs. Gresham and Craven, Ordsall Lane, Manchester, to have the details fully illustrated by actual experiment, and to examine the various parts during the course of manufacture. Messrs. Gresham and Craven are the manufacturers for the Vacuum Brake Company, and Mr. Gresham is the inventor and patentee of the leading details of the apparatus. We are exceedingly obliged to the firm for the very full explanation they have been good enough to afford us, and for the unreserved manner in which they have shown us the whole acting principles and details of the apparatus. The vacuum automatic brake is now a triumph of mechanical ingenuity, but at the same time its parts are so few in number, and so simple in character, that examination at once inspires confidence in the certainty of its action when wanted. Just as with other considerable inventions, simplicity and certainty have only been attained after years of effort and almost innumerable failures, or at least partial successes, and this is readily seen from the fact that although over 1,200 patents have been applied for in England on railway brakes during the past twenty years, yet only three pneumatic systems are at present extensively used throughout Britain, namely, the Westinghouse compressed air automatic, the vacuum automatic, and the vacuum non-automatic.

All these use the pressure of atmospheric air to furnish the power required to apply the brake blocks to the wheels, the first by increasing the pressure of air, and the second and third by diminishing the pressure within the apparatus, and so making the pressure of the atmosphere available.

The essentials of the vacuum automatic system are a means of obtaining a vacuum in chambers attached to each coach, cylinders to transmit the atmospheric pressure to the brake blocks, and means of applying and taking off that pressure at will from the engine or the guard's van, and, under some circumstances, means of applying the pressure by the passengers.

This brake fulfils all the requirements of the Board of Trade. It can be applied by the driver, by the guards, and by the passengers, if desired. It is self-applying when a train is broken into two or more portions by accident; and it is self-applying also in case of the train pipe or the brake apparatus itself becoming damaged. Under each vehicle is placed a brake cylinder, with valve complete in one fixing, having a connection by a small hose pipe to the continuous train pipe running from end to end of the train, and coupled between the coaches by means of hose pipes and couplings. On the engine is fixed an ejector, for the purpose of creating and maintaining the vacuum, the driver's valve being also upon it. To prepare the brake for use, or—as it is generally termed, to "create the vacuum"—the driver sets the ejector to work by admitting the required amount of steam. The pipe and all the cylinders are exhausted, and a vacuum of 20in. to 24in. is created in the apparatus throughout the train. When it is desired to apply the brake, the driver turns his handle to the position "on," opening the air valve and admitting the atmosphere to the train pipe and bottoms of the pistons, which it lifts up, as there is still a vacuum above them, and pulls the blocks to the wheels. To *release*, the valve is placed at "slow release" or "running" position. The ejector then withdraws the air let in to apply the brakes, thus restoring the equilibrium of the pistons and allowing them to fall and carry the blocks from the wheels.

Each coach is fitted with—(1st) A train pipe, with hose and couplings; (2nd) a cylinder, with valve complete.

The train pipe is used for conveying the atmospheric air to and from the cylinders. It is connected between the vehicles by hose and couplings, which shall be described presently.

We shall first describe the cylinder with its ball valve, as in this lies the element of automatic action. Referring to our illustration, the cylinder D, fig. 5, p. 595, is open ended, and is placed inside a wrought-iron vacuum chamber E. This chamber has two trunnions on its side, which are placed in carriers, to allow of oscillation, and compensate for the radial movement of the lever to which it is coupled.

The piston is made a very free fit in the cylinder D, and is packed with a rolling ring of indiarubber, which, as the piston moves, is rolled in compression between it and the cylinder, and makes a perfectly air-tight packing, and without friction. The piston rod is lined with brass, and works in a

THE VACUUM AUTOMATIC BRAKE.

Constructed by Messrs. Gresham and Craven, Engineers, Manchester.

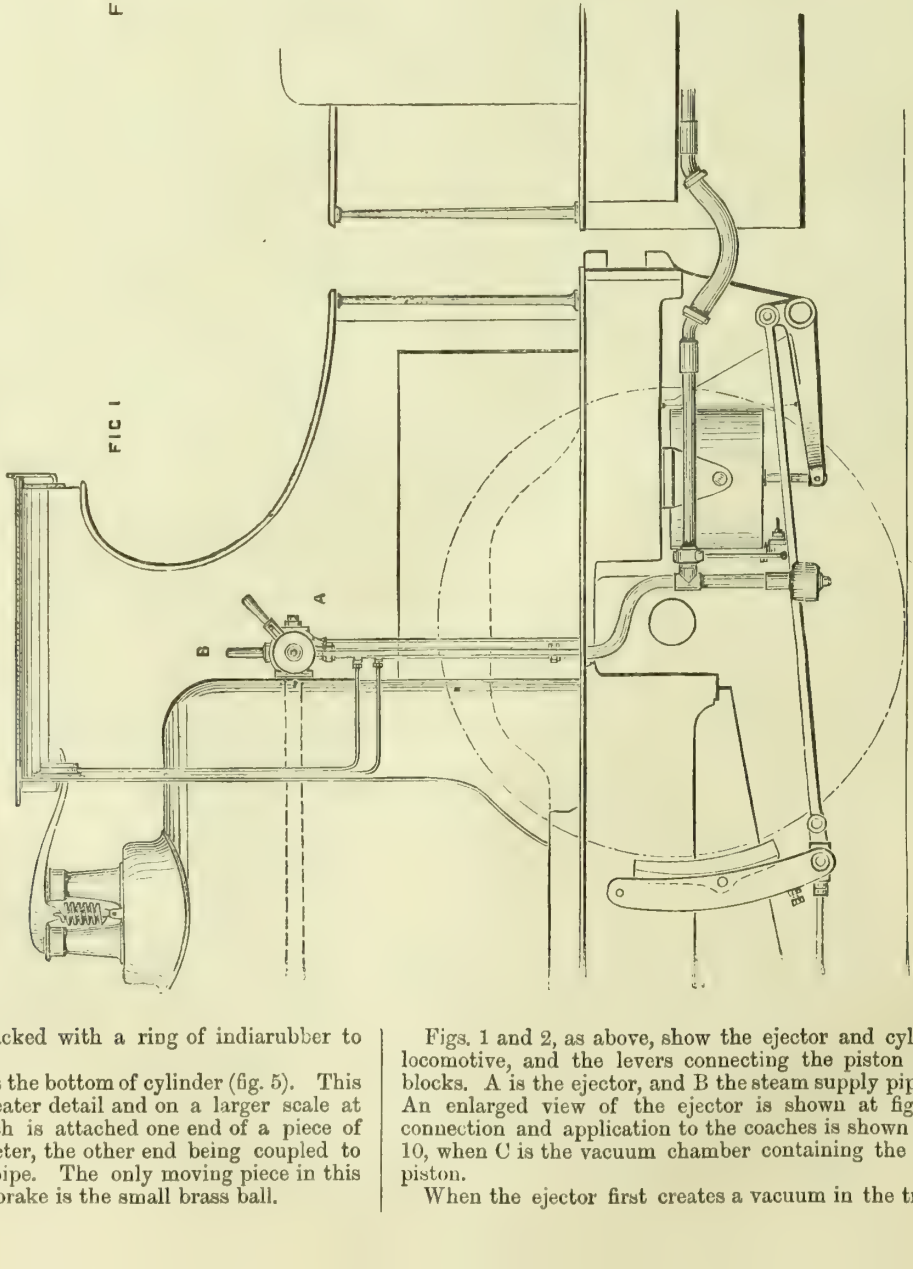


FIG I

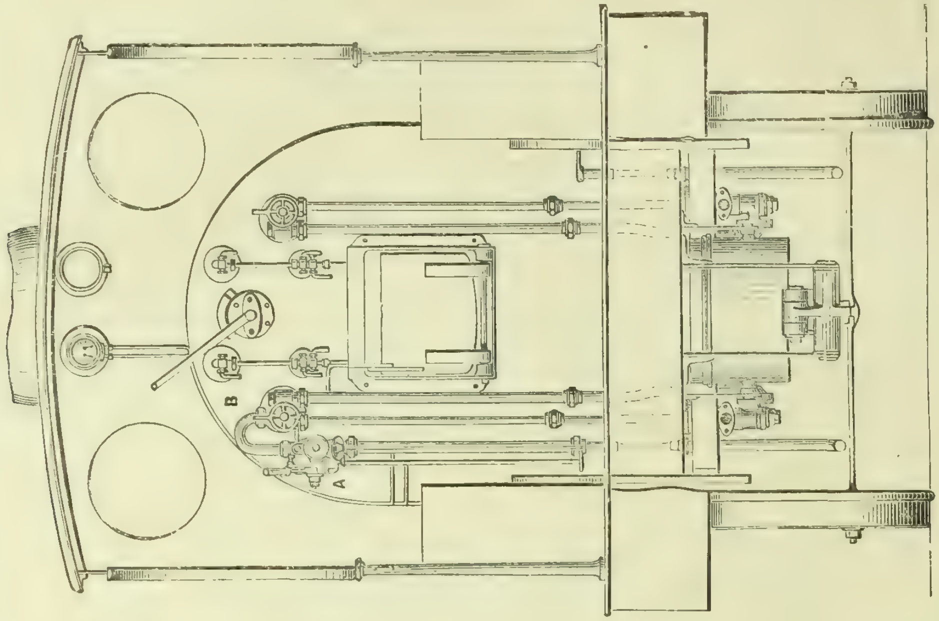


FIG.2

brass bush, which is also packed with a ring of indiarubber to keep it air-tight.

A ball valve F is placed at the bottom of cylinder (fig. 5). This valve, which is shown in greater detail and on a larger scale at fig. 3, has a branch, to which is attached one end of a piece of hose pipe ½in. internal diameter, the other end being coupled to a connection on the train pipe. The only moving piece in this valve during the use of the brake is the small brass ball.

Figs. 1 and 2, as above, show the ejector and cylinder, on the locomotive, and the levers connecting the piston to the brake blocks. A is the ejector, and B the steam supply pipe working it. An enlarged view of the ejector is shown at fig. 8, and the connection and application to the coaches is shown at figs. 9 and 10, when C is the vacuum chamber containing the cylinder and piston.

When the ejector first creates a vacuum in the train pipe, the

THE VACUUM AUTOMATIC BRAKE.

Constructed by Messrs. Gresham and Craven, Engineers, Manchester.

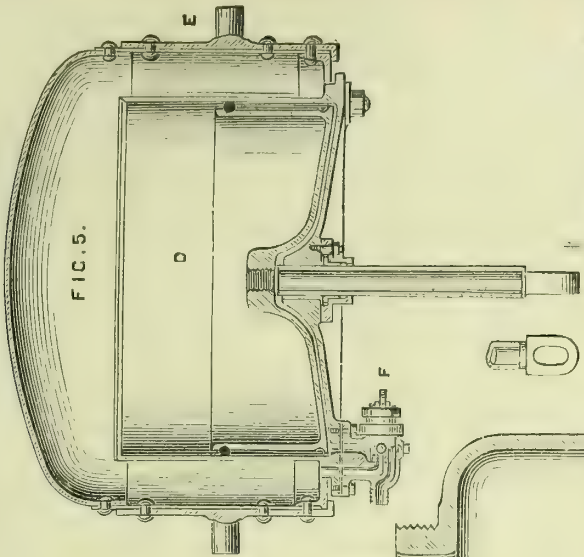


FIG. 5.

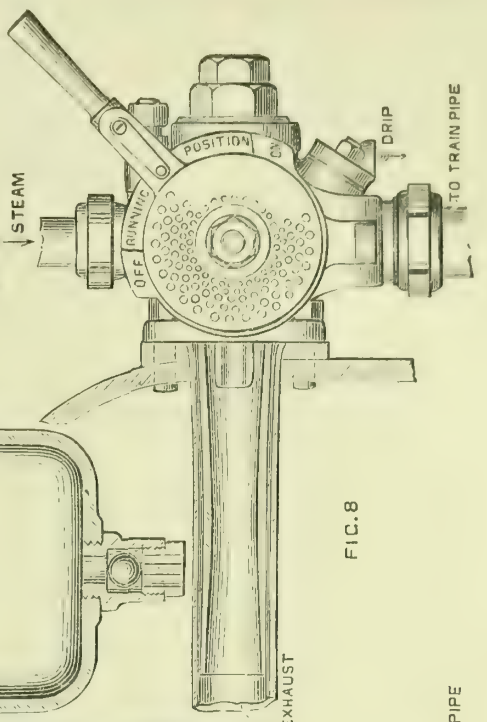


FIG. 8

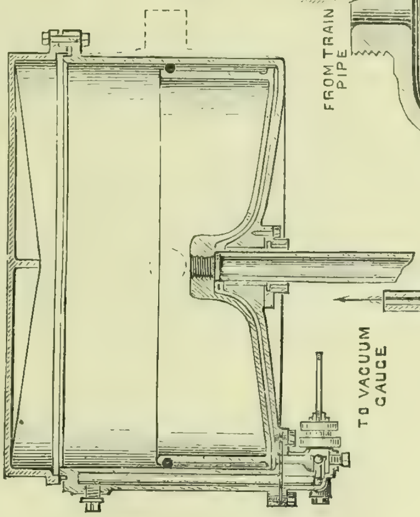


FIG. 4

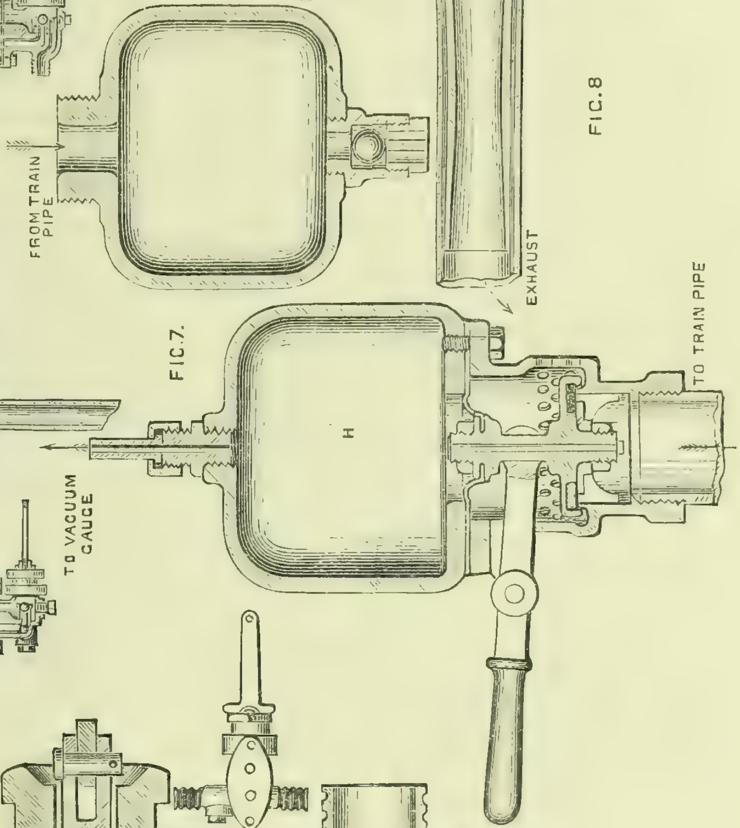


FIG. 7.

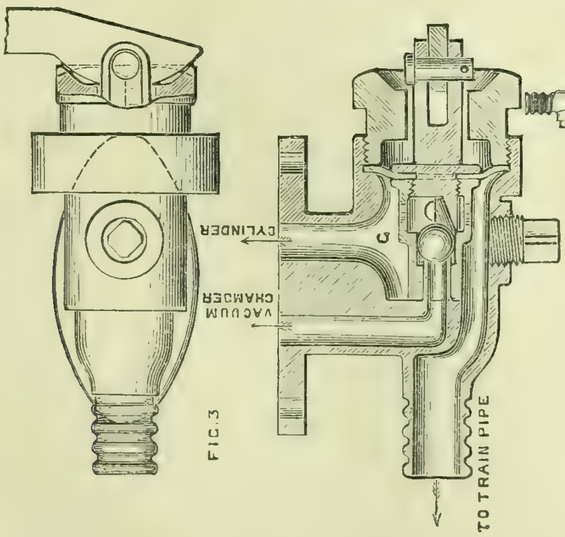


FIG. 3

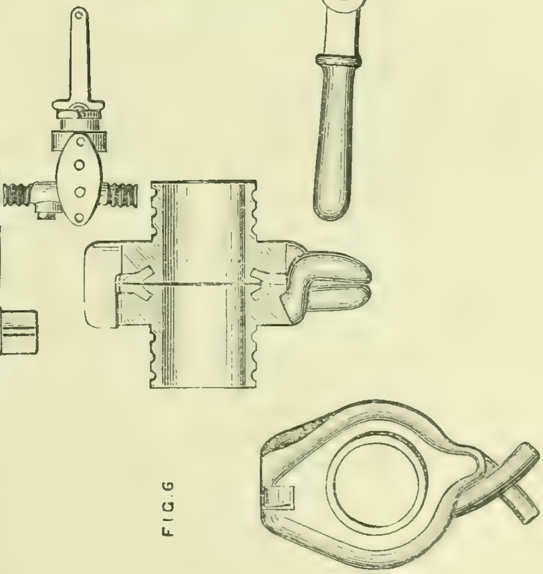


FIG. 6

air is withdrawn equally from both sides of the piston, and the pressure in the wrought-iron vacuum chamber is the same as that below the piston; the air contained is withdrawn to the train pipe from the vacuum chamber through the ball valve, and from the cylinder under the piston by the passage G (see fig. 3). Consequently, there is no pressure to move the piston in either direction, and it falls to the bottom of the cylinder and keeps off the brake blocks. If, however, air be admitted to the train pipe, then, in rushing into the vacuum chamber, it rolls over the ball valve and stops access to the chamber; the air, therefore, presses under the piston, and raises it up, with a pressure depending on the vacuum above and the amount of air admitted below. The usual vacuum used is about 20in., and with this the full pressure applied by the piston rod end is about 20cwt. with the dimensions of cylinders commonly used, 18in. in diameter by 9in. stroke. By admitting less air, the pressure applied may be graduated with great nicety up to that amount. To apply the brake fully, the driver's handle is turned to the position marked "on," fig. 8, and

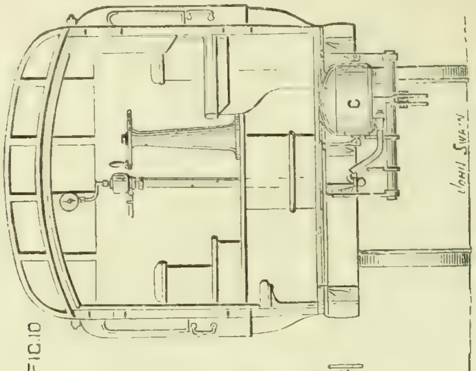


FIG. 10

THE VACUUM AUTOMATIC BRAKE.

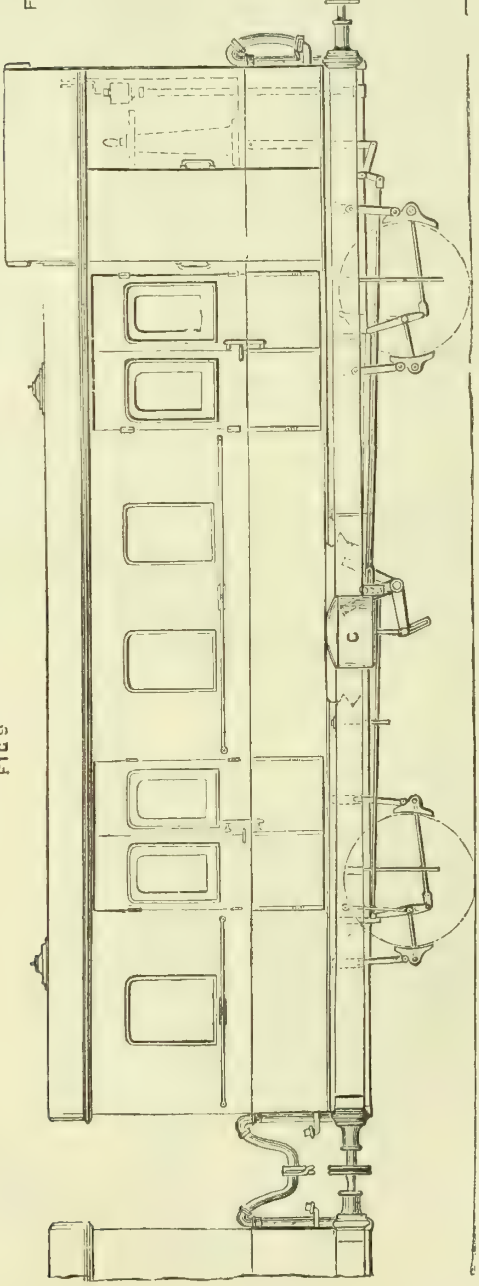


FIG. 9

this admits air through the numerous holes seen in the face of the disc. In order that the air may be admitted with great rapidity to the cylinders at the extreme end of the train, as well as near the engine, the ingenious and simple automatic valve shown at fig. 7 is utilised. It consists of a valve seated as shown, and closing the train pipe. A chamber H carries the vacuum gauge, and is closed by a rubber diaphragm attached to the valve spindle, but of smaller area than the valve; a small hole passes through the valve stem and allows communication between the chamber H and the train pipe. Suppose the valve closed, and a vacuum of about 20in. existing equally in the train pipe and in H, then the valve is obviously held against its seat by reason of its greater area. But if the pressure in the train pipe is increased by admitting air, the chamber H gets air much slower through the small hole, and so the atmosphere presses up against the diaphragm to a greater extent than it presses down the valve, so at a certain point the valve opens, and air at once rushes through the perforations to the train pipe. In this way, if the driver rapidly applies the brake, by opening his valve full to atmosphere, the pipes fill quickly, and the auxiliary valve opens also to admit air from the further end of the train, as well as from the engine. But when the pressure is gently applied, the valve does not act, because the chamber H is filled to the same pressure as exists in the train pipe. By this means, however long a train may be, the air may be admitted at intervals, so that no time is lost in travelling the whole length of the pipe. To take the brake off the driver moves the handle to the position "off," which causes the ejector to act rapidly, with a full supply of steam; and so the vacuum is rapidly created, and the pressure below the piston reduced to the same as that above. The piston then falls, and the blocks are taken off. The rubber rolling ring packing the piston is about ½in. diameter when not compressed, and is compressed when in position to ⅜in. It packs the piston so effectively, that when air from the atmosphere is fully admitted below the piston, the united leakage of piston and ball valve does not destroy the vacuum for some five hours. The full pressure below the piston can thus be maintained for any necessary length of time, far exceeding that required for any possible stop. When the driver's handle is in the position shown in fig. 8, or the running position, then the small ejector forming part of the large one is at work, and withdraws the air slowly, so that the brakes would be slowly taken off, and when off, the small ejector keeps the vacuum constant, by taking away any air admitted by leakage.

Where a coach or part of a train is detached accidentally, the train pipe breaks, and the air is at once admitted under the pistons, so that the brakes are at once applied to their full pressure, and would remain on for hours until the vacuum was destroyed by leakage. It is often necessary, however, to uncouple carriages and take the brakes off. This is done by means of the lever shown at fig. 3, which acts on a casing carrying the ball valve, and lifts the valve from its seat so as to admit air. When the coach is coupled up and the vacuum made, the casing allows the ball valve to act again, as it is pulled in by pressure of the atmosphere upon a diaphragm, as shown in the figure.

The coupling for the hose attachment to the carriages is admirably simple and ingenious, and is shown at fig. 6 in two views. Rubber washers are sunk in the faces, and two projecting pieces form a loose hinge, while a tongue projects and forms a guide. It is only necessary to slip these together, when the slight vacuum due to the action of the small injector at once causes the atmosphere to press them together, and the completed vacuum causes them to hold perfectly firm. At the same time a good pull separates them. The chamber shown to the right of fig. 7, with the ball valve under it, acts as a drip chamber, and allows any water to escape from the pipes, wherever the ball valve falls off, by the pressure rising to atmosphere. We watched with interest the tests shown us at Messrs. Gresham and Craven's, and saw the pressure applied indicated by pull on a spring balance. The full-sized model shown us is fitted up in the yard of the works, and consists of apparatus for ten coaches coupled up, just as in practice. A number of flags indicated the movements of the brakes. The rapidity of application is admirable, not more than two seconds elapsing between the movement of the driver's handle and the full application of the brake on the tenth coach.

With the new auxiliary valve, with trains of even fifty carriages, the pressure can be fully applied to the thirtieth carriage in 2¼sec., and to the fiftieth in 3½sec. We have before us the account of a test recently made by Sir Douglas Galton, at Messrs. Gresham and Craven's workshops, with fifty sets of brake apparatus, coupled up with the required amount of train piping, in which he states: "The new arrangement is shown on a drawing exhibited at the Paris Exhibition, and apparatus for a complete train of fifty carriages was put together and was in operation in the workshop of Messrs. Gresham and Craven, at Manchester, upon which I had the advantage of observing the time required between the action of the driver in moving the brake handle to set the brakes, and the application of the brakes to the wheels in the several parts of the train. The mean results obtained upon the apparatus were as follow:

On the	10th	carriage	$\frac{7}{10}$	seconds
,, ,,	20th	,,	1½	,,
,, ,,	30th	,,	2¼	,,
,, ,,	40th	,,	3	,,
,, ,,	50th	,,	3½	,,

These results are admirable, and prove the adaptability of the automatic vacuum brake to all trains, however long. Tests were also made by the same authority with fifty carriages upon the Manchester, Sheffield, and Lincolnshire Railway, on the 21st July of this year. The first stop was made at a speed of 32 miles per hour in 12 seconds; second, at the same speed, also in 12 seconds in a distance of 342ft. upon a level. Twenty-two carriages were slipped and stopped from 32 miles per hour in 12 seconds in 240ft.; their total weight was 268 tons, 12cwt. The automatic vacuum brake is a good example of combined mechanical ingenuity and practical skill applied to the solution of a most difficult and important problem.

THE WELLS LIGHT AT PARIS.

We have already referred to Messrs. A. C. Wells and Co.'s exhibit at the Paris Exhibition, which occupies a prominent position on the banks of the Seine, on each side of the Pont de Jena. Lamps are shown working every night, and inside the petroleum pavilion another is shown on a stand, together with drawings and details of various arrangements.

The principle of the Wells light is by this time very well known. The lamp burns the vapour of tar oil, produced from the oil by the heat of its own flame, and the oil is raised to the burner by pneumatic pressure, generated by a hand pump, worked at intervals of four or five hours.

Fig. 1 shows the arrangement of the standard form of apparatus very clearly, P being the tank into which oil is pumped by the pump M and pipe K. The action of pumping in this oil compresses the air above it, so that when the tap B 2 is opened the oil is forced up the standpipe A and round the burner tubes R. These tubes, having been previously heated, vaporise the oil, and the vapour passes along the horizontal pipe and down through the jet N, whence it issues in a long flame, which keeps the tubes R hot, and vaporises the fresh ascending oil. The air gradually expands and keeps sufficient pressure for four or five hours.

This description applies to all the forms of lamps which are shown at the Paris Exhibition, but, although the light is produced in the same way in all of them, each one is modified to suit various requirements. Taking the six lamps exhibited in order, we have:

1 and 2 are very powerful burners at the top of fixed iron masts, the oil being taken to the burners by flexible hose, and the burners lowered for attention by means of wires and windlasses. These are largely used for railway sidings and open spaces, where light is required night after night in the same position.

3. An elevated light at the top of a movable mast, fixed to the ground by spikes, burner being connected in the same way as in the last exhibit. This is intended for use where elevation, combined with a certain degree of portability, is required.

4. An extremely portable form of elevated light, which the makers call "swivel mast arrangement." The mast here is fixed to the tank itself, the weight of the tank being sufficient to uphold it. Tank and mast can be carried about together, and the burner is swivelled down for lighting and attention. The mast can be removed from the tank in a few seconds, and the burner from the top can be used on the ordinary tank stand pipe if required.

5. Here the oil is conveyed from the tank to the burner by a flexible tube, and the burner is mounted on a small tripod, which can be used upon a scaffolding, lowered down a dry dock, or moved about in any direction on the level.

6. This is an ordinary standard lamp, which is constantly being wheeled about on its carriage, to show its perfect portability. These carriages are of great use where many lamps are working together.

The lamps burn a cheap kind of tar oil, but in countries where this cannot be obtained they will burn petroleum. They are very largely used on the Manchester Ship Canal, and in large works, &c., in England. The construction is very simple, as will readily be understood from the previous description and reference to fig. 1. There is nothing to get out of order, and the fact that the lights are generally attended by labourers and navvies speaks for itself.

The drawings in the Exhibition, before referred to, show a method of supplying many burners from one central tank, the oil being forced through pipes by water pressure, obtained either from the town's mains or from an overhead tank. This makes a very simple arrangement for lighting shops.

Messrs. Wells have done good work in simplifying these lamps and successfully applying them to many uses. The lamps at the Exhibition were inspected by us in action several evenings, and gave a brilliant and agreeable light, much preferable to the arc lamp for outdoor work.

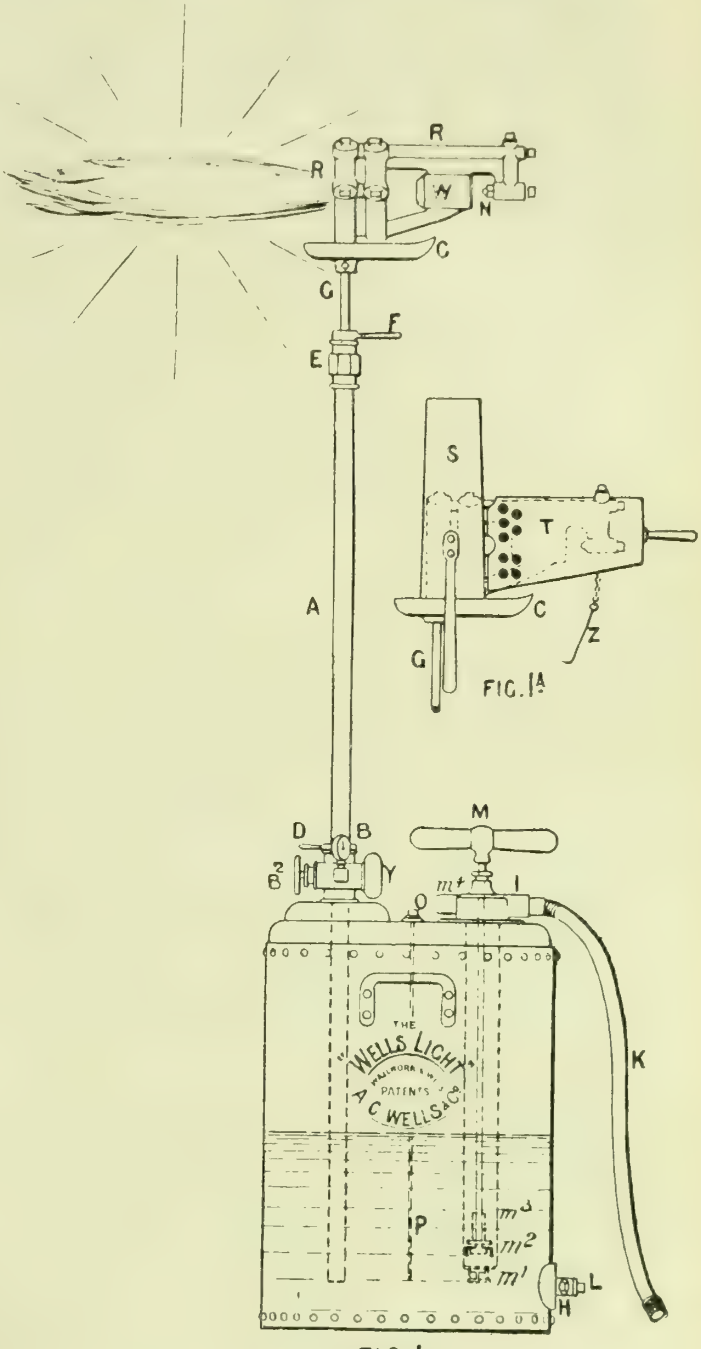


FIG. 1A

FIG. 1

IMPROVED PUMP VALVE SEATS.

A brief description is given in a German contemporary of a simple and effective means of securing tightness of pump valves. The plan followed consists simply in grooving the valve seats and inserting rubber cord in the grooves. The cord, as will be readily understood, is compressed when the valves seat themselves, and effectively guards against leakage. In addition to this, it prevents the shocks ordinarily produced by rapid closing, and prolongs the life of the seats. The importance of this will be readily appreciated by those familar with the working of pumps under high-water pressures. The rubber cord, when worn, can be easily and quickly replaced.

LOCOMOTIVES AT PARIS.

To an Englishman the locomotives at the Paris Exhibition are productive of almost personal congratulation. Only four English locomotives are to be seen at Paris, namely, one from the London, Brighton, and South Coast Railway shops, of their usual forward coupled type; one of the South-Eastern Railway Company's express engines of the four-coupled class, with leading four-wheeled bogie; a locomotive, by Neilson and Co., of Glasgow, for the Argentine railways; and finally, a large 7ft. 6in. single driver inside cylinder express passenger engine, from the Derby shops of the Midland Railway Company. This is an eight-wheel locomotive, with a leading four-wheel bogie, and its dimensions are as follow:—

	Ft.	In.
Diameter of Cylinder	1	6½
Stroke	2	2
Steam Lap of Valve	0	1
Full Gear Lead	0	0⅛
C. to C. of Cylinders	2	4
Diameter of Drivers	7	6
,, ,, Bogie Wheels	3	6
,, ,, Trailing ,,	4	4
Bogie Cr. to D. Cr.	10	0½
D. Cr. to Tr. Cr.	8	9
Bogie Centres	6	0
Total Wheel Base, Engine and Tender	43	2¼
Boiler Pressure	160lb.	
,, Barrel, Length	10	4
,, ,, Diam. Outside, mean	4	2
Firebox, Length Outside	6	6

No. of Tubes	244
Diam. of Tubes	242 = 1⅝in. 2 = 1½in.
Heating Surface—	
Tubes	1125·5 sq. ft.
Firebox	117· ,,
Total	1242½ ,,
Grate Area	19·6 sq. ft.
Weight—Working Order, Engine	43 tons.
,, On Drivers	17½ tons.
Tender Capacity, Water	3,250 gallons.
,, ,, Coal	3½ tons.
,, Weight in Working Order	30 tons.
Average Train Load	170 to 215 tons. Equal 9 to 13 carriages.
Scheduled Speed	53½ miles per hour.
Coal per mile	20 to 23 pounds.
Longest Run, without stop	124 miles.

Undoubtedly this engine, of which there are now quite a large number at work on the Midland line, is the finest locomotive at Paris, and far and away superior to anything exhibited by continental makers in every respect. The foreign locomotives are specially characterised by an infinity of complications in their valve gearing, and by extremely awkward and uncouth arrangements, and in these respects they adhere to the characteristics which are discarded for others of English origin by some continental makers of stationary engines who have been successful in competing with us.

One locomotive we notice, a fine engine of the Cie de L'Ouest Railway of France, is specially noticeable as having almost entirely discarded the usual complication of parts, and this one engine is very similar to an English locomotive, and is proof that a change is impending. We are not disposed to be too critical concerning the appearance of the majority of foreign locomotives exhibited, nor even to criticise unfavourably the square or rectangular chimney of the engines sent by the John Cockerill Co., especially as these chimneys are said to be satisfactory in practice; but we certainly are of opinion that the enormous multiplication of joints about a valve gear exposed to the grit and dust which is so marked a feature on continental and American lines is most undesirable and unnecessary. It would appear as if the crowding in of links, radial bars, &c., were absolutely necessary, to so great an extent has it been carried, and the contrast to the simple severity of the English engines is very striking.

The Midland engine has a steam sanding arrangement for adhesion purposes.

The engine shown by the South-Eastern Company, from their works at Ashford, is a 19in. by 26in. four wheels coupled. Its firegrate area is 16·78 square feet, and firebox heating surface 103·5ft. It has 202 tubes of 1⅝in. diameter, and 10ft. 8in. long, having 917ft. area, or a total heating surface of 1020·5.

The boiler is 4ft. 4in. in diameter, and the engine weight in working order is 41½ tons, distributed as follows: Bogie, 13 tons 8cwt.; driver, 15 tons 5cwt.; coupled driver, 12 tons 17cwt.; tank capacity, 2,650 gallons; coke capacity, 3½ tons. A special feature in this engine is the steam reversing gear, operated as follows: A combined steam and oil cylinder, like a Westinghouse air-pump in external appearance, and with both pistons on one rod, actuates a lever fixed direct on the reversing shaft. This is fixed immediately forward of the main driver. Steam is admitted to either side of the steam piston by a simple movement of a lever in the cab. The opening of the steam valve opens also a communication between the two ends of the oil cylinder, and this allows the steam cylinder to move and actuate the reverse. When steam is shut off the oil passage is closed by the same movement of the handle, and the oil, being incompressible as water, holds the gear rigidly in position. A rod, jointed to the reversing arm, actuates a pointer in the cab, which indicates the exact position of the link block, and when the pointer indicates the desired point of cut-off in forward or backward gear, a single short movement of the driver's handle to cut off the steam fixes the gear absolutely at the desired position.

There is thus absolutely no labour in moving the gear, the lever being a few inches long only, and the whole gear entirely free from complication or danger of becoming disordered. A very small steam cylinder is sufficient to move the gear, and the fatigue to the driver is entirely abolished. This is the neatest and best steam reverse gear it has been our pleasure to see.

Mr. Stroudley's London, Brighton, and South Coast engine has, as said before, forward coupled 6½ft. wheels, with 18¼in. by 24in. cylinders, and a tractive force of 110 pounds per pound of mean pressure. It has 333 tubes of 1½in. diameter, and a tube-heating surface of 1378·2ft., whatever that may be worth as obtained from tubes. Its really useful heating surface is 113·9 in the firebox, making a total of 1492·1.

The grate area is 20·65ft., and the wheel loads are as follow:—

	Ton.	Cwt.	Qr.
Forward driver	13	16	0
Main ,,	14	10	0
Trailing wheel	10	8	0
Engine total	38	14	0
Tender	27	7	0
Total	66	1	0 in working order.

The locomotive of the Ouest Cie., above named, is of the following dimensions:—

Cylinder	460 × 660 millimetres (18¼in. × 26½in.)
Traction	6 6 kilos. (92½lb.)
Driving wheels	2·040 metres coupled (6ft. 8¼in.)
Load on bogie	18,500 ks.
,, F. drivers	14,800 ks.
,, T. ,,	14,500 ,,
Total	29,300 ks.

Other interesting locomotives shown at Paris are No. 1 locomotive, the old four-coupled engine from the pedestal in front of the North-Eastern Railway Station at Darlington; the original Rocket of George Stephenson, of the Manchester and Liverpool Railway, or rather now from South Kensington Museum; and an old engine dated 1803, of Trevithick's, the same which was shown at Liverpool and Manchester in 1886 and 1887, and which, we believe, commenced life as a locomotive. In the special building devoted to the exhibit of Messrs. Cail et Cie., is a Crompton locomotive from the Nord Railway of France, with rear driving wheels of large dimensions, and which has now been in continuous work for forty years, and is yet in good order, a very good example of the soundness of the principle advocated by Crompton. These old locomotives are far removed from the Machinery Hall, where all the new engines are to be found, and are not very likely to be seen unless specially looked for.

The Rocket locomotive and Trevithick's engine are just to the right of the coloured fountains when entering from the Trocadero. Cail's exhibit is to the right of the main building, near the large gun, and is closed at or about 5 p.m.

ON GAS ENGINES, WITH DESCRIPTION OF THE SIMPLEX ENGINE.

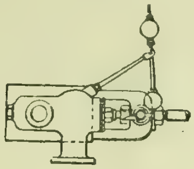
(Continued from page 565.)

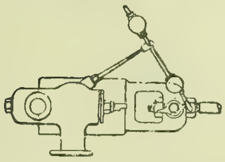
Air Governor—This consists of a pump barrel mounted on the slide, and moving to and fro with it; in this barrel is a piston made perfectly tight by packing rings. The rod of this piston is attached to the cover of the slide, and consequently holds the piston stationary; it is fixed to the piston by means of two indiarubber washers, which allow of a slight oblique motion, to compensate for the movement of the cover against the slide. At the end of this pump barrel is mounted a micrometer screw with a conical point, which affords the means of throttling, in a greater or less degree, the square hole communicating with the outer air. Near this end of the air pump, on its side and at right angles to it, is placed another little cylinder communicating with it at its lower end. In this second cylinder moves freely a small piston, the rod of which carries at its end a steel knife-edge. Between this knife-edge and the piston is a spring, tending to keep the piston down on its seat; this piston is moved up and down by means of a semicircular nut. The outer end of the knife-edge controls the valve for admitting the gas when the small piston is down on its seat.

The action of this governor is as follows. If the engine is running at, say 200 revolutions, the slide will be driven at a speed of 100 revolutions, and the large air pump will suck and force 100 cylinderfuls of air through the square hole at its extremity. Supposing that the micrometer screw is adjusted so as to allow only these 100 cylinderfuls of air to escape through the annular space partially closed by its conical point, then so long as the normal speed of 200 revolutions is not exceeded, the small piston will remain on its seat, and the knife-edge will encounter the gas admission valve and open it at each stroke to form the explosive mixture. If from any accidental cause the speed of the engine is increased, and the slide makes, say, 101 strokes, the piston of the air pump will suck and force an extra cylinderful of air, and as this cannot escape by the square hole, it will raise the small piston and its knife-edge, so as to miss the gas valve and fail to open it. No explosive mixture being formed, there will be a missfire, and the speed of the engine will be reduced. The governor is very sensitive, and will be very applicable to any further adaptations of the gas engine to boats or locomotives, as it will work equally well in any position, independent of level.

Pendulum Governor (Figs. 10 and 11).—For stationary engines another form of governor is recommended, as it is cheaper, and not liable to damage. This governor is based on the principle of the pendulum, but the method of its application is new, the essential novelty being that the pivot of the pendulum is absolutely fixed, and that the pendulum itself falls by its own weight alone, so that the time of its fall is invariably the same. It is composed of two weights fixed on a rod, in the middle of which is a pivot.

Fig. 10.





IG. 11.

This pivot is carried in a bearing fixed on the cover of the slide. The heavier weight, of lenticular form, is naturally placed at the bottom. The lighter weight, which is above the bearing, is of spherical form, adjustable by means of two nuts threaded on the upper part of the stem. By raising or lowering this smaller weight, the lenticular weight, at the bottom of which is fixed a steel arm provided with a notch, is balanced to a greater or less extent. On the slide is fixed a stem carrying an oscillating frame with two knife-edges, one of which at a given moment encounters and opens the gas valve, while the other and smaller knife-edge engages with the notch of the lenticular weight. Besides being heavier, the larger knife-edge is furnished with a spring, tending to cause the frame to swing below the stem of the gas valve, which it only opens when the frame is brought into a horizontal position.

The action of this arrangement is as follows. Supposing the normal speed of the slide to be 100 strokes per minute, the spherical weight must be so adjusted as only partially to balance the lenticular weight, so that its rate of fall may synchronise with that speed. At the moment of the back stroke of the slide, the small knife-edge engages with the notch of the pendulum. Then the slide makes its forward stroke, and the notch being still in gear brings the pendulum to bear with all its weight against the small knife-edge, the swing-frame oscillates, and becomes horizontal. The larger knife-edge encounters the gas valve and opens it, and the explosive mixture is formed. Should the slide travel at slightly accelerated speed, it will return in a shorter time than before; the small knife-edge will miss the notch, as the pendulum will fall in the same time as before, and its weight will not bear on the swing frame, which will remain in an oblique position and fail to open the gas valve; no explosive mixture will be formed, and the engine will slow down to its normal speed. It is evident that this governor is a very sensitive one, as the knife-edge and notch will hit or miss according to the fall of the pendulum, which must occur always in exactly the same time. There is no wear of parts, and the speed is regulated by simply adjusting the upper or spherical weight, which can be done while the engine is running.

Various modes of starting.—For engines of small size, not exceeding 10 H.P., starting is a very easy matter; a turn of the flywheel draws a charge of the explosive mixture into the cylinder and compresses it, ignition takes place, and the engine starts at once. This statement refers of course to the Simplex type of engine, in which ignition is effected as easily at a slow as at a high speed; but with other types starting is a much more difficult matter. Up to 10 H.P. one man can turn the flywheel and produce compression; beyond that size, and in proportion as the engines become larger, the number of men becomes a serious consideration, and for many years inventors have taxed their brains to discover some handy method of starting. A few of the more important of these schemes may be mentioned, but no good purpose would be served by describing them all.

The simplest of these plans was to store up in a separate receiver, during the time that the engine was running, a sufficient charge of explosive mixture, which when ignited at the proper moment would serve to start the engine. This plan unfortunately was open to two grave objections; the tightness of the retaining valves could not be ensured, and after a certain time the gas lost its pressure. There was besides the risk of serious accidents from the bursting of the vessel containing the explosive mixture, and the danger from this cause led to the discontinuance of the plan.

Other makers employed the pressure of the exhaust gases. This obviated the danger of bursting the vessels, but the leakage of the valves still remained, and it often happened that just when it was wanted there was no pressure left in the cylinder, and starting was impossible. Compressed air, springs, and other devices of a more or less practical nature were tried and abandoned, and a small auxiliary motor was at length adopted as the only reliable plan. This system is incontestably effective, but it is expensive, and for engines of any considerable size it costs as much as a small additional engine, besides the singularity of employing one engine to start another. With engines of still greater power the auxiliary engine itself becomes so large as to need a second smaller one to start it; so that the whole system would be strongly suggestive of a show card of various sizes of engines.

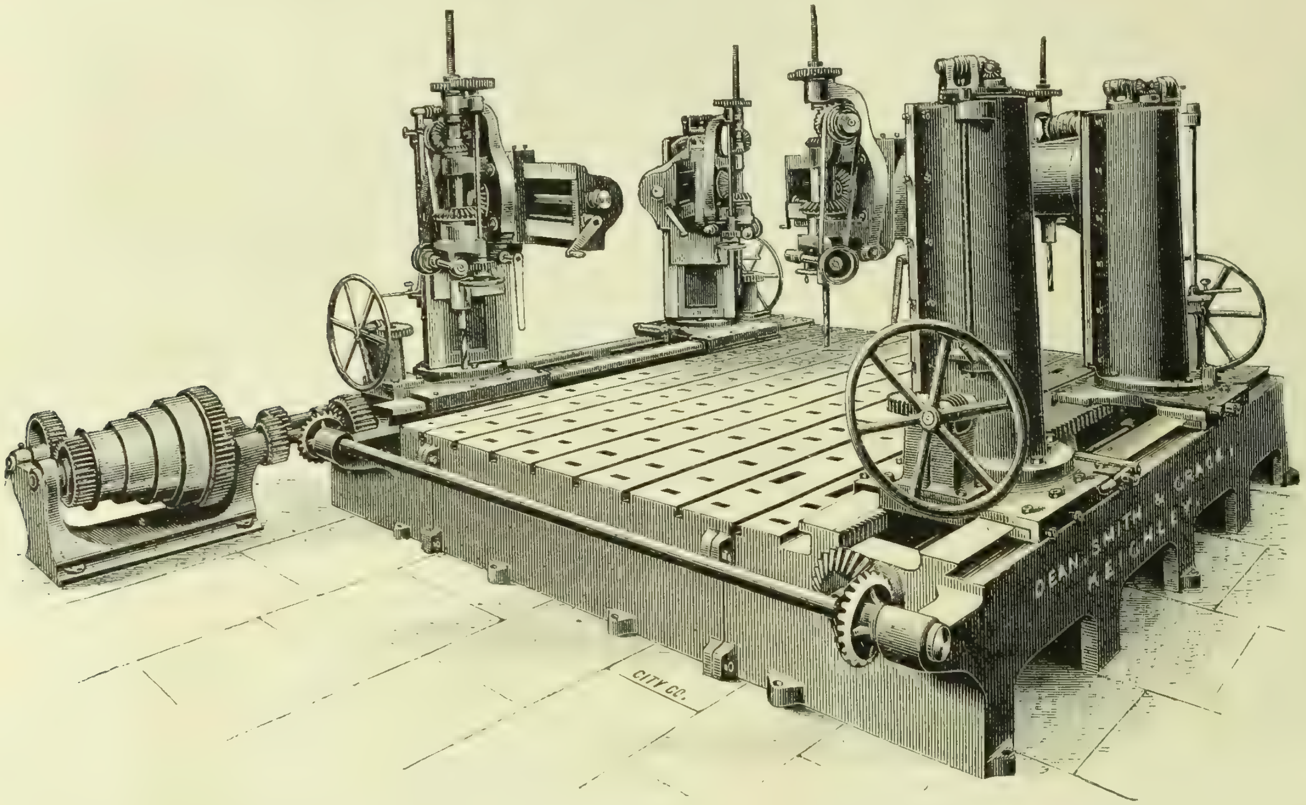
It is only recently, and after protracted research, that a satisfactory method of starting has been worked out; and it is the special method of ignition employed which has rendered its adoption easy, and its operation certain. The arrangement for engines of 20 horse power and under will first be described, and its increased simplicity for engines of larger power will then be pointed out.

For an engine of 16 H.P., for example, a small gas pipe furnished with a three-way cock is fitted on the igniting apparatus; an admission passage for gas traverses the barrel, and a small hole of suitable section communicating with the outer air is pierced in this passage. An indiarubber tube connects this gas pipe with the gas supply of the engine, and at the point of junction is fixed a small graduated cock (which may be called the gas cock), the degree of opening of which regulates the proportions of the explosive mixture. The method of starting is as fallows: The engine must previously have been stopped at the ignition point, which is easily done by means of the three-way cock. The induction coil is fitted with a contact-breaker which interrupts the flow of sparks between the platinum points. When this is done the three-way cock is first opened, and then the gas cock to the marked position. The flywheel is slowly turned to draw in the explosive mixture, which enters the cylinder through the seating of the porcelain stop. When the piston has made two-thirds of its stroke, the three-way cock and gas cock are closed. Then the plug of the large gas cock used when the engine is running is turned, and set at the position convenient for starting. The flywheel is turned backwards to compress the charge, the current switched on, the spark produced, the charge ignited, and the flywheel receives an impetus sufficient to start it. For motors of 20 H.P. and under, it is necessary to compress the charge slightly (as just described) because the passive resistances are proportionately great; but with larger engines this is not necessary, and the operation is as follows:—

A small pet-cock is fixed on the cylinder above the compression chamber, forming a communication between its interior and the outer air. The engine must be stopped, not at the point of ignition, but somewhat in advance, with the crank at an angle of 90 deg., which, as before described, is easily done by means of the three-way cock. This piston has then made about half its

QUADRUPLEX ANGULAR RADIAL DRILLING MACHINE.

CONSTRUCTED BY MESSRS. DEAN, SMITH, AND GRACE, ENGINEERS, KEIGHLEY.



stroke; the gas cock is opened to the marked position as before, as is also the three-way cock. As the gas is under slight pressure, it enters the cylinder through the seating, and draws in air with it by the small oblique hole. The explosive mixture thus formed gradually fills the space behind the piston, expelling the burnt gas by the cock at the top of the cylinder, which must be opened previously to that for the admission of the gas. In about a minute (for a 50 H.P. engine) the cylinder is full of explosive gas, and the cock above the cylinder, the gas cock, and the three-way cock are then closed. As before, the large gas cock is opened to the starting position, the current switched on, the charge ignited, and sufficient impetus given to the flywheel to start the engine. By this method the large engines which have now been at work more than a year are started with the greatest ease.

(To be continued.)

QUADRUPLEX ANGULAR RADIAL DRILLING MACHINE.

We illustrate here a very convenient machine constructed by Messrs. Dean, Smith, and Grace, engineers, Keighley, consisting of four radial angular drilling machines, mounted above a strong planed worktable. The table is 14ft. long by 9ft. 6in. by 2ft. 3in. deep, and carries upon each side a strong slide bed, upon which move the columns carrying the radial arms. Each of these arms can swing on the column through 45 deg. by worm and wheel gear, and each has a travel vertically of 15in. by power. Each column moves along the slide bed by a large handwheel, worm and wheel, and also rack motion. Further, each arm carries a drill carriage, which can also swivel through 45 deg., and is traversed along the arm by screw handle. The drilling spindles are of steel, 2¾in. diameter, with vertical traverse of 15in. travel on radial arm 4ft. 1½in., and radius of extreme sweep 6ft. 3in.; rectangular surface covered 11ft. 8in. long by 7ft. 9in. wide, and admit from spindle to worktable 1ft. 4½in. The machine will drill holes up to 2½in. diameter out of the solid 15in. deep. It is driven by means of a four-speed cone and powerful treble gear. Any one drilling spindle can be stopped and started independently. The machine is a most useful one where many holes have to be accurately drilled in a casting, and admits of rapid action and easily attained accuracy of adjustment.

THE DOOM OF STEAM.

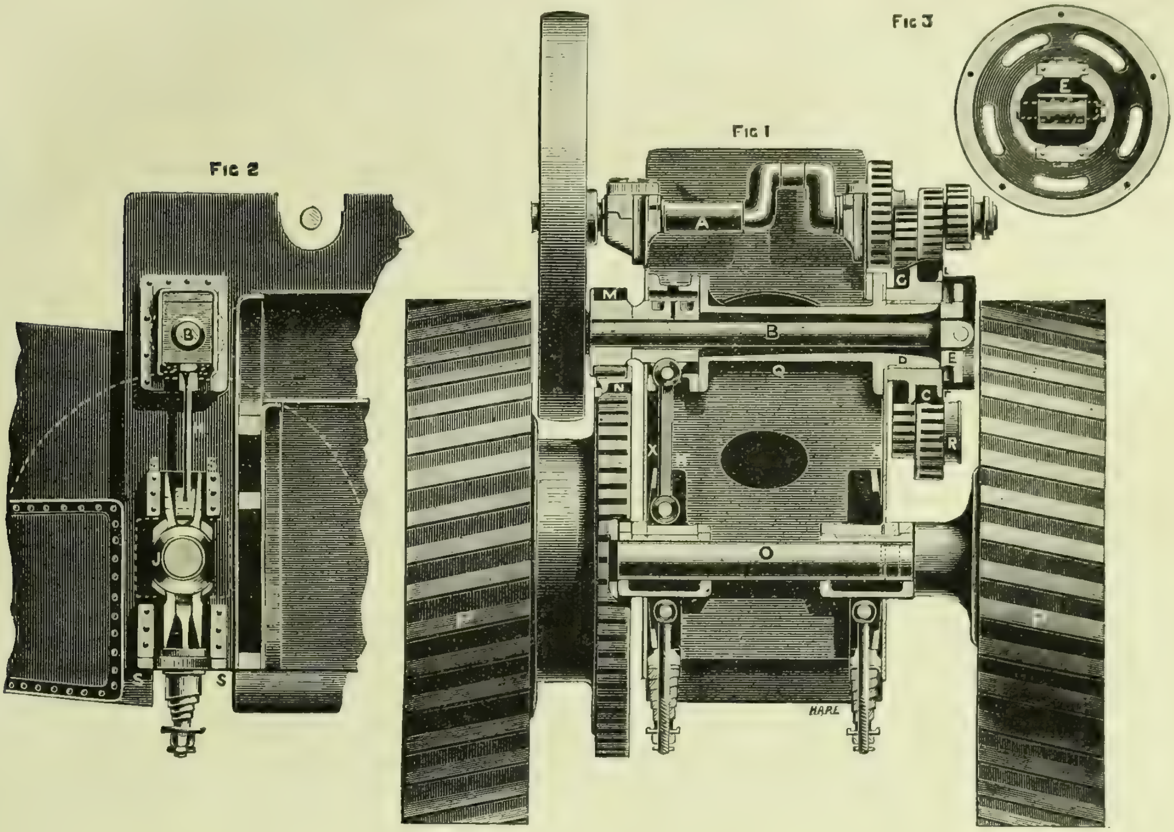
"The great development in electricity will be, I am firmly convinced," said Mr. Edison to an interviewer in Paris, "in discovering a more economical process of producing it. At present we only get from coal consumed about four or five per cent of its latent electricity. The rest is wasted in heating water, expanding steam, pushing pistons, turning wheels, and finally causing a dynamo machine to operate. A process will ultimately be found for extracting 90 to 95 per cent of the latent electricity directly from the coal. Then steam engines will be abolished, and that day is not far off now. Already we can get electricity direct from coal to the amount of 90 per cent, but only for experimental purposes. When I was on shipboard coming over I used to sit on deck by the hour and watch the waves. It made me positively savage to think of all that power going to waste. But we'll chain it up one of these days, along with Niagara Falls and the winds. That will be the electric millennium."

PETROLEUM BEDS OF UPPER BURMAH.

The *Burmah Gazette* contains the following account of a survey of the petroleum beds of Upper Burmah by Dr. Fritz Noetling, of the Geological Survey:—"The oil wells of Yenangyoung, or more properly Twingoung and Bemé, have long been famous, but hitherto there has been the greatest discrepancy in the various accounts of their number and productiveness. The field at present contains 524 wells, but of these only 281 are productive; and Dr. Noetling estimates the daily yield to be at the very least 15,000 viss, or 450,000 viss a month (a viss is about a gallon), a remarkable confirmation of the estimate of Major Storrer, published in 1871, which put it at 4 lakhs of viss a month. The output, however, is nothing to what it might be with proper methods and appliances. The oil-bearing strata consists of soft sandstone, which the Burman, with his primitive tools, digs through at a great expenditure of time and labour. In no case does he get lower than 310ft., leaving nearly 100ft. of the oil-bearing stone, the richest portion of the field, wholly untouched. Under other conditions, Dr. Noetling estimates that the production might be raised to 50,000 viss a day. This gives 18¼ million viss a year, or about half the total importation of both Russian and American oil in 1887-88.

PATENT SPRING ARRANGEMENT FOR TRACTION ENGINES.

CONSTRUCTED BY MESSRS. CHARLES BURRELL AND SONS, ENGINEERS, THETFORD.



In the *Practical Engineer* for 12th July last, we illustrated an eight horse power spring traction engine, shown at the Windsor meeting of the Royal Agricultural Society by Messrs. Chas. Burrell and Sons, of Thetford. We now have pleasure in giving an illustration showing the spring arrangement in detail, which we shall describe presently. For a long time Messrs. Burrell have kept the important problem of mounting traction engines on springs constantly before them, and more than thirty years ago their chain traction engines were mounted upon spiral springs fitted into the axle boxes. This type of engine proved a favourite in many districts because of its lightness, and economy of fuel and repairs. Many of these engines are still in use, and are doing excellent service on the farms in Norfolk, Suffolk, Cambridgeshire, &c.

It is well known that the mounting of chain-road locomotives upon springs is a very simple matter, but the application of springs to a spur-geared traction engine is a more difficult one, hence some of the plans hitherto introduced have been much too complicated to be of real service. It is not only necessary to arrange the details so that the up and down motion of the main axle, when passing over rough roads, shall not affect the pitch circles of the spur-driving gear, or interfere with the proper action of the compensating apparatus; but it is equally important that the springs should be free to act, without being influenced by the transmission of the power through the gearing. The patent spring arrangement illustrated was introduced by Messrs. Burrell at the Newcastle-on-Tyne Show of the R.A.S.E., 1887, and has been fitted to engines during the last two years, and given satisfaction. The range of the springs is sufficient to allow the engine to be driven at high speeds over ordinary highways. We are informed that, as the speed of the engine is increased, the vibration appears to be reduced, and the engine runs as smoothly as a carriage.

For use in towns, where the jar of the engines would cause damage to property near which they had to travel, this invention is invaluable, for even when running past at a high speed there a marked absence of all trembling of the ground; but of course the chief advantage of an engine being efficiently mounted on springs is the great saving in wear and tear. Fig. 1 gives an end sectional view of a traction engine through the axle and countershaft carriages, shewing the arrangement of the springs. Fig. 2 is a longitudinal section. These illustrations are so clear that very little description is needed. The main axle O, in fig. 1, is supported in axle boxes of the usual type, except that the load is carried by springs arranged underneath, having lock-nuts to adjust the range or compression, as shown. It will be seen that the axle box and the countershaft bearing on the main gearing side are coupled by a link H, shown in both figs. 1 and 2; therefore, the pinion M and the spur wheel N rise and fall together, due to the action of the springs. The spur wheels C C revolve on a sleeve D, see fig. 1, and they drive the countershaft B through a universal joint, as shown by fig. 2; therefore, the rising and falling of the countershaft does not affect the gearing. It will be seen that Messrs. Burrell have introduced a practical and satisfactory method of mounting spur-geared traction engines on springs, without any additional complication.

CORROSIVE ACTION OF SEA WATER.

An interesting series of experiments have recently been carried out by the Dutch State Railways, for the purpose of ascertaining exactly the relative resistance of various pigments to atmospheric changes and to the corrosive action of sea water. The results have proved that the red-lead paints are less affected by atmospheric influence than those which are composed of the brown oxides of iron, on account of their adhering more closely to the metal, and of their possession of greater elasticity. It was also discovered that any sort of paint afforded an increased protection if the plates were pickled in hydrochloric acid before its application. The prevention of corrosion by salt water was found to be possible by the admixture of the oxide of some electro-positive metal, such as caustic lime and soda; but the efficiency of such a covering diminished when its alkaline properties had been neutralised by the absorption of carbonic acid. Magnesia, however, was proved to be the most serviceable, seeing that it does not absorb carbonic acid; and not only does it protect the iron from galvanic action, but it also does not affect the anti-fouling qualities of the paint.

BIRMINGHAM COMPRESSED AIR POWER COMPANY.

THE half-yearly meeting of the Birmingham Compressed Air Power Company was recently held at the offices, 25, Waterloo Street. Mr. H. Wright (chairman of the company) presided, and the other directors present were Messrs. W. Harris, H. L. Müller, and R. H. Taunton. The report, which was taken as read, stated that since the date of the last report the third engine had been completed. The three engines had been worked alternately for testing purposes and for an experimental supply of air power to customers. The working of the gas producers, boilers, engines, and water-cooling arrangements not having come up to the high standard of expectation, the engineers and contractors had agreed on, and had in hand, such improvements as experience had suggested. Those would be carried out without interfering with the delivery of the air power which might be required. The mains now laid amounted to about 4¼ miles, ranging from 2½in. to 7in. in diameter. The largest sizes, nearest to the works, would be large enough for any increase in the extension of the smaller mains. Further extensions were suspended until it was found in what direction they might be required. A regular supply to customers was commenced on 1st July last. There were fourteen works now connected with the mains, and taking a regular supply. The committee were in communication with twenty-three other firms who had expressed their desire to use air power; but most of them postponed its application until an efficient meter had been decided on. Existing customers were arranged with on the basis of their present steam power, pending the adoption of a meter. The question of an efficient meter was not yet definitely settled. During the past half-year trials had been continuous, and from those it was hoped to be able to select one which could satisfy requirements. It would be impossible to make any accurate estimate of the income or profits until the supply to customers was registered and paid for by meter. The most careful approximate estimate which could at present be made led to the expectation of a moderate dividend so soon as the public took the produce of two of the compressor engines, which it was expected they would do in a short time. The balance sheet showed that the capital outlay up to the present time, exclusive of work in progress, had been £104,243 8s. 6d.—The Chairman, in moving the adoption of the report, said the company was now in active operation, although on a small scale. So far as they had gone they had given complete satisfaction to their customers, and the application of air power he had no doubt would rapidly extend in the district that was allotted to them. At present they had thirteen customers, who were using the compressed air daily. One of these customers was a wiredrawer, one a bedstead manufacturer; four were engineers, machinists, or ironfounders; one a mediæval brassworker, one metal tube manufacturer, one brassworker, one gimlet manufacturer, one shovel manufacturer, one glass decorator, and one tallow melter. The glass decorator used the compressed air for blowing sand for engraving purposes, and he found that by using the air it obviated the necessity of arranging a blow-pipe. The directors were in communication with twenty-three other firms, who were unwilling to take the power until they could make definite terms with the company for supplying by meter. As soon as terms could be arranged those firms would take the power, and he had no doubt others would follow. When they had succeeded to the extent of giving full employment to two engines out of the three—it was their intention always to keep one engine in reserve for fear of accident—there would be in all probability a margin of profit which would enable them to declare a dividend which, if not large, would be satisfactory. As compressed air could be used in almost every trade, he had every confidence that the number of their customers would gradually grow, and that the company would be a successful one. In Paris 5,000 clocks were worked by the compressed air company. Instead of the weights of the clock being wound up, the air supplied to them worked them properly and effectively. Air, too, in Paris was used for an enormous number of small purposes, and he might mention also that it was used to work the dynamos for electric lighting. It was said that about 8,000 electric lights were supplied entirely by means of dynamos worked by air power. There would ultimately be an extension of the use of air power in a similar direction, he had no doubt, in this country, and he hoped that their business would improve to the extent of enabling them speedily to employ another engine. If they had three engines working and another in reserve, their profits would be larger, and a more satisfactory dividend would be declared, because the material increase in their business would involve but a very slight increase in the expenditure. In reply to questions, the Chairman said the receipts from the customers at present amounted to about £1,800 per annum, and if the twenty-three firms referred to in the report were added the receipts would be increased by about £3,200, thus raising the total takings to about £5,000 per annum. The mains were laid down in the streets to the works, and he believed the whole of the twenty-three firms would become subscribers in a short time. After their working expenses were paid they would have from £8,000 to £10,000 working capital. If they had full work for an engine—and they would very soon—he thought the total amount of their expenses would be about £4,000 a year. Against that would be the revenue, which ought to amount to £5,000 or £6,000. An additional £2,000 would cover the outlay for working a second engine, and then, as their business increased and more engines were added, their profits would be larger. The directors would do all in their power to keep down the expenses, and as an earnest of their determination in that respect he might inform the meeting that they had decided to reduce their fees from £1,200, at which figure they were orginally fixed by the shareholders, to £900 per annum.—Mr. W. Harris seconded the resolution, which was carried, and the meeting terminated with a vote of thanks to the chairman for presiding.

EXPLOSION OF A COPPER PIPE AT DEPTFORD.

THE frightful catastrophe on board the steamship Elbe some time ago will still be fresh in the minds of our readers, and a widespread interest in the strength and testing of copper pipes was occasioned by that accident. Mr. Woodthorpe has written a valuable report to the Board of Trade, which is just issued by them, on the late explosion at Deptford, Kent, by which one man was killed and ten others injured. As it well illustrates the difficulties of constructing copper pipes for high pressure, and proves the necessity of the greatest care and further investigation, we publish it here in an abridged form.

The casualty occurred at 11-35 a.m., on the 9th April, at the works of the London Electric Supply Corporation, Limited, Stowage Wharf, Deptford.

The pipe which gave way was a "bend" or "elbow" of copper, the inner radius, at the throat of the bend, having been about 10¼in., and the distances from the faces of the flanges to the intersection of the centre lines through the two portions of the bend, which were at right angles, were respectively 4ft. and 1ft. 6in.

The internal diameter was 9in., and the original thickness of the sheets from which the elbow was manufactured was ¼in., but this had become slightly reduced in the working at various parts. The copper was supplied by Messrs. Williams, Foster, and Co., Swansea—this firm has since sold the business to a limited company—and the bend was made from two strips, 4ft. 7in. by 1ft. 2⅝in. by ¼in., and 5ft. 6in. by 1ft. 2⅝in. by ¼in. respectively, the latter, being the longer, forming the back of the bend.

The sheets having been shaped to form the two sides of the bend, the edges were thinned, by hammering, to form the scarf of the joint, the length of lap, according to the usual practice of the firm, being about ⅝in. The two parts were then drawn together by wrought-iron clamps, or by strong wires, and then brazed. In the latter operation two coppersmiths were employed, one to look after the inside, and the other to watch the bottom of the seam over the fire. The seams were cramped in two places in order to assist in keeping the laps together as much as possible during the brazing. After the pipe was brazed, it was planished, and the flanges were then brazed on. The flanges used were $15\frac{15}{16}$in. diameter externally, $9\frac{9}{16}$in. internally, and ⅞in. thick, the proportion immediately surrounding the pipe being 1½in. deep; eight 1⅛-in. holes were drilled in each flange. The position of the bend which failed is shown on fig. 2 (F), and figs. 3 and 4, p. 604, give views of this pipe after the occurrence of the explosion.

The spelter used was composed of copper and zinc in the proportion of eight parts of the former to seven of the latter.

The pipe was made by Messrs. Isaac Storey and Sons, coppersmiths and brassfounders, Knott Mill, Manchester, and was one of four similar bends supplied by them to Messrs. Hick, Hargreaves, and Co., Soho Ironworks, Bolton, which firm is constructing the extensive machinery now being laid down at the Deptford Works of the Electric Supply Corporation.

The elbow, before being sent from Messrs. Storey and Sons' works, was, it is stated, carefully examined and subjected to hydraulic pressure. One flange is marked "360lb. test press, E. 13, 14," and is intended to be a record of the test, which does not appear to have caused any defect to exhibit itself.

The copper bend failed close to the brazing for a length of 15½in., near the middle portion of the pipe; the fracture, after extending at either end through the unbrazed portion of the copper, ran partly round the flange, and then, for a distance of 8in., again ran parallel to the seam at one end, as will be clearly seen from fig. 4. The pipe was drawn out of its lower flange, which was bolted to the cast-iron pipe (marked A on fig. 2), and the latter, by the reaction of the issuing steam, was violently displaced, in consequence of which the piers which had supported three of the horizontal lengths of cast-iron piping were overturned and two of the pipes were fractured as shown, the steam continuing to be discharged at B until shut off at the boilers.

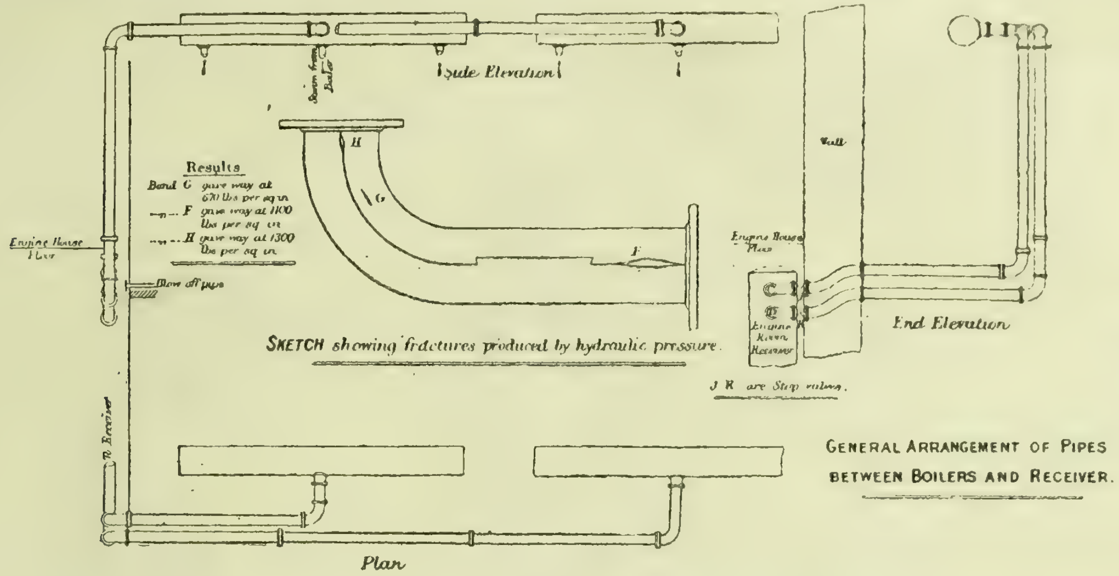
The destruction of the bend was complete, and, as far as I am aware, the failure exceeds in extent that which has been recorded in any previous instance where a copper pipe has given way. I am of opinion that the presence of water in the range of piping was the immediate cause of the explosion. The workmanship in the copper elbow was, however, very defective, and although the bend was designed to possess a nominal factor of safety of about ten, it is extremely probable that it would soon have failed, under steam, at the working pressure.

Whether or not the elbow, had it been well made, would, on the occasion of the explosion, have resisted the pressure within it, cannot be decided with the data now obtainable, but there is reason to think that the pipe would have stood had it been originally sound.

General Remarks.

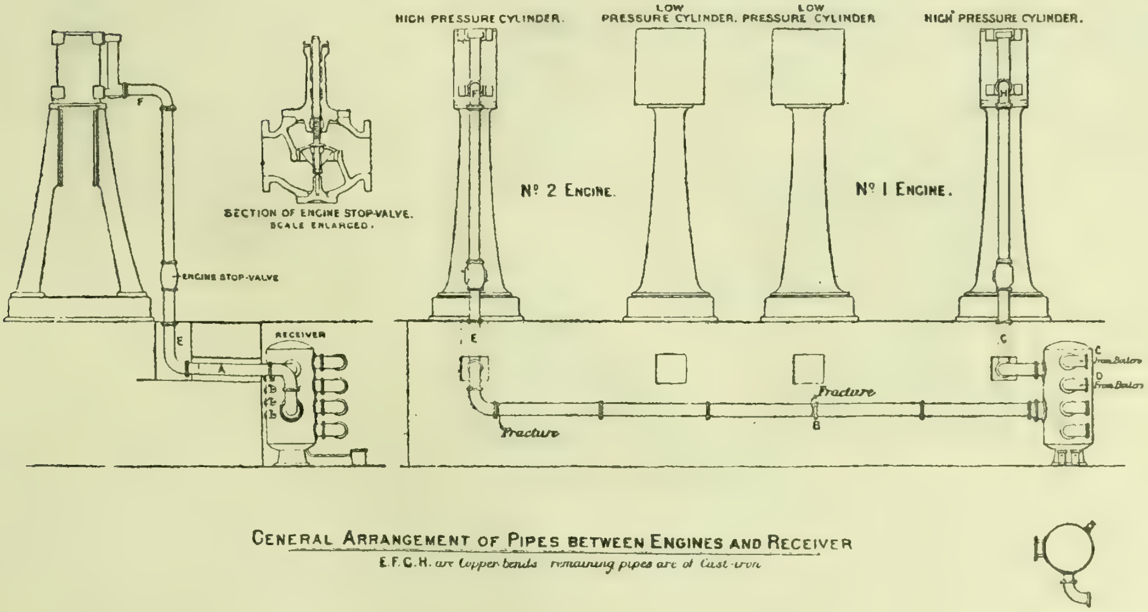
Of the extensive plant which is being laid down at Stowage Wharf, Deptford, for the purpose of generating electricity to light the City and

West End of London, 12 boilers and two engines have been erected, but although the principal portions of the work have been placed in position, they are not yet in a finished condition. All the boilers have been supplied by the Babcock and Wilcox Company, and the safety valves are to be loaded to 200lb. per square inch. Each boiler is fitted with a stop valve, and pipes from these are led to wrought-iron drums, one drum being fitted for each battery of three boilers. A range of steam pipes is led from each drum to what is called a receiver, placed in the basement of the building. The arrangement of pipes from the boilers are shown on fig. 1, which also gives the positions of the stop-valves fitted on these pipes near the receiver. With the exception of the short curved pipes attached to these stop valves, which are of cast iron, and of the bends, which are of copper and brazed, the remainder of the pipes now referred to are of wrought iron, about ½in. thick, having their flanges screwed on and subsequently brazed. At the time of the explosion steam was being supplied by six boilers, three of which were connected to the "receiver" (see figs. 1 and 2) at C and others at D, the total lengths of the steam-piping intervening being about 57ft. and 90ft. respectively, and the vertical distances between the centres of orifices on receiver and those of the upper horizontal portions of the pipe being 21ft. 10in., and 23ft. 10in. in the two cases. It is stated that the curved pipe near the receiver was tested by *employés* of the Electric Supply Corporation, and the other pipes and bends between the boilers and "receiver" were fitted by them, but were said to have been tested by the Babcock and Wilcox Company, by whom they were supplied.



GENERAL ARRANGEMENT OF PIPES BETWEEN BOILERS AND RECEIVER.

FIG. 1.



GENERAL ARRANGEMENT OF PIPES BETWEEN ENGINES AND RECEIVER

E.F.G.H. are Copper bends remaining pipes are of Cast-iron

FIG. 2.

The two sets of engines were manufactured by Messrs. Hick, Hargreaves, and Co.; they are compound and fitted with Corliss valve gear on both cylinders, the latter being 28in. and 56in. in diameter, with a stroke of 4ft. Each set of engines is intended to drive a large dynamo, and is designed to work at 180lb. pressure per square inch, and at 70 revolutions per minute, to indicate 1,500 H.P. Fig. 2 shows the general arrangement of steam-piping. It will be seen that copper bends are fitted at E, F, G, and H, but the remainder of the piping is of cast iron, extending from the "receiver" to the high-pressure cylinders, the difference in height, where the pipes are connected to these, being fully 26ft. The lower horizontal pipes were supported by brick piers, one under each length, a small iron roller being placed between the pipes and piers to enable the former to move freely, as their lengths varied with the temperature. The cast-iron pipes between the receiver and the bend E (the failure of which is the subject of this inquiry) were 10in. in bore and about 1in. thick, the flanges being $1\frac{3}{16}$in. thick, and connected by ten 1in. bolts. The piping above the bend E was 9in. in bore.

No drain pipes were fitted at any part of the ranges of steam-piping, but to the bottom of the receiver two automatic traps were connected by ¾in. gas piping; these were the only means provided for freeing pipes and receiver from water.

The receiver and the piping between that and the high-pressure cylinder were supplied and fitted by Messrs. Hick, Hargreaves, and Co., and the copper bends were introduced with a view to better provide for the effects of expansion in each range of piping. With respect to the thickness and workmanship, extracts from correspondence which passed between the makers of the engines and Messrs. Storey and Sons show that those concerned were alive to the necessity of using great care in the operation of brazing and of employing copper of sufficient thickness.

Mr. Henry Storey, a member of the firm who made the copper bend, stated: "I do not know that we have made any tests of copper. We generally take 30,000lb. in our calculations. I have no data as to any pipe we might have tested to destruction. I have examined the bend which gave way. I do not think the work is perfect; it is not as good as it might be. Had we known it to be in the condition it was we most certainly would not have allowed the pipe to be used in any work. The pipe failed through the brazing for a length of about 15in. From the appearance of the fracture, I conclude that a flaw, extending to about half the thickness, existed. I think it was possibly caused in hammering after the brazing."

It would accordingly appear that nothing suspicious was detected in the outward appearance of the finished bend, or the latter would not have been allowed to leave Messrs. Storey's works. Had it, however, been examined with care, I think some of the defects might have been discovered, although these may in some cases remain hidden. There is good reason to believe that more reliable work would be produced if the manner in which a pipe resists internal stress were better understood by coppersmiths generally.

As it appeared after the explosion, the inferior quality of the workmanship was most evident. Considerable portions of both seams were very open, the spelter having run through, and the effective thickness of the copper at the fractured joint was reduced, in consequence of this and the seam having "drawn," to about $\frac{1}{12}$th inch. At one part, where a flaw existed on the outside of the inner lip of the scarf, the thickness of copper remaining did not exceed $\frac{1}{32}$nd inch.

The fracture at the part where the elbow first gave way presented a ragged appearance. Covered on the inside by a thin streak of spelter, the copper, which did not exhibit the characteristic silky appearance, but was more or less granular and without lustre, had a thickness varying from $\frac{1}{32}$in. to $\frac{3}{16}$in. in the length of 15½in., where the rent followed the outside edge of the seam, the latter being open in several places. Adjacent to the copper was the coarsely granular lip of the outside lap. This had been fused in many places, and was, for the greater part, covered with the spelter which had run through the joint while over the fire. The seam on the inside was also considerably open at different parts. The lower flange which had been blown off had, clearly, been but slightly attached to the pipe; it appeared to have been brazed at the upper edge, but the brazing of the remaining part of the flange next the pipe was defective, and it required little examination to see that the brazing of the other flange was also very unsatisfactory.

With regard to the part which yielded first, it is evident from its appearance that the seam had "drawn" while over the fire, and that the outer lip of the scarf had been in some places washed away by the molten spelter, the free zinc in which would rapidly combine with the copper, and form an alloy whose melting point would be considerably lower than that of pure copper. The seam while being brazed was, doubtless, heavily charged with spelter, and the man who was watching the inside of the pipe should have become aware that the spelter had "drained" or run through. The second man, who closed up the joint with an iron "paddle," which protects the seam from the heat of the fire, and thereby temporarily stops the "draining," should also have seen that the joint was defective, for it is apparent that the outer lip of the scarf was severely injured, as pointed out.

No. 1 engine had been tried under steam before the day of the explosion, and in this way, since the pipes were in free communication, steam was on one or two occasions within the bend which exploded, the pressure ranging from 45lb. to 120lb. per square inch.

On the day of the explosion steam was admitted to No. 2 engine for the first time, at 10-20 a.m., and the engine was kept running, for about 20 minutes, at about 35 revolutions per minute, the pressure varying from 75lb. to 85lb. per square inch. At 10-50 a.m. No. 1 engine was started, the pressure rising from 100lb. to 135lb. per square inch, and the revolutions being 65 to 70 per minute. This engine was stopped a little before 11-30 a.m.

About 11-35 a.m., the pressures on the boilers being 152lb. per square inch, preparations were made to again start No. 2 engine. It had been "barred round" four or five times by a small engine fitted for

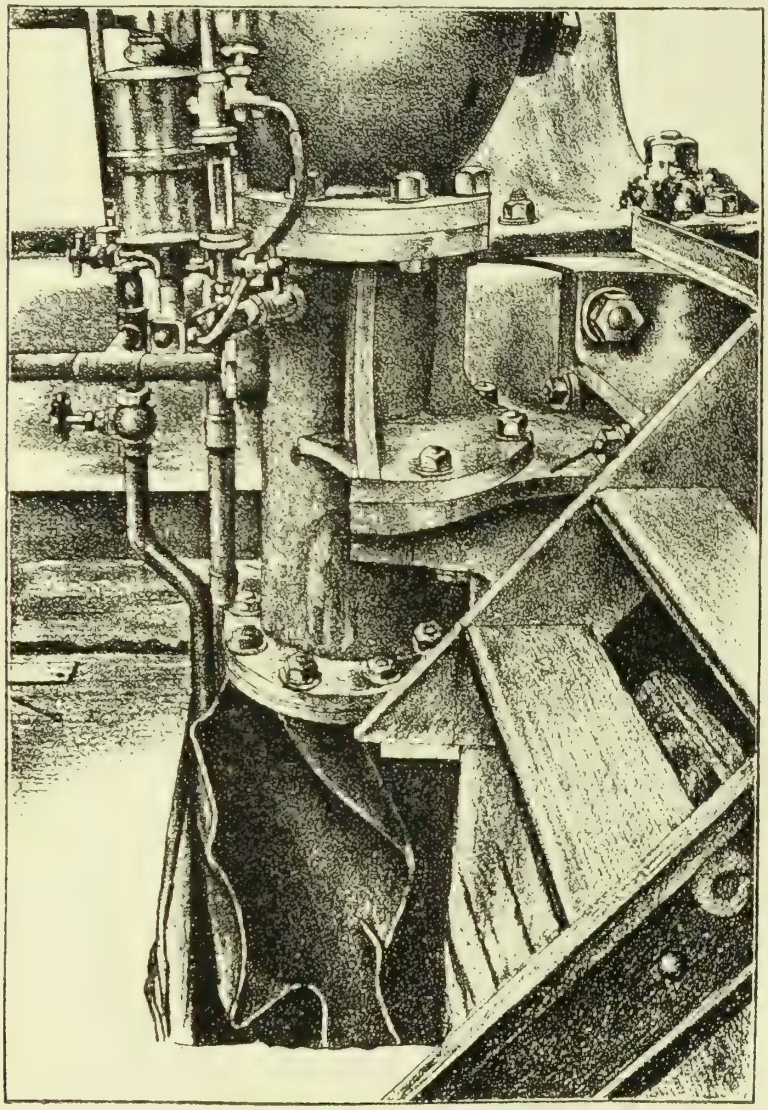


Fig. 3.

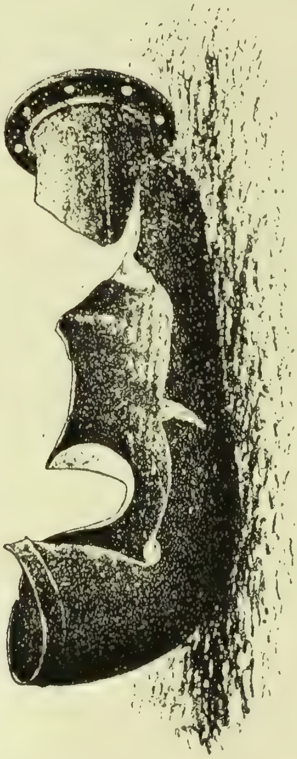


Fig. 4.

that purpose, and Sharrocks had just commenced to open the engine stop valve when the explosion occurred.

The bend had been, altogether, subject to steam pressure for about 4½ hours, the pressure varying from 45lb. to 152lb., the latter pressure being on the pipe for a short time only. The construction of the stop valve referred to will be seen from fig. 2. On turning the wheel the small valve is first lifted, but the large valve is not lifted until the spindle has revolved twice, and the small valve moved through a distance of half an inch.

(To be continued.)

HEAT ENGINES OTHER THAN STEAM.—II.

(*Continued from page 587.*)

In the steam engine, if it is double-acting, such a series of operations is usually completed in each revolution of the engine for each end of the cylinder; that is to say, once for each end, or in one "in" and one "out" stroke of the piston. The engine at the commencement of one stroke, say the "out" stroke, receives the steam; the piston moves forward; the steam is cut off, and, the piston still moving forward, the steam expands; the piston getting towards the end of its stroke, the exhaust valve, or port, is opened (connecting with the condenser, if it is a condensing engine); the piston completes the stroke, then moves backwards till the "in" stroke is complete, and steam is again admitted.

This succession of operations is called a "cycle." We shall see that the cycles of different forms of heat engines vary considerably. In all indicator diagrams the "cycle" is represented by the continuous line enclosing a space, whose height, as I have said, at any point represents the pressure existing at that part of the length of the stroke.

As I shall have to compare the relative performances of some of the various kinds of heat engines used for power purposes, it will be as well that I should give some description of the mode which is adopted in making tests of these performances. For a thoroughly complete and detailed account of such a series of tests, it seems to me that I cannot do better than refer you to the report of the judges on the electric motor trials, published in the *Journal* of the Society of Arts for the week ending the 15th February last (No. 1,891).

I will not trouble you with the description of the mode adopted in making a complete test of a steam engine (this mode being practically based on that used by Sir Frederick Bramwell and Mr. Anderson at the trials of engines made for the Royal Agricultural Society at their Cardiff meeting many years ago), but will ask you to examine the trials of gas-engines, as being more germane to that we have to consider. Trials of such engines as these, to be satisfactory, must give an absolute record of the quantity of gas consumed in the engine itself, and, in the case of those engines using gas for the ignition of the explosive mixture, this should also be measured, and, if possible, separately. Samples of the gas should be taken at frequent intervals during the trial, which samples should be afterwards analysed, so that the calorific value may be accurately ascertained. The pressure and temperature at which the gas is supplied to the engine must be measured; indicator diagrams should be taken at frequent intervals throughout the "run;" the power given forth by the engines should be absorbed by some reliable brake, the load which this puts upon the engine, or, in other words, the resistance which this opposes to the motion of the engine being accurately ascertained; the temperature and quantity of the cooling water must be measured, not only as this water flows to the motor cylinder, but also as it leaves it; the number of revolutions of the engine throughout the whole run should be recorded, and the average number per minute, at frequent intervals during the run must be taken as a check; the run must occupy a sufficient length of time to eliminate any errors arising from heating up the mass of metal of the engine; and, lastly, every instrument used throughout the trial should have readings taken from them at very frequent intervals, and these instruments should all be calibrated and tested for accuracy, both before the trials are made and after they are concluded.

Further than this, a trial of sufficiently long duration should be made with the engine running with its utmost load on, *i.e.*, exerting the utmost power which it is capable of exerting; another trial should be made with the engine running at about half-power; and a third with the engine running "light;" the above records being taken for each trial, and the results of each used to verify or check those obtained in the other trials. The exact diameter of the cylinder and stroke of the piston should be obtained, and any peculiarities in the construction of the engine, or in its working during any one of the runs, should be recorded. Experiments should also be made to determine the value of the control of the governor when the work is suddenly taken off the engine.

Having run your trials, and obtained all the information here suggested, and anything else which you can possibly think will be of the slightest value, the question arises how to state, so as to be readily comprehended, that which has been learnt, or, in other words, how to "boil down" the mass of information thus obtained, so as to make the performance of the engine readily comparable with that of other engines.

The commonly accepted way of doing this nowadays is by showing the results of the performance of the engine on a balance-sheet (as on this page); *i.e.*, you debit the engine with so many units of heat delivered to it (these units being contained in the quantity of coal used to stoke the boiler furnace, or in the number of cubic feet of gas which your gas meter tells you has been supplied to the engine during the trial), and you credit the engine with the number of units which have been turned into work, with the number of utits passing away in the exhaust, with the number of units passing away in the jacket water in a gas or petroleum engine, and with any other loss which there may be; and by this means you are able to tell exactly, and at a glance, what proportion of the total heat units delivered to the engine has been effectually utilised by it, and what proportion of the total heat units is represented by each particular head of loss.

BALANCE SHEET OF MESSRS. DAVEY, PAXMAN, AND CO.'S SIMPLE ENGINE.

Dr.	Units.	Cr.	Units.	Percentage.
To the heat developed in furnace:—		By heat expended:—		
In the combustion of wood:		1. In evaporating the water in the wood and heating its steam to 385°	9,557	·32
From Carbon	79,331	2. In heating the wood and the air required for its combustion from 70° to 385°	3,884	·13
„ Hydrogen	4,816	3. In evaporating the water in the coal and heating its steam to 385°	8,374	·29
In the combustion of coal:		4. In heating the coal and the air required for its combustion from 70° to 385°	129,321	4·44
From Carbon	2,481,400	5. In displacing the atmosphere by the products of combustion of the wood and the coal with the air needed for their combustion	53,394	1·83
„ Hydrogen	337,475	6. In heating the excess of air	130,980	6·34
„ Sulphur	9,071	In displacing the atmosphere by the excess of air	53,509	
		7. In evaporating the water in the boiler	2,090,300	71·78
		8. In radiation and convection	271,307	9·32
		9. In ashes and unconsumed fuel	53,915	1·85
		10. Unaccounted for	107,552	3·70
	2,912,093		2,912,093	100·00

In the motor trials for the gas engines, the judges adopted the plan of calculating for each explosion, or for each working stroke of the engine, its proportion of the total heat units, and they turned these into their value in foot-pounds of work, and then compared these with the foot-pounds per explosion, represented by the indicator diagrams; those represented by the heat rejected in the jacket water, and those represented by the heat passing away in the exhaust; coupled with the slight amount due to other losses, these three principal heads of use and loss represent the total heat units per revolution supplied to the engine.

Turning these into percentages, it will be found that in the Atkinson gas engine (of which we shall have to speak later on) the heat turned into work, as shown by the indicator diagrams, was 22·8 per cent; the heat rejected in the jacket water was 27 per cent, and the heat rejected in the exhaust, lost by imperfect combustion, and otherwise unaccounted for, make up the balance of 50·2 per cent.

In the Crossley engine, the heat turned into work was also 22 per cent, and in the Griffin engine was practically as much—that is to say, is represented by the red cube which we used last week.

I think I have now sufficiently explained the theoretical portions of our subject, and that we may devote the rest of our time to investigating the practical results which have been obtained.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

GAS ENGINES AND SAMUEL BROWN.

We reprint a letter addressed to our contemporary the *Engineer*, from Mr. H. G. Harris, on Samuel Brown's gas engine, which will interest our readers :—

Sir,—I have read the letter from Mr. Hyde Clarke, published in the last issue of your journal. While thanking Mr. Clarke for the valuable and interesting information given therein as to Brown's gas engine, and what it could do, I should like to point out that between 1807, when the gas engine of M. de Rivaz—not M. de Rivur, as either the printer or Mr. Clarke has called it—and 1860-1, the date of Lenoir, there were numerous suggestions for gas engines, many various kinds were constructed and tried, some of them with a certain measure of success; but the time at my disposal for the lectures was limited, and it was not necessary to refer to these engines except when some special feature in connection with them still survived, as in the case of Barnett.

However, it might have been better if, instead of using the phrase, "noteworthy practical success," I had said, "noteworthy commercial success," and this would probably have prevented the shock to Mr. Clarke's patriotism. I will take care that in the reprint of the lectures, which the Society of Arts propose at once to issue, this alteration is made.

It may be of interest if I state that a full account of Brown's engine can be found in the book of Mr. Dugald Clerk, on "The Gas Engine," to which I several times referred. The engine is there called "a gas-vacuum engine," and is described—see page 2—as "a very cumbrous machine for the amount of power produced. A partial vacuum is produced by filling a vessel with flame, and expelling the air it contains, a jet of water is thrown in and condenses the flame, giving vacuum. The atmospheric pressure thus made available for power is utilised in any engine of ordinary construction." H. G. Harris.

5, Great George Street, Westminster, S.W.,
August 19th.

QUERIES AND REPLIES.

73. **Process for Cooling Water at Coates' Mill.**—I shall be obliged for any particulars of the process for cooling water to be employed at Messrs. Coates' new mill, at Paisley.—Lever.

Answer.—The quantity of water to be dealt with at Messrs. J. and P. Coates' mill, Paisley, is about 3,000 tons per hour, from engines of a total of 12,000 I.H.P. The cooling apparatus consists of a wrought-iron girder frame, 635ft. long, 24ft. wide, and 30ft. high, carried on concrete piers. The hot condensed water from the engines flows into a well, and will be pumped to a tank in the centre of the frame; from which tank it escapes into troughs leading to sprinklers, then over lath work to subdivide it minutely and expose large cooling surface to the air. From this it falls into the reservoirs cooled.

81. **Bolts for Flange.**—In making a flanged joint fluid tight by means of bolts and nuts, what considerations should be taken into account in estimating size, number, and strength of bolts to be used? The fluid pressure being 100lb. per square inch, total amount of separating force due to pressure 10 tons, and length of flange measured along pitch line of bolts being 6ft., what should be the diameter and number of bolts?—C. P. W.

Answer.—In making a flanged joint fluid-tight by means of bolts and nuts, the considerations which are generally taken into account are: (*a*) The intensity of the fluid pressure, which in a measure limits the distance between the bolts, and in connection with (*b*) the area of the surface exposed to the fluid pressure determines the total pressure or separating force which has to be resisted by the bolts. (*c*) It is necessary for the purpose required that we know the total length of bolt flange, so that we may arrange the number of bolts, and therefore their distance apart between certain prescribed limits of maximum and minimum pitch, which latter is generally given as a multiple of the diameter of the bolts used. (*d*) In order that we may determine the amount of tension which each bolt may be subjected to, it is necessary for us to know the effective area of the bolts used—*i.e.*, the area at the bottom of the thread, and to fix upon a value for the working stress which is to be allowed on the material of the bolt. The data given are as follow :—

Intensity of fluid pressure 100lb. per square inch.
Total amount of separating force due to pressure = 10 tons = 22,400lb.
Length of flange measured along pitch line of bolts, 6ft. = 72in.

Then, assuming that the working stress should not exceed 4,000lb. per square inch, and that the bolts used are made to Whitworth standard, then area at bottom of thread of

½in.	Whitworth screw	= ·121	sq. inch area or	·394in.	dia. at bottom of thread
⅝in.	,,	= ·204	,, ,,	·509in.	,, ,,
¾in.	,,	= ·304	,, ,,	·622in.	,, ,,
⅞in.	,,	= ·422	,, ,,	·733in.	,, ,,
1in.	,,	= ·554	,, ,,	·840in.	,, ,,

We may now select one of the above sized bolts, and by a series of trial and error calculations obtain a result to suit our requirements; but the writer prefers to approximately estimate the minimum diameter of bolt at the bottom of the thread, from the formula

$$d = \frac{\text{eight times the separating forces in pounds,}}{\text{working intensity of stress} \times \text{total length of flange in inches.}}$$

Therefore,

$$d = \frac{8 \times 22{,}400}{4{,}000 \times 72} = \cdot\dot{6}2\dot{2}\text{in.},$$

which is equivalent to a ¾in. bolt (at the bottom of the thread). The number of bolts will therefore be $\frac{22{,}400}{4{,}000 \times \cdot 304} = 18\cdot4$; that is to say, 19 bolts will be required, and their pitch will evidently be $72 \div 19 = 3\cdot8$ nearly, which is about five times the nominal diameter of the bolt—a very fair proportion. The answer to the question would be, therefore, 19 bolts ¾in. diameter.—Omicron.

83. **Stern-tube Bearing.**—What should be the diameter of the stern-tube bearing for engine of 4,000 horse power, making 90 revolutions per minute?—C. P. W.

Answer.—A propeller shaft going at 90 revolutions per minute is required to transmit 4,000 horse power. The diameter D of the shaft bearing in inches is required. Presuming the shaft to be of wrought iron, and the radius of the crank orbit in feet say equals R, while P equals the average power in lbs. applied at the crank pin. Whence $90 \times 2 \times 3\cdot1416 \times R\,P = 4000 \times 33000 = 132000000$, and $90 \times 2 \times 3\cdot1416 = 565\cdot488$. And $R\,P = \frac{132000000}{565\cdot488} = 233420$. Allowing a safety factor of 8, which is perhaps not more than sufficient considering the sudden and severe strains to which the shafts are subject, we have a co-efficient of 100. Therefore $RP = 233420 = 100\ D^3$, whence $D^3 = 2334\cdot20$, and $D = \sqrt[3]{2334\cdot20} = 13\cdot3$in. nearly.—W. A.

Answer.—I beg to inform "C. P. W." that for 4,000 indicated horse power the stern shaft should be about 14in. diameter, as given by the following formula—

$$\sqrt[3]{\frac{64\ \text{I. H. P.}}{\text{Revs.}}}$$

J. R.

80. **Book on Locomotives.**—Can any of your readers inform me of the best book on railway locomotives—chiefly Midland Railway locomotives?—W. B.

82. **Oscillating Engine.**—If CP be the crank and PQ the piston rod of an oscillating engine, find the velocity ratio of P to Q, and set out result in diagram. Find also the angular velocity ratio of CP and PQ at any point of stroke.—C. P. W.

84. **Brake Straps on Cranes.**—What is the usual method of calculating the breadth of brake straps on ordinary cranes?—W. R.

85. **Morton's Ejector Condenser.**—Can any of your readers give me a description of Morton's Ejector Condenser, with a sketch, if possible?—Crankum.

86. **Working Drawing of Crane.**—Will you kindly permit me to ask any of your readers if they could give me information as to where I could get a working drawing of a crane; also, if there is a book published on shading?—J. H.

87. **Diameter of Piston Rings before Cutting.**—In the case of cast-iron piston rings of equal thickness, *i.e.*, where the inside and outside circumferences are concentric, could you give me the diameter of the ring before being split, in terms of the diameter of the cylinder? Also, where the ring is ⅛in. thicker in the middle than at the split ends, what would be the diameter of the ring before being split? A text-book I have says $\frac{1}{16}$ larger diameter than the cylinder, but this seems to me excessive.—H. V.

88. **Hughes' Patent Packing.**—I am anxious to know the principle of Hughes' patent packing for piston rods. A sketch would much oblige.—Athalia.

89. **Cement for Joints of Iron Pipe.**—Will some reader kindly state the best kind of cement for the joints of iron pipe in connection with a stove? Putty has been used, but with very unsatisfactory results.—Ignoramus.

TO CORRESPONDENTS.

Subscriber, Haslingden.—Your suggestion for an aerial system of electric transport is impracticable in the form you give it. It would be impossible to utilise telegraph lines for the purpose. The late Professor Fleming Jenkins devoted much attention to the subject, and perfected a system which he called "Telpherage." There are two such lines at work now, one at Glynn, and a model "Telpher" railway at the Birmingham Electrical Exhibition. The "Telpher" system can never equal the ordinary railway system, and was intended by its inventor only as a feeder to the main lines.

D. W. M.—You will find full information as to calculation of wheels required for screw-cutting in our answers to queries in the past few weeks.

D. S., Drayton Park.—You had better not experiment on dynamo-winding; the system you describe would not act well for an armature. It would be impossible to go into the matter of armature-winding here, but you will find full information in many good text books. You will find it better to purchase accumulator cells from the E. P. S. Co. than attempt to make plates for yourself. There are many practical difficulties.

Student, Cornholme.—Write to Secretary, Marine Department, Board of Trade, London, or apply to any of the numerous teachers of navigation in Liverpool.

Amicus, Widnes.—In a steam pipe 40ft. long and 1½in. diameter, at 40lb pressure, there will be no loss of pressure with the steam at rest. It depends entirely on the discharge area of the injector in use whether the fall in pressure is great or small with the injector at work.

T. H. B., Liverpool.—We are much obliged for pamphlet on Colour Blindness, which we shall carefully read.

J. B. W., Newton-le-Willows.—If a pump be attached to a hermetically-sealed cistern, which is quite filled with water, it will be impossible for the pump to draw from that cistern. The term "suction" is by no means accurate, but it is intended to denote the fact that when a piston is moved in a cylinder a "suck" is produced in a pipe attached to that end from which it is moving. Suction (so called) is due to the pressure of the atmosphere, which forces into any space whose pressure is reduced below atmosphere. In pumping from a well the pressure of the atmosphere forces the water up the supply pipe after the movement of the pump reduces the pressure within.

MISCELLANEA.

There is a North British engine with a history, viz., the one that ran the last train over the ill-fated Tay Bridge in December, 1879. After lying at the bottom of the river Tay for three months it was recovered and partly rebuilt, and may now be seen at work on the Glasgow and Dunfermline traffic.

A new gravity railway is proposed for Fairmount Park, Philadelphia. On the new road the passenger cars will be drawn up the plane by powerful electric motor cars of over 60-horse power each, which will be entirely separate from the regular cars, and will run up and down the inclined plane only, there being no use for them elsewhere.

Proposed Electric Railroad.—It is stated that a private company has been formed with the intention of constructing an electric railway from the town of Lanark to Hamilton, the motive power to be obtained from Stonebyres, one of the series of the Falls of Clyde. The object is to afford the people of Lanark a more direct journey to the city *viâ* Hamilton than by way of Carstairs Junction. The capital has, it is said, been subscribed.

Electric Lighting in Newcastle.—A special meeting of the Newcastle Town Improvement Committee was held on August 26th, to take into consideration the alterations made by the Board of Trade in connection with the proposals entered into between the Corporation and the two electric lighting companies. These, we understand, will be adjusted, and the actual carrying out of the work contemplated by the companies be soon carried into effect.

Messrs. J. & A. Churchill hope to publish in September an important work on Fuel and its Applications, by Dr. E. J. Mills, F.R.S., and Mr. F. J. Rowan. It will be the first volume of a large work on Chemical Technology of which Mr. C. E. Groves, F.R.S., will be the general editor, and which will be founded on one written by Richardson and Ronalds, familiarly known as Knapp's Technology. Messrs. Mills and Rowan's work on Fuel is in reality a new work, in which the applications of fuel to arts and manufactures as introduced by the most modern discoveries is given to the scientific world. The volume is profusely illustrated.

National Association of Blast Furnacemen.—A two days' conference of delegates connected with this association, and representing 4,500 men, was concluded at Middlesbrough on August 16th. It was resolved to divide the area of the association into two districts, each with separate officials, and to have full control over its funds and management. A central executive, with power to deal with all questions affecting the general welfare of blast furnacemen, was appointed. The headquarters of the association remain at Middlesbrough. An office for the Cumberland district will be opened at Workington.

Cooking by Electricity.—The *Electrician* says that the Hotel Bernina, at Samaden, has for some time been lighted with electricity, power being supplied by a waterfall. As during the day this power is not required for lighting, and is therefore running to waste, the proprietor of the hotel has hit upon the idea of utilising the current for cooking when it is not required for lighting, and an experimental cooking apparatus has been constructed. This contains German-silver resistance coils, which are brought to a red heat by the current; and it has been found possible to perform all the ordinary cooking operations in a range fitted with a series of such coils.

Artificial Leather.—Dr. George Thenius, of Vienna, has invented a process for the manufacture of artificial leather from red beechwood. The best wood for the purpose is taken from fifty-eight to sixty years old trees, cut in the spring, which must be worked up immediately, bark peeled off, steamed, treated with chemicals in a kettle under pressure, and exposed to several more operations which the inventor does not mention, as he wants to have them patented. From the prepared wood, strong and thin pieces are made by means of heavy pressure. The inventor states that a solid sole leather can be obtained, which he claims is superior to the animal leather in firmness and durability, and can be worked up in the same way as animal leather, nailed and sewed.

A Steel Railway Carriage.—It is stated that an American inventor has nearly completed a novel railway carriage. The distinctive feature of the carriage is the fact that it is all iron or steel. The roof, sides, and ends are made of steel boiler plates riveted together, and it is nothing more nor less than a big boiler. It is not quite round, however, being somewhat the shape of a horseshoe—the round part being the top. In the bottom it is said are several steel girders packed in cement, much the same as in the Pullman carriages. Along the sides is an array of windows precisely similar to those of an ordinary passenger carriage. The top of the car is destitute of the heavy roof and ventilating arrangement that is seen on ordinary carriages. It is said that ventilation is to be secured by pumping air into the coach through pipes. These pipes in winter will furnish warm air. There is also a system of ventilators around the windows. The inventor says that it will not burn up, it will last longer, it will not telescope in a collision, and it is cheaper.

Discovery of Mines in Sweden.—A company which was formed this year for the purpose of prospecting the district of Gellivara, in Sweden, has discovered extensive mines of argentiferous lead, copper, manganese, graphite, and iron to the north of Gellivara, and at no great distance from the railway. The lead ore, which exists in great abundance, is said to contain more silver than that found in the celebrated Sala Mines, and is pronounced by experts to be the richest ore of the kind hitherto found in silver. Gold sand has also been met with in some of the mountain streams. About 30 years ago some Russian geologists obtained 5lb. of gold and some platina in the same neighbourhood after working a few weeks, but the washings were abandoned, owing to the Government insisting that the Russians should become Swedish citizens. The copper mines at Skrikerum, which had not been worked since 1832, have recently been re-opened, under the management of Professor Blomstraud, of Luna, and Dr. Rudelins. It was in these mines that selenium was first discovered by Berzelius in 1817.

Wave Motors.—The idea of utilising the force of the waves and tides to actuate motors has been a favourite one with many inventors, and a practical application is now in operation at Ocean Grove, New Jersey, U.S.A. This is the wave motor invented by Mr. N. O. Bond, consisting of a series of swinging gates, submerged to some extent at all tides, a rod at the top of each gate actuating the piston of a pump for elevating water. Each incoming wave strikes the gates and swings them inward, thus operating the pumps. The gates are secured at the top to steel rods, whose ends oscillate in bearings formed by two piles. These bearings were well greased, but after the gates had operated for some time the bearings were examined, and it was found that none of the lubricant had been used up; consequently, the inventor thinks that it will only be necessary to erect the apparatus in a substantial manner, after which it can be operated without expense. Each gate is 12ft long, and it was found that the force acting to move the gates inward was about 500lb. per square foot in a calm, and 800lb. in heavy surf.

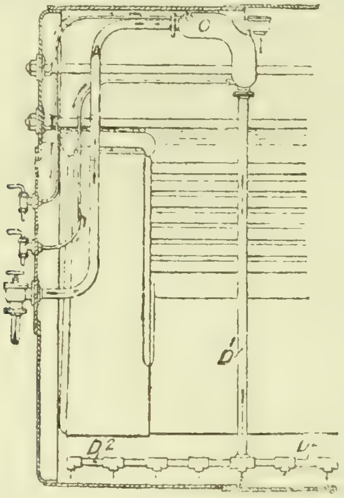
Improvements in Odessa.—A Moscow correspondent says that for several years past Odessa has been the principal shipping port for the vast quantities of grain which come from Bessarabia, the Crimea, Poltava, Kiev, and Kharkov, and the shipments from that port are now at least 12 times more important than they were 50 years ago. Last year 120,000,000 poods were despatched from Odessa, and the facilities for shipment are not utterly inadequate to the requirements of the trade. It is, therefore, intended to extend the mole which shuts in the harbour on the north-east side, and to construct upon it a series of grain elevators which will be accessible to ships of heavy burthen. A railway is to be laid down in the neighbourhood of the Andrassow Quay to within about 100 metres of the mole, and this space will be spanned by a bridge constructed at a sufficient height above the water level to allow large vessels to pass under it. Below the railway vast granaries are to be constructed and arranged in such a manner that 22,000 bags of grain can be easily discharged in ten hours. There will be 48 cylindrical grain elevators on the mole, each 50 metres high, with an internal diameter of 15 metres, and will be constructed of iron. It is stated that the South-Western Russian Railway Company is willing to contribute £800,000, and the Government half that sum, towards the undertaking.

Death by Electricity.—An inquiry is now being held by the Supreme Court of the United States as to whether execution by electricity will be painless and certain. According to Mr. Myron Law, the superintendent of the electrical department of the Brush Electric Company, Philadelphia, the enforcement of the death penalty by means of electric currents would not only be agonising beyond conception, but would also be barbarous in the extreme. He cites a few instances of the pain felt by those who have received severe electric shocks. Six years ago one of his men, named John Smith, cut an electric wire which he thought to be "dead." Standing on the ladder, with one hand the man grasped the ruptured wire, which fed 48 lamps, and had a current of 2,200 volts passing through it. With the other hand he held by means of plyers the other end of the wire. Immediately he made most heartrending screams for help. His hands were riveted fast, and his whole body was undergoing terrible contortions. The electric current of a strength of 2,000 volts was passing through his body and pinned him to the spot. A rope was thrown over his hands, and he was jerked from his perilous position. Both his hands were burned terribly, and his whole system was shattered. When he had sufficiently recovered, a few days later, to be able to walk and talk intelligently, he said that his sufferings were terrible beyond description. Another man in the employ of the Philadelphia company once received the full force of a current of several hundred volts. In removing his hands from the wire, one of his fingers dropped off, having been burnt almost to a cinder by the current. During the accident his face showed in a frightful manner intense pain, and his body was in a constant tremor. Of course, electricity can instantaneously kill a person, but in that infinitessimally small space of time of the transition from life to death the person will suffer inconceivable pain. Although the speed of electricity is 286,000 miles per second, the killing cannot be so instantaneous as to preclude all pain. Every particle of the nervous tissue is polarised, and polarisation causes each particle of matter to revolve on its axis, which means the stretching of the nerves out of all proportion, and consequently the most intense pain.

ILLUSTRATED PATENTS.

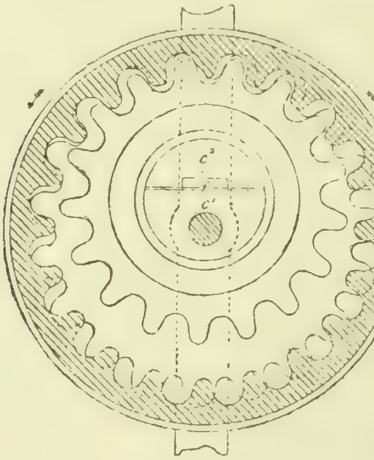
3957. Steam Boilers, J. Gilmour, 17, Oswald Street, Glasgow.

Feed water is supplied through the pipe A, to a chamber C supported in the steam space of the boiler. In this chamber the feed is heated, mixed with steam, and conducted through the pipe D^1, and perforated cross-piece D^2, to the lowest portion of the boiler for water circulating purposes. By extending the pipe D^1 upwards into the feed-heating vessel C a sediment chamber is formed between the pipe and the lower portion of the vessel. In a modification the latter appears as an open trough-shaped chamber, along which the feed flows before entering the down pipe. For primarily raising steam a donkey engine would be employed to extract water from one portion of the boiler, and to deliver it to the heating chamber, steam being admitted to the latter by an independent pipe.—March 14, 1888. [8½d.]



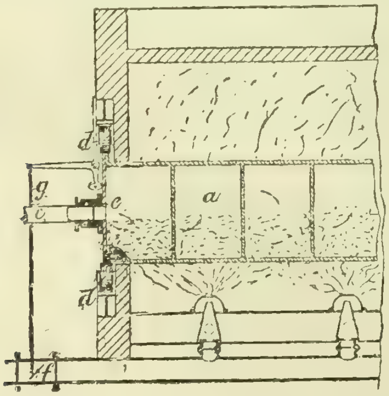
4085. Differential Pulley Blocks, W. Wood and T. Wrightson, Teesdael Ironworks, South Stockton-on-Tees.

In blocks of the class illustrated, the eccentric is formed of separate parts C^1, C^2 in order to take up the wear by inserting liners at the point f.—March 16, 1888. [8½d.]



3967. Oxygen and Nitrogen. A. Brin, 59, Brompton Crescent, London, S.W.

Relates to apparatus to be used in the extraction of oxygen and nitrogen from atmospheric air by means of baryta, consisting of a cylindrical retort a, heated by carbonic oxide and air; and rotated by any suitable means on rollers d. The retort is divided into compartments by partitions, these being perforated alternately at the top and at the bottom, so that the baryta is completely acted upon by the air during peroxidation, or by the vacuum during deoxidation, as the baryta is alternately raised up and let fall in consequence of the revolution of the retort. A tube c is provided for the air, being connected to the rotating retort by a metallic spring washer e. To automatically regulate the temperature, the valve f in the carbonic oxide supply pipe is operated by a lever g, the other end of which bears against the head of the retort, and is operated by the latter as it expands or contracts under the action of the heat. The retort is protected on the outside by a layer of asbestos and potassium or sodium silicate.—March 14, 1888. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

August 6th.

12403 Governors, W. C. Morison, Suffolk.
12405 Furnaces, H. W. Whiting, London.*
12408 Casting Metals, M. R. Moore, London.*
12409 Condensing Apparatus, M. Blumrich, London.
12411 Injectors, T. Sweeney, London.*
12415 Drite Screws, C. D. Rogers, London.
12417 Wood-screws, C. D. Rogers, London.*
12424 Propellers, L. Vallet, London.
12426 Propulsion of Vessels, H. Lobdell, London.*
12429 Driving Bands, E. R. Hyde and R. C. Horner, London.*
12432 Connecting Shafts, J. L. Huber, London.
12433 Condensing Smoke, J. T. Ellis, London.*
12447 Gas Engines, H. Hoelljes, London.*
12460 Treatment of Smoke, S. Elliott, Newbury, Berkshire.
12467 Valves, R. T. Baines and W. N. Baines, London.
12472 Gas Engines, W. P. Thompson, Liverpool. (H. C. Covert, United States.)*
12475 Couplings, F. Titterton, Stratford.
12482 Furnaces, J. Gresty, Manchester.
12491 Connecting Tubes, E. Edwards, London. (Rudolf von Schmitz, Germany.)
12500 Ingot Iron, T. Twynam, Chiswick.
12501 Joints for Pipes, J. H. Darby, London.
12502 Governing Gas, F. W. Lanchester, London.
12503 Dynamo-electric Machines, F. V. Andersen, London.
12505 Oil Presses, A. L. Blackman, London.
12508 Gas Engines, J. R. Harper and J. Lilly, London.
12509 Shaft-end Bearings, Gustave de Laval, London.
12511 Carding Engines, C. A. Caflisch, London.
12512 Heating Feed-water, J. Kirkaldy, London.
12520 Furnaces, E. Barrett and J. H. Ogden, London.

August 8th.

12527 Renewable Tires, L. Milne and E. Price, London.
12533 Pipe Gripper, G. H. Turner, Folkestone.
12552 Electro Motor, J. H. Barry and G. B. Lückhoff, London.
12555 Projectiles, Prosper van Campenhant, London.
12558 Spring Motor, G. F. Redfern, London. (R. Hessé, France.)
12561 Boring Machine, A. Lyle, London.
12562 Looms, E. Barthe, London.

August 9th.

12571 Motors, W. P. Thompson, Liverpool. (E. Loze, Belgium.)
12572 Oil Lamps, W. P. Thompson, Liverpool. (G. Kempeneers, Belgium.)
12581 Lock Nuts, J. K. Sinton and W. Byers, Newcastle-on-Tyne.
12583 Stud Chains, C. Woodhouse, Birmingham.
12595 Raising Sunken Vessels, G. H. Leane, London.
12598 Oil Presses, A. L. Blackman, London,
12600 Steam Generators, F. Livet, London.
12601 Cutting Coal, A. Lyle, London.
12604 Noiseless Wheel, A. I. Rath, Hyde.
12606 Draw-bar Springs, J. E. Berkley, London.
12613 Steam Generators, W. Chambers, London.
12617 Type-setting Machines, London. (The Thorne Machine Co., United States.)

August 10th.

12627 Brake, J. A. Yeadon and R. Middleton, Leeds, Yorkshire.
12632 Nut Locks, T. Norman and G. Taylor, Sheffield.
12633 Buffers, P. W. Watts, London.
12636 Apparatus for Evaporation, C. W. Guy, London.
12647 Current Dynamos, G. C. Fricker, London.
12650 Lamps, P. T. Harris, Glasgow.
12654 Engine Recorders, H. Wilkie, Glasgow.
12657 Water Gauges, J. Cameron, Liverpool.
12660 Flanging Plates, F. Somerscales, London.
12661 Packing Piston Rods, S. A. Johnson, Poplar.
12663 Governors, J. Stott, London.

August 12th.

12681 Hot Gases, L. Hill, Stockton-on-Tees.
12690 Ice-making Machines, G. E. O. Lange, London.*
12694 Valves, J. Lillie, London.
12697 Coupling, M. Mannesmann, London.*
12700 Hydraulic Engines, E. J. Miller, London.
12706 Lock Nuts, A. McLachlan, London.
12711 Steam Engines, J. G. Moore, London.

August 13th.

12714 Dust Collectors, R. L. Downton and J. W. S. Downton, London.*
12717 Ventilating Fans, W. Matthews and J. Yates, Manchester.
12724 Couplings, I. Kling, London.*
12725 Drilling Machines, U. Eberhardt, London.*
12726 Metal-forming Rolls, C. A. Bertsch, London.*
12733 Type-writers, B. A. Brooks, Glasgow.
12734 Lock Nut, A. Bladon, Derby.
12743 Washer, R. D. Ferguson, Greenock.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

CHEAP PREPAID RATES FOR ADVERTISEMENTS OF

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THE

PRACTICAL ENGINEER,

SEPTEMBER 6TH, 1889.

TO OUR READERS.

So many letters have recently been forwarded to us asking for information on matters relating to patents and patent law, that we have resolved to open a column to be specially devoted to the interests of patentees, inventors, and manufacturers. In it we shall answer queries upon patent matters, and our readers are invited to freely avail themselves of this section for information upon patents and inventions. While we add this feature to our journal in order to give interesting and valuable information on doubtful points to engineers and inventors generally, yet our answers will be so framed that in no case can the invention of the individual querist be publicly disclosed.

ELECTRICITY AS A MOTIVE POWER.

AT the present time we are often told that electricity is the motive power of the future, and in proof of this assertion our informants point to the great advances made in electrical science in recent years, and the growing use of electromotors for many purposes. It is forgotten by those who make statements of this kind that, after all, as yet electricity can hardly be said to legitimately claim rank as a prime mover at all. It is only a means of transmitting energy, sometimes of storing it, but not of originating it. Electric currents are, of course, produced by a battery in which some chemical action is proceeding, but as yet no chemical action has been discovered so energetic and, at the same time, so cheap as that produced by the combustion of coal. As mistaken ideas on the possibilities of development upon this subject are by no means uncommon among electrical engineers and inventors generally, we shall shortly discuss the various means at present known of obtaining electric energy, and shall principally consider those means by which electric currents may be originated in some other way than from some other prime mover. Where a steam engine requires to be set to drive a dynamo, and so generate current, it is obvious that, however economical the dynamo may be, yet it cannot possibly generate current equivalent to the entire energy of the steam engine. The current generated may approach nearly to the total mechanical power of the driving engine, but it can never equal it. This is, of course, well understood by competent electrical engineers; but we remember distinctly conversations with fairly good practical electricians which clearly proved that they had not realised completely the impossibility of expecting more, and such inventors have described machines to us which were really attempts at perpetual motion, although not recognised as such. Currents, therefore, which are generated in this way are transmitters of power, generated by some prime mover, but are not to be considered in the same light as the prime movers themselves. If, however, currents could be generated from the combustion of coal or gas direct, to give greater economy than the steam engine does at present, no doubt steam and gas engineers would require to consider their position very seriously. At present several methods are known of obtaining electric current from heat direct, without the intervention of engine machinery, but they are far more wasteful than the steam engine, and give a far smaller proportion of useful work in the form of electrical current than would be given by using the fuel to raise steam and move an engine which drives a dynamo. Perhaps the best known mode of getting an electric current direct by the agency of heat is the thermopile. This instrument depends for its action on the fact that when bars of certain metals are placed in good contact at one end and connection made at the other, say by wire—if the end be heated, and the other kept cool—a current is generated which flows continually so long as the unequal heating is maintained. It is strictly necessary that one end should be kept cool and at a lower temperature than the other. The metals most commonly used are bismuth and antimony, and by constructing numerous couples, all connected to each other, and heated at an extremity, while kept moderately cool at the other, powerful electric currents may be generated. The expenditure of heat is, however, very great in proportion to the current energy produced, so that electric energy produced in this way is far more expensive, in equal amounts, than when the apparently more indirect process of steam engine and dynamo is resorted to. One reason of this low efficiency is found in the fact that this form of apparatus depends for its energy on the difference of temperature at the two ends of the compound metallic bars, and as this difference is but slight, the efficiency is also low. Wherever an apparatus, of whatever kind, depends on difference of temperature for its action, that apparatus is subject to the second law of thermo-dynamics, and the maximum energy which it can possibly give can never exceed that determined by that well-known law of thermo-dynamics.

Another method of obtaining motive power from heat is that recently brought into prominence by Mr. Edison, although not originated by him, and it depends on the demagnetisation of iron by heat. So long as a piece of iron is at a comparatively low temperature it has powerful magnetic properties. It can be attracted by a magnet, and caused to become a magnet itself by the passage of an electric current around it in a certain manner. But if it be heated to redness, then its magnetic properties disappear, so that a magnet no longer attracts it, and cannot do so until it cools again. It will be readily seen that if a wheel could be constructed with a number of iron spokes which could be rapidly heated and cooled, then it would be possible to so arrange a permanent magnet that it would cause this wheel to be revolved.

Suppose that one spoke or arm is being attracted to the permanent magnet and reaches it; if then the magnetic power of the spoke or arm were suddenly destroyed, the magnet could no longer influence it, and it is evident that the magnet would attract the next spoke and allow the hot one to move from under it. In this way, by destroying the power of being attracted by each successive spoke as it came near the permanent magnet, and keeping each spoke hot until out of the attractive range of the magnet, a pull can be caused from the permanent magnet, and the wheel can be kept in rotation. This is what Mr. Edison has done in his experiments. He has constructed a wheel, parts of which can be rapidly heated and cooled, and so made to rotate under the influence of a magnet. In recent remarks to an interviewer at Paris, he seems to consider this mode of obtaining motive power or electric current as likely to compete with steam in the near future.

In our opinion, Mr. Edison will find, after some further experiment, that he is mistaken. The range of temperature upon which the machine depends is very little, and the possible efficiency is measured just as certainly by that range as in any other form of heat engine, and, consequently, the efficiency must be low—much lower than that of the ordinary steam-engine practice. If electricity is ever to have a chance of rivalling steam as a prime mover, some other method must be discovered. If some form of battery could be devised in which the zinc plate was replaced by coal, and where chemical action proceeded without the direct evolution of heat, then, no doubt, very high efficiencies, or equivalents of electric energy, might be hoped for. In the ordinary battery a much larger proportion of the total chemical energy of the action proceeding between the metal and the acid is given in the form of current; but here combustion, in the sense of oxidation at high temperature, does not proceed at all. Indeed, comparatively little heat is evolved during the chemical action, as most of the chemical energy in a well-arranged battery is transformed directly into electrical energy. A battery has been constructed using carbon as the positive element, and fused nitre as the electrolyte, which gives a powerful current; but here, we fear, the practical difficulties are insuperable, even if nitre could be produced at a sufficiently low rate, which is of itself problematical. The only other form of battery which might possibly develop electric force cheaply, is Groves' gas battery, and that has been long known, and is, practically, no further advanced than where Groves left it nearly forty years ago.

If a cheap form of battery using carbonic oxide gas and hydrogen could be devised, no doubt it might be available for motive power; but the ifs are so numerous, and the knowledge of the conditions of the problem are as yet so slight, that we feel perfectly safe in disregarding Mr. Edison's prophecy so far as the near future is concerned. In this case, we are of opinion that even if some well-understood scientific fact were demonstrated or discovered, which obviously involved the practicability of electricity as a motive power, it would take at least fifty years of experiment and trial before it could be reduced to practice. This has been the invariable experience of all great inventions, and is well exemplified in the history of the dynamo itself. Although Faraday's discovery was made so long ago, it took years to produce the old magneto-electric machine, and a further term of years to work out the details of the dynamo from the first inception of Farley. Steam, gas, and machine tools have all been developed slowly, and electricity as a prime mover will certainly develop no faster. Meantime, engineers concerned in the perfection of steam and gas engines, may proceed with their labours undisturbed by the clamour of the coming electrical age.

THE DOCK LABOURERS' STRIKE.

Employers of skilled labour have long recognised the right of those in their employ to combine in their own behalf in order to get the best monetary and other terms possible for themselves. Industrial warfare between employers and employed is, after all, not one whit more keen than the competition between different firms for work, and such competition is now-a-days recognised as an almost inevitable accompaniment of our existing industrial conditions. In this world, after all, no man, or body of men, can get into a position of influence or comfort except by showing fight and determination, and whatever bad features may be common to trade unions, yet it is an undoubted fact that combination has enormously improved the condition of our workmen. At no previous time in the history of our country has their influence been so great, either for the good or ill of the whole community.

Unskilled labourers, however, have had exceedingly hard times, and have not combined among themselves like the skilled workmen, partly from the severity of competition among themselves, and partly from the want of the necessary education and funds.

The present strike of the London dock labourers has commanded almost universal sympathy from the moderate and reasonable nature of their demands, and from the general knowledge of the very hard conditions of life among these men. Their demands are briefly these: a minimum of 6d. per hour between the hours of 8 a.m. and 6 p.m.; 8d. after 6 p.m.; a minimum sum of 2s. per man for each engagement, and the abolition of what is known as the "plus" system of sharing excess.

To those who have observed the distressing scenes occurring regularly before the gates of the London docks, where thousands of men are eager for even temporary employment at the lowest rate, it is satisfactory to think that even a slight mitigation of their sad condition is possible. We sincerely hope that better times are in store for these men, and the practical sympathy of all classes with them at present would seem to point to an improved standard.

ELECTRIC RAILWAYS IN AMERICA.

In a paper read before the National Electric Light Association, Niagara Falls, U.S.A., Mr. G. W. Mansfield estimates that on July 1st of this year 113 miles of electric street railway were in actual operation, and 267 miles building. This gives a total of 380 miles of electric railway at present existing in the United States.

The system most used is that in which a stationary steam engine drives a dynamo, and the current is transmitted to the electro-motor upon the cars by cable and rolling contacts. Cards taken from an engine rated at 110 nominal horse power, and driving such a dynamo, showed a maximum power of 121 I.H.P., and a minimum of 15·56. As the result of many experiments, it is found that the average power required by a car carrying 58 passengers per round trip in Boston is 8·8 ampères, or 5·9 electrical horse power.

Mr. Mansfield considers, however, that where 10 motor cars with two cars are used, 15 horse power per car is a fair dynamo capacity, and provides sufficient excess energy to meet all conditions.

This, our readers will remember, corresponds with the maximum power usually allowed in our steam tram engines for ordinary city work. The Americans have adopted electrical power very largely, but we hardly think that we would submit in this country to the class of overhead conductors used there. If electric tramway traction is to be used in this country, it must be in the form of accumulator engines, carrying their store of electrical energy. Experiments have been made in London on accumulator cars, and are now being made in Birmingham at intervals. The cable cars in Birmingham, however, now give very satisfactory results, which may retard the endeavours to adopt electricity.

BIRMINGHAM COMPRESSED AIR POWER COMPANY.

The report of the late meeting of the Birmingham Compressed Air Power Company, appearing in our last issue, is by no means lively or reassuring reading for those financially interested in the scheme for supplying compressed air power in towns. It proves, in our opinion, the extreme improbability of any serious competition between compressed air and steam or gas power. This company has expended on capital account up to this time no less than £100,000, and although they have been in existence for several years, they have only some 13 customers, from whom they at present receive some £1,800 per annum, and they hope presently to add 23 firms to their clients and increase their income to £5,000 per annum. This statement seems to show a terrible shortcoming when compared with the hopes and predictions of the promoters. As yet the company cannot be said to compete with gas power in the most remote manner, and their hope of earning any substantial dividends would seem but small. Even supposing that they have no working expenses whatever, £5,000 per annum would only pay five per cent on the capital already sunk. In our opinion, compressed air has little or no chance of successful competition with gas or steam, at least in this country, where both powers are remarkably cheap and efficient.

A NEW STEATITE SUPPLY.

In view of the extended use of steatite for the construction of gas-burner tips, and for some portions of many regenerative gas lamps, it is interesting to note that Mr. J. R. Royle, of the India Office, Westminster, London, writes to our gas contemporaries stating that a trial consignment has been obtained from India. The samples may be inspected by those interested at the India Office any day between 11 a.m. and 3-30 p.m. It is stated that steatite of good quality can be obtained from India at much lower prices than at present rule the London market.

There are doubtless many industrial purposes to which steatite may be applied, if it could be sold at a sufficiently low rate.

THE TRANSATLANTIC RECORD.

The City of Paris has again surpassed her previous performances, arriving on Wednesday, last week, at New York, after making the trip from Roches Point to Sandyhook in 5 days 19 hours 13 minutes. This is nearly three hours faster than her previous best passage.

THE MANCHESTER SHIP CANAL.

At a meeting of the shareholders of this great undertaking, Lord Egerton, the chairman of the directors, made some interesting statements as to the progress of the work, from which it appears that no unforeseen difficulties have occurred. Out of the whole number of cubic yards of excavation required for the canal, estimated at 44,143,284, about 24 millions still remained to be excavated, and at the present rate of progress there was no doubt that the work would be completed within three years from the date of commencement. The directors have contracted with Messrs. Arrol, the well-known builders of the Forth Bridge, for all the bridges and ironwork connected with them to carry railways across the canal at various points. The chairman also stated that the Corporation of Manchester had begun the works which were necessary to purify the Irwell and Medlock, from which the canal would be supplied. Sir J. C. Lee stated that the directors of the London and North-Western Railway, of the Lancashire and Yorkshire Railway, and of the Cheshire Lines Committee, the Midland Railway, and the Manchester, Sheffield, and Lincolnshire Railway Company had visited the canal, and were convinced of the important and feasible nature of the scheme. He believed that the London and North-Western Railway Company and the Lancashire and Yorkshire Railway Company would submit plans to join up their lines to the canal terminals. The directors would require to apply for more capital, as they had only £300,000 available for the expenses of working, and Parliament would be approached for additional powers in November.

According to a shareholder residing on the banks of the Bridgewater Canal, the stench during the summer months was almost unbearable. Lord Egerton and Sir J. C. Lee stated that the Medlock water used should be duly disinfected.

We very much fear that the problem of disinfecting such large volumes of water is much more difficult than the directors of the canal or the Manchester authorities suppose. Otherwise it is difficult to see why the Thames and the Clyde have remained so long in their present condition.

WATER CONSUMPTION IN STEAM ENGINES.—III.

In our last article we illustrated the most commonly adopted method of calculating the weight of steam shown by the indicator diagram, by taking the pressure in the cylinder at a point in the expansion curve near the end of the stroke, just before exhaust commenced.

If, instead of doing this, we had continued the expansion curve to the end of the stroke at T (fig. 1), we should have had the whole capacity of the cylinder filled with steam at the final pressure TL, which we find by measurement is very nearly 11lb. absolute.

As the "clearance space" will vary with different engines and makers, and, as already explained, the determination of the water consumption from the diagrams can at best only be regarded as comparatively approximate, we may for the present, in order to simplify the calculation, leave the "clearance" out of consideration.

If, now, we let A = area of cylinder in square inches, S = length of stroke in feet, then the cubic feet of steam at the terminal pressure T, discharged from the cylinder per revolution of the engine, or double stroke, will be $\frac{A}{144} \times 2\,S$, and if R = the number of revolutions per minute, the cubic feet of steam used by the engine per hour will be represented by the expression—

$$\frac{A}{144} \times 2\,S \times R \times 60 = \text{cubic feet of steam per hour} \qquad (1)$$

Having found this quantity, it will simply require to be multiplied by the weight of a cubic foot of steam at final pressure T (whatever that may be found from the diagram to be) to give the number of pounds of water discharged per hour in the form of steam; and this again, divided by the total indicated horse power, will give the weight of steam consumed by the engine per indicated horse power per hour, as shown by the diagrams.

If we put w to represent the weight of a cubic foot of steam corresponding to any pressure T, the complete calculation would be represented as under :—

$$\text{Pounds of water per I.H.P. per hour} = \frac{\frac{A}{144} \times 2S \times R \times 60 \times w}{\text{I.H.P.}} \qquad (2)$$

In *The Practical Engineer* for August 2nd last, p. 527, the method of calculating the indicated horse power was explained, and the calculation may be expressed as follows :—

$$\frac{\text{Area of cylinder} \times \text{Twice length of stroke in feet} \times \text{Revolutions per minute} \times \text{mean effective pressure}}{33000} =$$

indicated horse power.

Or, using our previous nomenclature, and *m.e.p.* for mean effective pressure—

$$\text{I.H.P} = \frac{A \times 2S \times R \times m.e.p.}{33000} \qquad (3)$$

By substituting this expression for the I.H.P. in formula (2) we get—

Pounds of water per I.H.P. per hour =

$$\frac{A}{144} \times 2S \times R \times 60 \times w \div \frac{A \times 2S \times R \times m.e.p.}{33000}$$

$$= \frac{33000 \times A \times 2S \times R \times 60 \times w}{144 \times A \times 2S \times R \times m.e.p.};$$

and cancelling out and reducing we get—

Pounds of water per I.H.P per hour =

$$\frac{33000 \times 60 \times w}{144 \times m.e.p.} = \frac{13750 \times w}{m.e.p.}.$$

That is to say, we can find the pounds of water in steam used per indicated horse power per hour by any engine from the indicator diagram, if we multiply the constant number 13,750 by the weight of a cubic foot of steam, at the pressure shown at the end of the stroke, as at T in fig. 1, and divide by the mean effective pressure as obtained by measuring up the cards, without taking the trouble to calculate the indicated horse power.

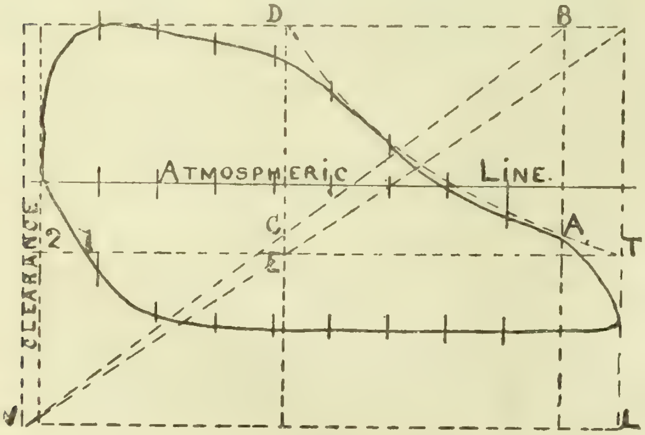

Fig. 1.

Taking our previous example, fig. 1, where the terminal pressure TL is nearly 11lb. absolute, we find from a table of the properties of saturated steam that a cubic foot of steam at 11lb. pressure is ·02891b.

Then 13750 × ·0289 = 397·375, and as the mean pressure is 12lb. (see *Practical Engineer*, August 23, p. 578), dividing this, we have 397·375 ÷ 12 = 33·1lb. of water per I.H.P. per hour.

From this requires to be deducted the amount saved by compression, as before, which can be ascertained by multiplying the above total quantity by the ratio which the line T1 (the cylinder at the point 1 in compression curve being again filled with steam for the length 2, 1, of the same pressure as the terminal pressure) bears to the total length of stroke T2. Thus the line T1, representing 37in., and the stroke being 40in., we have $\frac{33{\cdot}1\text{lb.} \times 37}{40} = 30{\cdot}6$lb. of water per indicated horse power per hour, which is very nearly the same as obtained in our previous calculation. The slight difference is explained by the fact that the final pressure is in reality a fraction under 11lb., but the whole number has been taken for facility of calculation and illustration.

When the final pressure T is 12lb., we find, turning to our table of volumes and weight of steam, that 1 cubic foot of steam at this pressure weighs ·0314lb., and multiplying the number 13,750 by this gives the number 431·75, which then only requires to be divided by the mean effective pressure to give the pounds of water consumed by the engine per indicated horse power per hour.

Proceeding in this way for 13lb., 14lb., and so on up to 65lb. or as much higher as necessary, we can find a series of numbers which require only to be divided by the mean effective pressure in any particular case to give the water consumption at once.

In the accompanying table, which has been compiled in this way, the figures under column T represent the terminal pressure, and those in column W are the numbers found as above, which only require to be divided by the mean effective pressure from any diagram to give at once the pounds of water per indicated horse power corresponding to the terminal pressure opposite which the number is placed.

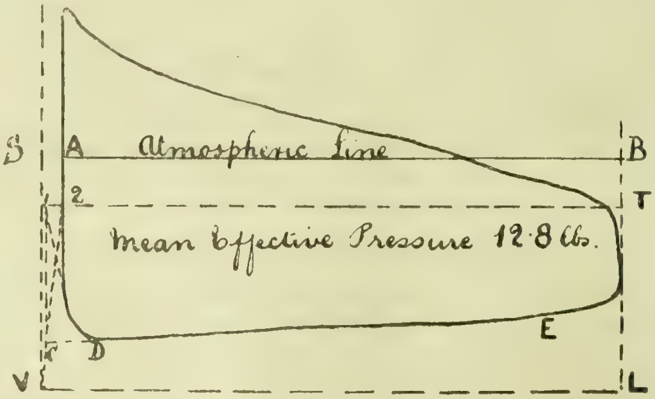

Fig. 2.

As an example for the use of the table, we will take the diagram shown in fig. 2, which shows little or no compression. A clearance line VS requires first to be drawn at a distance SA from the end of the diagram, which should bear the same ratio to the total length AB of the diagram that the amount of clearance bears to the total capacity of the cylinder. If, for instance, the cubic inches of water necessary to fill up the clearance space in the way already described in a previous article be found to be say $\frac{1}{30}$th the capacity of the cylinder, then SA must be made equal to $\frac{1}{30}$th of AB.

Generally, where the amount of clearance is not accurately known, the clearance line SV may be drawn at a distance from the end of the diagram equal to $\frac{1}{30}$th the total length of the diagram, or of the atmospheric line. Thus, if a card be taken with a Richards indicator, and the diagram is five inches long, then SA may be set out a distance equal to 4lb. on the $\frac{1}{24}$in. scale, or four inches on a scale of ½in. to the foot.

Having determined the clearance line and the point T at the end of the stroke, by producing the expansion curve until it cuts the vertical line BL (fig. 2), from the point T draw a horizontal line T 2, 1, parallel to the atmospheric line AB, and draw the line of no pressure or pure vacuum VL at a distance corresponding to 14¾lb. below AB measured by the scale of the diagram. From V draw the diagonal V2, and produce the back-pressure line ED of the diagram until it intersects the diagonal V2 at the point C. From C erect the perpendicular C1, cutting the horizontal line T 2, 1, at point 1. Then the correction for the water consumption will require to be made by multiplying the result found as before by T1, and dividing by T2, which will show in this case an increase instead of a saving, as in the previous case, from compression.

The terminal pressure T on diagram, fig. 2, we find, measuring TL by the $\frac{1}{12}$in. scale, is 12lb. Referring to our table, opposite 12 in column of terminals T, we find in column W the number 431·75. The mean effective pressure found by measuring up the diagram is 12·8lb., and 431·75÷12·8=33·73lb. water per I.H.P. per hour. Correcting for clearance or compression, we find the length T1, measured on a scale of $\frac{1}{2}$in. to the foot, is 74, and T2 is 72, so that we have $33·73 \times \frac{74}{72} = 34·7$lb. nearly, as the corrected water consumption shown by the diagrams.

Water Computation Table.

T	W	T	W	T	W	T	W	T	W
4	154·00	17	598·125	30	1021·625	43	1432·75	56	1837·
5	189·75	18	631·125	31	1053·250	44	1464·375	57	1875·5
6	224·125	19	664·125	32	1084·875	45	1497·375	58	1897·5
7	259·875	20	697·125	33	1116·500	46	1527·625	59	1929·125
8	294·25	21	730·125	34	1148·125	47	1557·875	60	1959·375
9	328·625	22	763·125	35	1179·750	48	1589·500	61	1989·625
10	363·	23	797·5	36	1211·375	49	1621·125	62	2019·875
11	397·375	24	826·375	37	1244·375	50	1652·75	63	2052·875
12	431·75	25	859·375	38	1277·375	51	1683·	64	2084·5
13	464·75	26	893·75	39	1309·000	52	1713·25	65	2114·750
14	497·75	27	925·375	40	1339·250	53	1744·875	66	2145·000
15	532·125	28	957·000	41	1369·500	54	1775·125	67	2176·625
16	565·125	29	988·625	42	1402·500	55	1806·75		

We may express the mode of using the table by the following *Rule.*—Find the terminal pressure on the diagram by producing the expansion curve to the end of the stroke. In the column of terminal pressures, T in table, find the corresponding pressure, or the nearest to it, which can be found by interpellation, and opposite this take the number in column W. This number, divided by the mean effective pressure, will give the pounds of water per indicated horse power per hour, which will require correction for compression and clearance in the manner already described.

PRESSURE AND VACUUM GAUGES—I.

Although steam pressure and vacuum gauges are familiar, at least in outward appearance, to all engineers, and most of us are acquainted in a general way with the principles of their construction, yet the amount of care and thought which has been lavished upon the details and upon the method of testing and obtaining accuracy are but little understood by the great body of those using the instruments.

In the early days of steam the mercury column was chiefly relied upon as a means of determining pressure, and it is still used as the standard of comparison for the purpose of graduating existing gauges. It is very accurate and trustworthy when properly handled, but it is also cumbrous, and cannot be used where there is oscillation, as on locomotives. The type of gauge most commonly used now was invented by M. Bourdon, a Frenchman, about thirty years ago, and it is stated to have been suggested to him while he was repairing the copper worm pipe of a still which had become flattened. He attempted to restore it to its original form by forcing water into it under high pressure. He then noticed that the flattened tube tended to uncoil itself, and that the greater the pressure applied the greater the amount of uncoiling. Applying this principle, he reasoned that if a flattened tube of hard elastic brass were bent upon itself, closed at one end, and fluid pressure from any source applied to its interior, then it would unbend to an extent depending on the pressure applied. If, then, the pressure be measured corresponding to various amounts of unbending by means of a standard mercury column, and an indicating pointer attached to show the extent of the unbending, then we have a gauge which is portable in form and accurate in indication. Fig. 1 shows a view, part in section, of an ordinary form of pressure gauge. The brass pressure tube A, shown in section and in transverse section at D, is firmly soldered to the piece B, terminating the screw C, and is stopped at the other end also. The steam or other fluid under pressure is admitted by the small hole in C, and fills the tube. The tube then tends to straighten itself, and a link *c* pulls upon a lever *b*, which moves on the fulcrum *a*, and by means of a toothed rack *d* rotates a small pinion *e*, and with it the spindle *f*. This spindle *f* carries the pointer, which moves round the dial, and indicates by its position the pressure of the steam or other fluid. It will be seen that a very small movement of the tube, in the effort to straighten itself, is magnified to a large movement at the end of the pointer, and accordingly it is most important that all slack or back lash should be avoided as much as possible. At the same time friction must be reduced to a minimum, or the pointer will not return accurately to zero when the pressure is removed. In the most common form of these gauges the brass case E is used as a framework upon which to attach the various parts, and when well made it is satisfactory enough, and it is indeed the construction used by M. Bourdon himself; but where the fastenings are in the least degree insecure such gauges are very apt to be inaccurate in their readings. If the screw C be the least slack in the case, then it permits movement of the tube A by any vibration, or by any accidental touch or push, and so may indicate pressure when none exists, or may require a considerable pressure before it

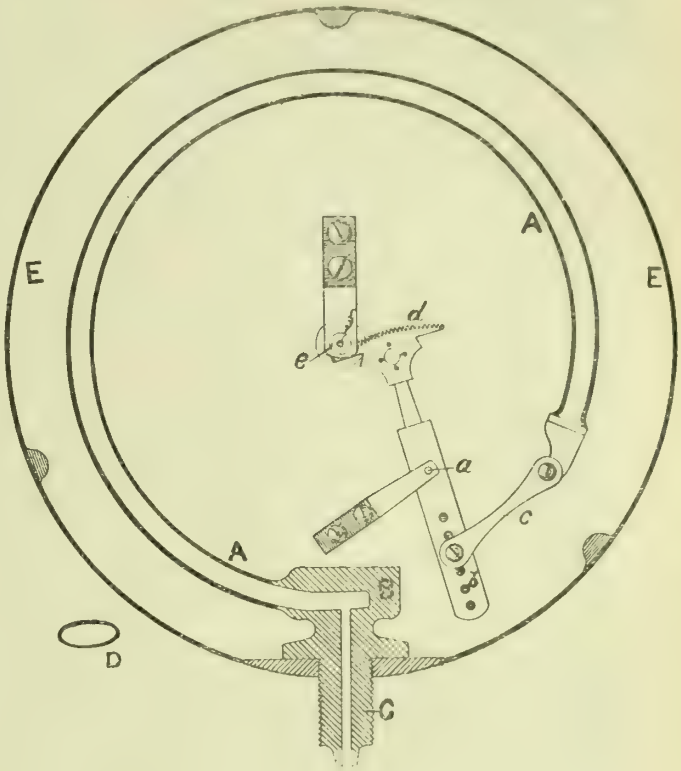

Fig. 1.

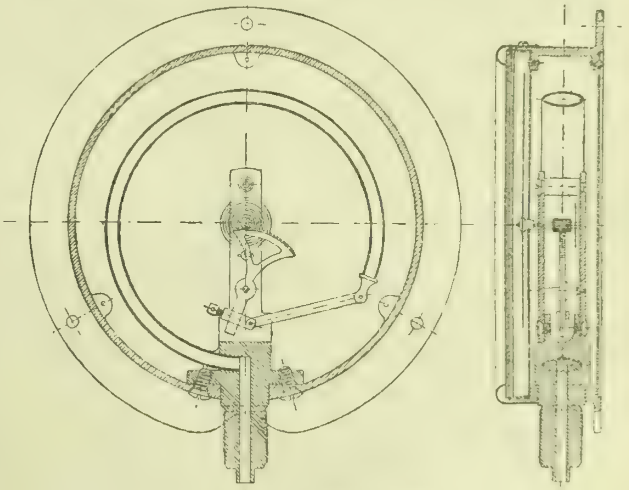

Fig. 2.

indicates anything at all. Any shifting of the brackets carrying the fulcrum *a* or the spindle *f* may also seriously affect the reading. In view of these circumstances, Messrs. Schaffer and Budenberg, the well-known gauge manufacturers, of Manchester, prefer to so construct their gauges that no part of the mechanism is attached to the case, but is all carried on one piece of metal, cast solid with the screw, to which the pressure, or rather Bourdon tube is attached. In this way there is no possibility of displacement due to defective fastenings, and even should the screw shake in its case, no perceptible effect is produced on the dial. Figs. 2, 3, and 4 are sections of such gauges. In fig. 2 the toothed quadrant and pinion are used to move the pointer spindle. In fig. 3 the toothed quadrant is dispensed with, and the connection is made direct from the end of the Bourdon tube to a lever on the pointer spindle. In fig. 4 the toothed quadrant is used, but the Bourdon tube is constructed of steel instead of hard brass. Where high pressures are used it is necessary to adopt the steel tube, to which we shall refer again.

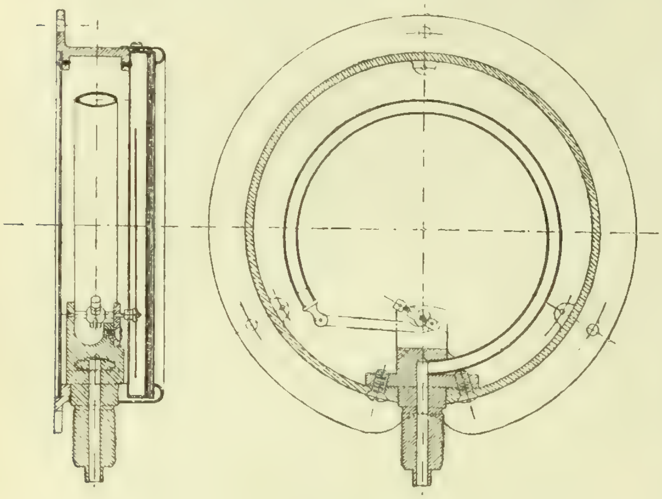
Fig. 3.

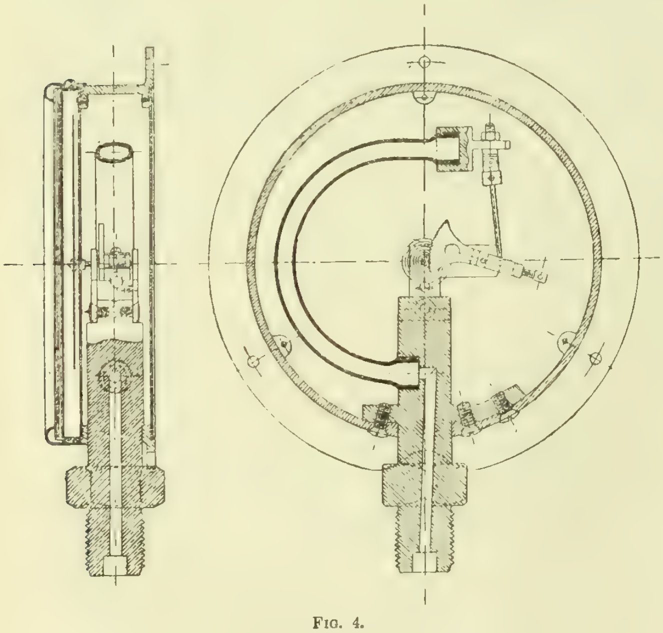
Fig. 4.

However carefully a gauge may be made and designed, it is necessary to graduate the dial plate of each separately, and by actual comparison with a standard mercury column. Messrs. Schaffer and Budenberg were good enough to show us the whole process of manufacture in actual operation, and to test for us the various gauges, to show how each was graduated.

The gauge, all complete, but with a blank white dial, is screwed to a connection leading to an open mercury column and a force pump. The pump is set in action, and it forces up the mercury on a measured scale, on which is marked the number of pounds per square inch, corresponding to the height of the column. The column ascends the whole height of the building, and the position of the mercury is read by assistants placed at the various points. In this way a series of marks are made upon the dial of the gauge, corresponding to every increase of 1lb. pressure, and the dial is then finished with the graduations as determined experimentally. This looks a laborious process to apply to each gauge in a works manufacturing many thousands every year, but it is the only way to obtain perfect accuracy from each gauge.

To compare different gauges the apparatus shown at fig. 5 is used. It consists of a hydraulic cylinder, having a piston acted on by a screw and hand wheel. The gauges are attached to couplings prepared for them, and their indications may be compared with a standard tested gauge by merely turning the hand wheel and forcing the fluid into each. Oil is used preferably for this testing.

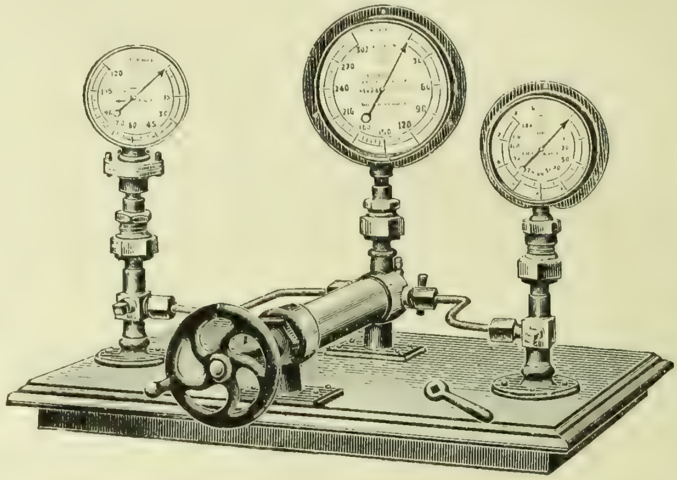
Fig. 5.

In our next article we shall give further details of vacuum and high-pressure gauges, and describe modes of testing whether a gauge is trustworthy or not.

DECORTICATING MACHINERY FOR RAMIE.

A very great amount of attention has been devoted to the growing and treatment of the ramie plant, but as yet without much practical success so far as our European markets are concerned. The fibre procured from this plant much resembles flax, but has difficulties in preparation all its own. Messrs. Thomas Barraclough and Co. are introducing machinery for the treatment of the plant at a speed which bids fair to bring the fibre into extended commercial use, and seems to have overcome, in great part, the difficulties which have till now retarded the development of this industry. Our illustration shows, at fig. 1, p. 619, a power-driven ramie breaking and scutching machine, and, at fig. 2, a similar hand-driven machine. The stems are placed upon the inclined table, shown in both illustrations, points upwards, and the feed roller, shown close to the end of the table, draws them in and passes them round a central fluted roller rotating in contact with and into which work two fluted rollers pressed home by springs.

The stems pass away from these rollers downwards, and are struck by scutching blades revolving at a high speed, which scrape or beat off pieces of bark. The stems, however, are not passed out of the upper rollers entirely, but are drawn back upon reversing the machine. The fluting of the crushing or spreading rollers is varied so as to suit wet or dry stems. When the stems are taken back, they are passed to an attendant, who separates out the worst fibre, and during the withdrawing movement the scutching blades are moving in the opposite direction, and so very completely decorticate the stems. The machines are strongly made, and many of the details, such as the reversing gear, are most ingenious.

There are now in use in the United States more than 3,650 central electric stations for light and power. There are 210,000 arc lights and 2,000,000 incandescent lamps. There were 59 electrical railways in operation in March last, and 86 roads in process of construction. The increase of capital in electrical investments last year amounted to $70,000,000. These we should say are very significant features, and they point unmistakably in the direction of further inventions and discoveries.

ON GAS ENGINES, WITH DESCRIPTION OF THE SIMPLEX ENGINE.

(Concluded from page 600.)

Working with Petroleum Vapour.—In France, where the duty on petroleum and its products is very heavy, its application to gas engines is and must be very limited; but in the provinces and in districts where there are no gasworks, a motive power certain in action and easy of application is a matter of considerable importance. An attempt was therefore made to improve on previous applications of this source of power, and in the last combination this attempt has been successful.

Previous methods, as is well known, consisted in passing air through or over volatile liquids, the surfaces of contact being increased in several different ways. The petroleum was allowed to percolate through porous substances, or was agitated by vanes to facilitate evaporation. These methods involved the following inconveniences: The liquids which were used, of very low density —from 0·650 to 0·700—were composed of various elements of different densities, and the air which passed over them was at first carburetted by taking up the more volatile constituents, until the liquid increased in density, and the constituents became more and more difficult of evaporation, until at last a useless residuum was left, which had to be thrown away. The engine, which worked well at first, gradually slowed down, until it ceased to develop any motive power. In addition, the intense cold caused by the evaporation reduced the liquid to a condition unfavourable to the saturation of the air. This difficulty was surmounted by applying heat, either to the air before its introduction, or to the liquid itself, but the gradual impoverishment of the liquid still remained.

Another very serious defect accompanied all the systems employed. During the distillation of the petroleum to obtain the light essences, a certain proportion of organic and mineral substance was carried over by the vapours given off, and these again were taken up in an impalpable form by the air during its contact with the liquid, and when subjected to the high temperatures produced in the slide and cylinder formed a thick crust, which after a few days not only necessitated a thorough cleaning out, but also affected the moment of ignition by clogging the edges of the ports. This of course refers to the slide, but the result was equally objectionable; whether the above-named process was adopted, or whether the liquid was directly introduced into the cylinder by spray or injection pumps, a rapid incrustation resulted in either case.

Carburator.—To get rid of these defects a novel form of arrangement was adopted. A receiver containing products of low density is placed immediately above a spiral horsehair brush fixed in a jacketed chamber heated by the hot water from the motor, which neutralises the refrigeration due to evaporation. Below this receiver is fixed a cock with a graduated disc, by which the supply of the liquid is regulated according to the consumption of the engine. Close to this is another cock, admitting the hot water coming from the cooling jacket of the engine, and this water, at a temperature of about 50 deg. Cent. (122 deg. Fah.) mixes intimately with the petroleum vapour, which it carries along with it in its fall on to the brush, and by the time that it reaches the lower receiver the complete evaporation of the light essence has been effected. A safety valve through which the gas is admitted to the motor obviates any backward ignition. It might be thought that the water would absorb a part of the light essence, and so cause a considerable loss; but this is not the case, and experience shows that the whole of the carburetted vapour is volatilised. The only constituents absorbed by the water are the mineral and vegetable substanced before-named, and all incrustation from this cause is completely prevented. After several months' working, the engine is in as good condition as on the first day. Moreover, there is no fear of the gradual impoverishment of the liquid, as the whole of the volatile constituents are evaporated from each part as it flows through, so that the working is always regular from beginning to end, and the power given off is always the same.

Engine Trials.—The Simplex engine has been tested with the following gases: coal gas, Dowson gas, gas from the Lencauchez generators, petroleum vapour, wood gas; and with all of them it works equally well. In spite of the high initial pressure to which the explosive mixture is subjected, the working is always easy and noiseless. The result is attained by determing the point of ignition not at the dead point, as proposed by Beau de Rochas, but somewhat later, when the piston has already made part of its forward stroke. At first sight it might be supposed that this would entail a loss of power, but experience shows that though the area of the diagram is diminished, the power registered by the friction brake is greater. Starting is also made easier by this method of working.

The application of gas engines for driving dynamos has often led to fallacious results, and so far cannot be said to have been a success. It must be acknowledged that in most installations, especially those on the incandescent systems, to which it has been applied, the light has not been steady, but subject to fluctuations disagreeable and trying to the eye-sight. On this account the use of gas engines for lighting purposes has been very restricted, altough from the nature of things there should be a large field for their employment in that direction. It has been sought to remedy this defect by employing a double cylinder engine and a countershaft, with flywheels on both countershaft and dynamo. The evil is thus diminished, but at the needless expense of higher first cost, increased space required, and a more complicated engine, as a better result may be obtained by simpler and cheaper means. Several months' experience at Mr. T. Powell's works in Rouen shows conclusively that a gas engine with a single cylinder driving directly on to a dynamo placed as close as possible to the flywheel, gives a better result than the complicated arrangement above described.

This statement can easily be practically demonstrated. All that is required is, first to drive a dynamo in close proximity, trusting to the normal slip of the belt to minimise the fluctuations of speed, and then to drive it at a considerable distance. A marked advantage, which may easily be explained, will be found to result from the first plan. With short belts the shock of the explosion is not communicated to the dynamo; but, on the other hand, by driving at long distance the shock increases the whipping of the belt and transmits an amplified blow to the dynamo. Some persons urge the objection that the slip of the belt under the first-named conditions causes a loss of power; but this does not seem to be the case, as the number of lamps lighted per horse power per hour is the same at a short as at a long distance, as has been confirmed by experience. But even admitting that there is a slight waste of power, the loss is certainly less than that resulting from the use of a countershaft, which, as demonstrated by recent experiments in the United States, may amount in some cases to as much as 20 per cent of the power transmitted.

Tests of Consumption.—Trials were carried out on the 7th and 8th November, 1885, by Dr. Aimé Witz, of Lille. Leading dimensions of the engine: Diameter of cylinder, 7⅞in.; stroke, 15¾in.; speed, 160 revolutions per minute. The effective work given off by the motor was measured off by a Prony brake, the arrangement being that adopted by Messrs. Steward and Brooks. The ordinary lighting gas used contained about 5,400 calories per cubic metre (about 600 heat-units per cubic foot) at constant volume; the Dowson gas, comparatively rich in carbonic oxide, about one-fourth of that quantity. Mean pressure of the town gas, 20 millimetres (¾in.) of water; of the Dowson gas, 55 millimetres (2⅛in.).

(7th November, 1885.) Duration of trial, 1 hour; effective H.P., 6·70; consumption of town gas per effective H.P. per hour, 22·09 cubic feet; reduced to 0 deg. C. and 760 mm. barometer, or 32 Fah. and 30in. barometer, consumption 21·55 cubic feet; water per effective H.P. per hour, 5·47 gallons; temperature, entering, 51 deg., effluent, 135 deg. Fah. Duration of trial, 2 hours; effective H.P., 8·67; consumption, 20·66 and 20·12 cubic feet; water per effective H.P. per hour, 4·44 gallons; temperatures, 51 deg. and 144 deg. Fah. Duration of trial, 1 hour; H.P., 9·28; consumption, 21·23 and 20·73 cubic feet; water, 4·38 gallons; temperatures, 50 deg. and 172 deg. Fah.

(8 November, 1885.) Dowson gas. Duration of trial, 2 hours; H.P., 7·12; consumption, 89·97 and 88·03 cubic feet; water, 5·83 gallons; temperatures, 48 deg. and 144 deg. Fahr. Duration of trial, 30 minutes; H.P., 3·61; consumption, 188·14 and 114·85 cubic feet. Duration of trial, 30 minutes; H.P., 5·26; consumption, 100·71 and 97·88 cubic feet; consumption of oil (Moehring), 5·68oz. per hour.

Other trials of the simplex motor have given the following results: A 50 H.P. engine, working with a load of 35 to 40 effective H.P., consumes daily, with a Dowson generator rather underpowered, 51lb. of English anthracite coal per hour, equivalent to a consumption of from 1·148 to 1·30lb. per effective H.P. per hour, inclusive of everything. A 16 H.P. engine, supplied with coal gas and working with a load of 12 effective H.P., uses 2,327 cubic feet per day of 10 hours, or 19·4 cubic feet per effective H.P. per hour. These two engines are in constant work, and their consumption is calculated from the daily records kept for several months, and not from experiments.

From the low consumption obtained by the use of poor gases, a considerable development of the manufacture of large gas

THE BÉNIER HOT-AIR ENGINE.

CONSTRUCTED BY MESSRS. BÉNIER, ENGINEERS, PARIS.

(For description see page 617.)

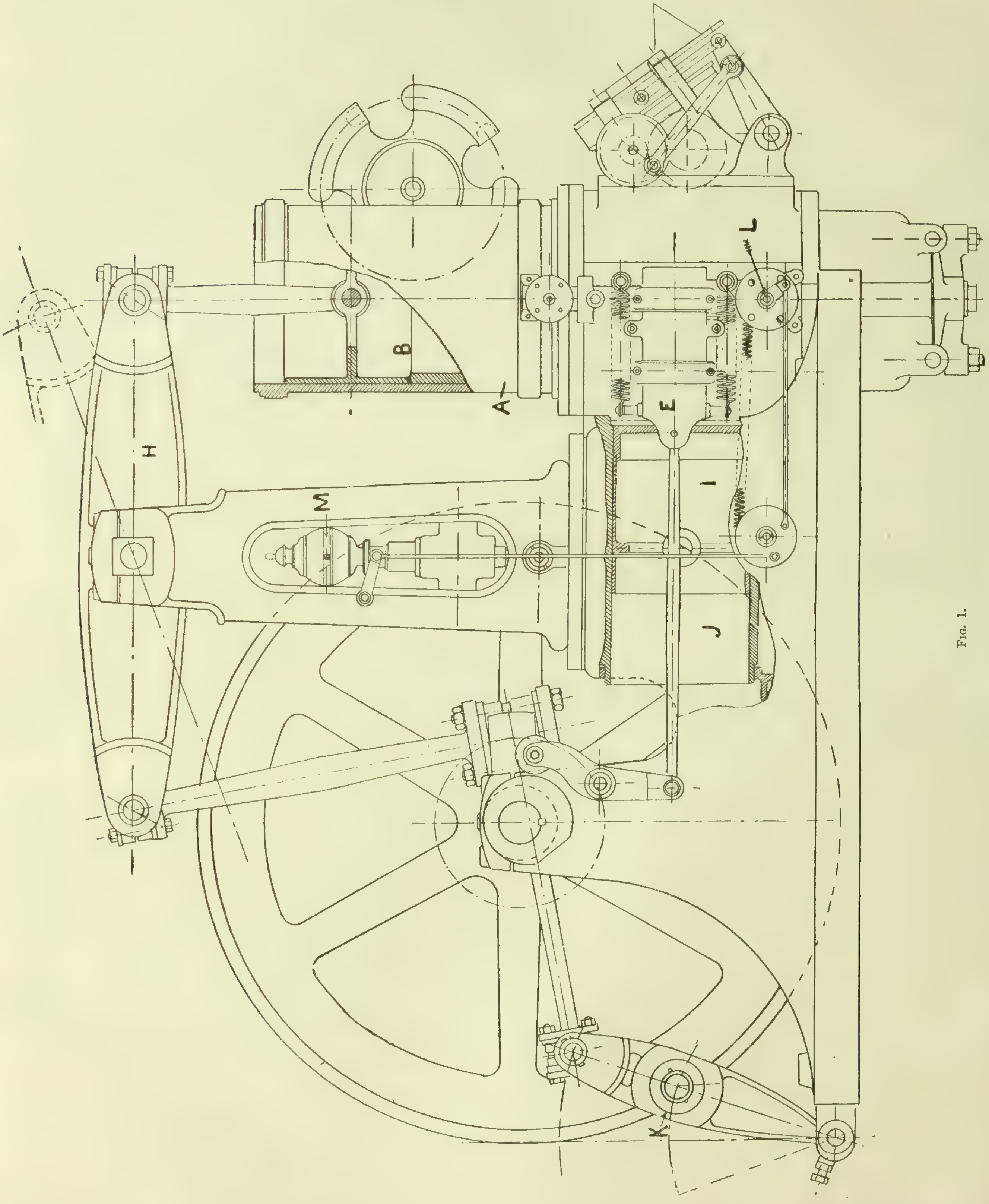

FIG. 1.

engines may safely be predicted; for their consumption is more economical than that of the best steam engines. This has now been conclusively proved.

In the foregoing rapid sketch engines of types other than those of Lenoir and Beau de Rochas have been passed over, since the principles of their construction were not those from which the Simplex engine has been evolved. A more complete description of those principles would have required a whole treatise, and would have been beyond the scope of the present paper. Those who desire to go deeper into this matter may be referred to the works of those distinguished scientists whose researches have done so much to promote the development of the gas engine.

The author must acknowledge his obligations to the important works of Dr. Aimé Witz, whose theories have constantly guided his investigations; and also to the writings of Messrs. Dugald Clerk, R. Schöttler, and Gustave Richard, which are the most complete of all that have appeared upon this subject.

A study of all the patents which have been taken out for gas engines, although a laborious task, will doubtless be undertaken at some future time, and will prove not only interesting but materially useful to those who have set themselves to accomplish the triumph of gas as a motive force over its rival steam.

THE BÉNIER HOT-AIR ENGINE AT PARIS.

We have referred to the satisfactory work done by the Bénier hot-air engine, at the Paris Exhibition, in several of our recent issues, and described in general terms the principle upon which the engine acts. We now illustrate and describe with some detail the construction and arrangement of this interesting motor.

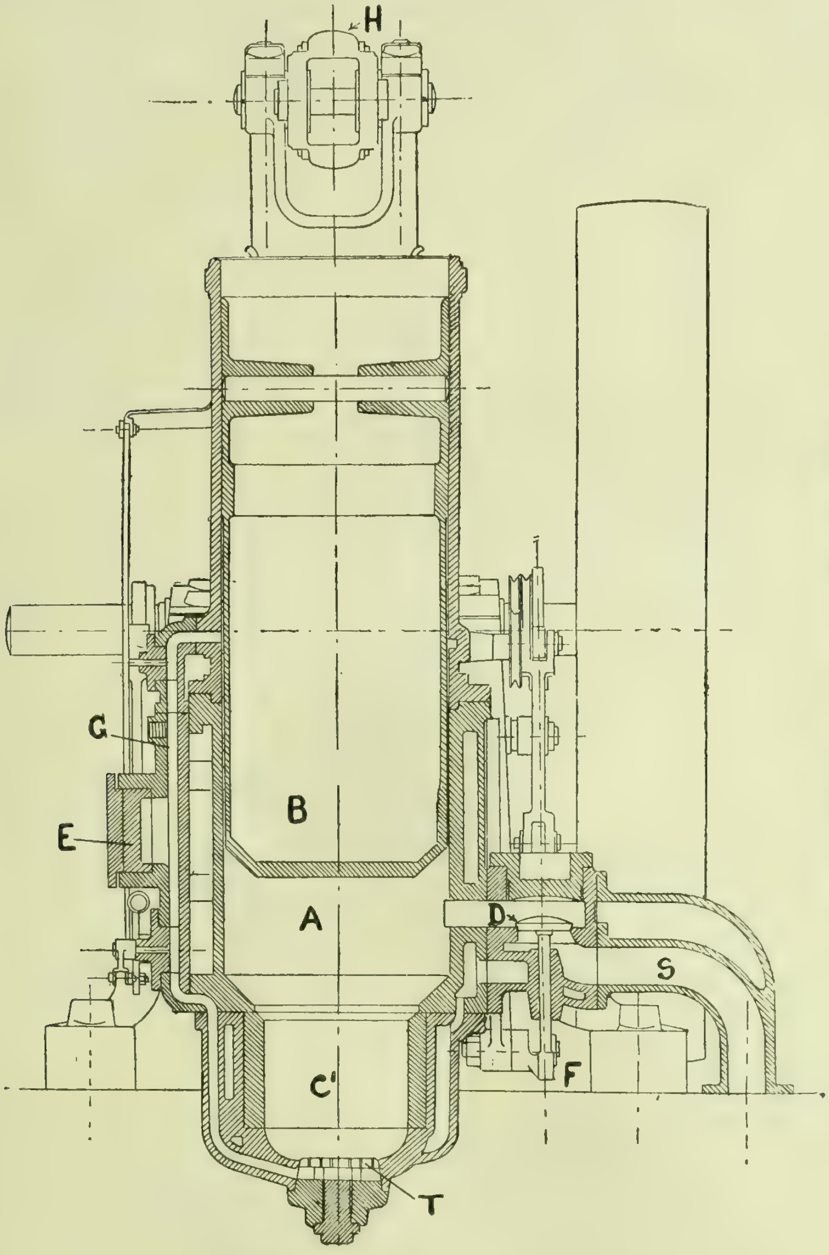

Fig. 2.

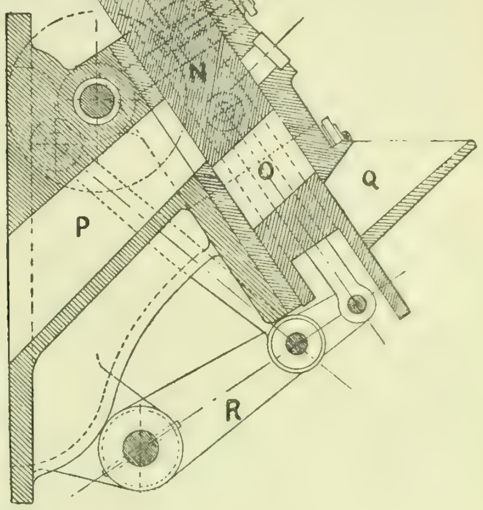

Fig. 3.

It belongs to the class of furnace hot-air engines first introduced by Avenir de la Gree, and long ago experimented upon by Sir Geo. Cayley in our own country, where solid fuel is burned in a reservoir under pressure, and the hot products of combustion are used to propel the piston of an engine. Perhaps the most recent and best known of such engines in Britain are those of Wenham, about 1871, and Brown, a little later. The Buckett engine, now manufactured by the Pulsometer Engineering Co., of London, is also of this type. In all of these engines, however, the air pump compresses air into the combustion chamber at a nearly constant pressure, and the power is due to the increased volume consequent on heating. Besides, the air, after heating—that is, the mixture of unburned air—and products of combustion, flow through valves to the motor cylinder. Unless the valves are most carefully designed this is an objectionable feature, as loss is caused by the cooling of the hot gases in passing through ports, and the valve is apt to be warped and bent by the heat and destroyed by the grit.

In the Bénier engine these difficulties have been met in a very interesting way. The reservoir under pressure is entirely dispensed with, and the furnace is introduced directly into the cylinder, as is common in gas engines of the same type, such as the Brayton in America, and the Simons some years ago in this country. The engine may be described as a "Rider" hot-air engine, in which the furnace is transferred from the exterior to the interior of the cylinder, and arrangements are made to take in a fresh charge of air at every stroke.

It consists of two cylinders, a pump cylinder and a motor cylinder, and the crank connections are so arranged that the pump piston follows the motor in the direction of revolution by about a right angle. The pump by a suitable valve takes in a cylinder full of atmospheric air at every stroke, and at a proper time communication is opened between the pump and the motor cylinder during the compression stroke of the pump, and while but little pressure exists in it. The air is forced into the furnace and cylinder, and the pressure rises to its highest point when the motor piston has moved slightly forward. After that point, the pressure is kept up by fresh supplies from the pump until nearly half motor stroke; then communication between the two cylinders is cut off, and the motor piston expands the hot gases to the end of the stroke, while the pump piston again begins to take in a charge of fresh air. On the return stroke, the motor piston expels the products of combustion.

Referring to our illustrations, fig. 1, p. 616, is a side elevation of the nine-horse power engine partly in section. Fig. 2 is a vertical section through the motor cylinder, and fig. 3 is a section of the fuel supply valve, showing its action. On figs. 1 and 2 B is the motor or working piston of the trunk type made exceedingly long for a reason which will appear shortly; A is the cylinder in which it works, C^{1} is the internal coke furnace, E is the pump air valve which admits air to the pump cylinder J, and opens communication at the proper time with the furnace C^{1} and the motor cylinder A. The air pump piston I is driven from the lever K connected up to the crank as shown, so also is the beam H, which is driven from the working piston by the connecting rod shown. The standard or pillar M supports the bearings carrying the beam fulcrum. The governor M communicates, by the linkage shown, with the spindle L, actuating a throttle or distributing valve, so arranged that its movement determines whether air from the pump shall pass by the upper portion of the passage G and enter the cylinder by an annular space round the trunk piston B, or by the lower portion through the furnace grating T. D is the exhaust valve, and F the lever from which it is driven by a cam upon the crank shaft (see fig. 2). The valve E is also driven from a cam upon the crank shaft and linkage, as shown on fig. 1.

The action is as follows: The air-pump piston I moves out towards the open end of the cylinder J, and takes in a supply of air through the slide valve E, which is moved in one direction by a cam, and returned by the spiral springs. On the return stroke the piston I begins to compress the air, but meantime the working or motor piston B has descended nearly to the bottom of the cylinder, and expelled its contents to the air through the exhaust valve D and the exhaust pipe S. The valve D first closes, and then E opens, after shutting off communication with the atmosphere, and air under slight compression finds its way into the furnace grating T, where it blows through the coke fire, filling it, and the pressure increases as the pump piston nears the in end of the stroke. The motor piston is now moving out, and as the air is much hotter than before, the expansion line is higher than the compression line of the pump. The volume of the motor cylinder is also greater, so that, as the result of the operation, power is produced. The engine is single-acting; one impulse is given at every stroke, so that on the down stroke, while the pump is taking in a fresh charge and the motor piston is expelling its products through the exhaust valve D, the engine depends on the flywheel to keep it moving.

The governor acts by sending more or less air through the furnace. In one position the throttle valve, controlled by the spindle L, sends more air upwards than downwards, in the passage G; and when full power is required, it sends most of the air through the fuel, and so gets a fiercer flame within. Fig. 3 shows the fuel slide valve N, having a port O, which alternately opens to the port P, communicating with the furnace C^{1}, and the hopper Q, which is supplied with fuel in small lumps, one at a time. The lump falls into O, and then the lever R carries the slide to the port P, where the fuel drops into the furnace, and communication with the outer air is cut off. A small wheel with buckets, shown on the side of the cylinder A (fig. 1), partly on dotted lines, feeds the coke piece by piece from a hopper to the pocket Q.

The engine is exceedingly ingenious, and is an advance upon previous hot-air engines in several points of detail.

The makers guarantee the consumption as follows, per working day of ten hours:—

Horse power.	Pounds of coke per 10 hours.	Kilogrammes of coke per day of 10 hours.
4	144	65
6	198	90
9	242	110
12	308	140
15	385	175
20	496	225

The makers also state that financially it saves 75 per cent as compared with gas engines of equal power, and 40 per cent as compared with steam engines. Many engines are now at work in France, and the engines we saw in Paris recently worked with great smoothness and without trouble. The 15 H.P. engine is at work in the Great Machinery Hall of the Exhibition driving electric lights, and the 6 H.P. is in the hot-air engine section on the Quai d'Orsay.

OIL AS A METALLURGICAL FUEL.*

At the Pennsylvania Steelworks, Steelton, Pa., a series of trials has been made with oil as fuel in steel-heating and open-hearth steel furnaces, with the following results:—

First Trial.—Hot 14-inch ingots, six to a charge, were heated in two Siemens heating furnaces in the blooming mill, the oil being put in first in March, 1888. The oil used had been partly refined, so that the paraffine and some of the naphtha were removed. During a run of six weeks the consumption of oil was about 6½ gallons per ton of blooms, including the oil required to keep the furnace hot every Sunday.

Second Trial.—The same partly refined oil was employed for melting in a 30-ton open-hearth furnace, the charge being cold scrap and pig, with ore. Although the gas was carried from the producer to the furnace, a distance of about 300ft., the oil consumption, as the average of a month's run, was 48 gallons per ton of ingots, including the oil required to keep the furnace hot over Sunday.

Third Trial.—Oil was introduced on June 11th, 1888, to heat six Siemens heating furnaces in the blooming mill, and has since then been constantly used. For a period of six months, including the fuel consumption on Sundays, and including the heating of some cold ingots, the consumption of Lima oil was six gallons per ton of blooms. The quantity of oil required naturally varies with the product of the mill. Under the most favourable circumstances—charging hot ingots, and with all the stock supplied which the furnaces can handle—4½ to 5 gallons of oil are required per ton of blooms. Cold ingots must remain in the furnace for about three hours.

Fourth Trial.—Lima oil was used for heating a 30-ton open-hearth furnace, the producer being located near it. As the average of a six weeks' run, 54 gallons of oil were required per ton of ingots, including the fuel consumption over Sundays and for starting the furnace. The record of the first week was 46·7 gallons of lima oil per ton of ingots. It was found that the loss is somewhat greater than with coal gas, and that some trouble was experienced from the fact that fine particles of oxidised iron clogged the checkers.

Fifth Trial.—Work in a 5-ton open-hearth furnace, in use since December, developed a fuel consumption ranging between 50 and 55 gallons of oil per ton of ingots.

Sixth Trial.—Oil was applied to the raising of steam under two 100 horse power return-flue tubular boilers, the temperature of the feed water being about 160 deg. Fah. The results showed an average evaporation of about 12lb. of water per pound of oil, the best twelve hours' work being 16 pounds of water evaporated per pound of oil. At the relative prices of oil and pea coal, the former is not as economical under boilers as the latter.

In all of the trials the oil was vaporized in the Archer producer, an apparatus for mixing oil and superheated steam, and heating the mixture to a high temperature. From 0·5lb. to 0·75lb. of pea coal is used, per gallon of oil, in the producer itself.

THE AGE OF STEEL.

There is an interesting article in the new number of the *Quarterly*, in which the writer traces recent developments in the manufacture and use of steel—a development so extensive in comparison with that of all previous periods as to justify us in regarding the present time as "The Age of Steel." The extreme rapidity with which steel has superseded iron for shipbuilding is the more remarkable when we remember that it is the development of scarcely more than a single decade. Between 1866 and 1876 only three small ships were built of steel in the United Kingdom, and the decision to build the Cunarder Servia, launched in 1881, of steel, was, even at that recent period, considered a very bold one. In 1878 the quantity of steel used for steamships was only 2,682 tons against 243,717 tons of iron; but in 1887 195,907 tons of steel were used for steamships, 14,333 tons for sailing vessels, and only 24,052 tons of iron for steamers and 28,150

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* Trans. Am. Inst. of Mining Engineers, by E. C. elton.

DECORTICATING MACHINE FOR RAMIE.

CONSTRUCTED BY MESSRS. THOMAS BARRACLOUGH AND CO., ENGINEERS, MANCHESTER.

(For description see page 614.)

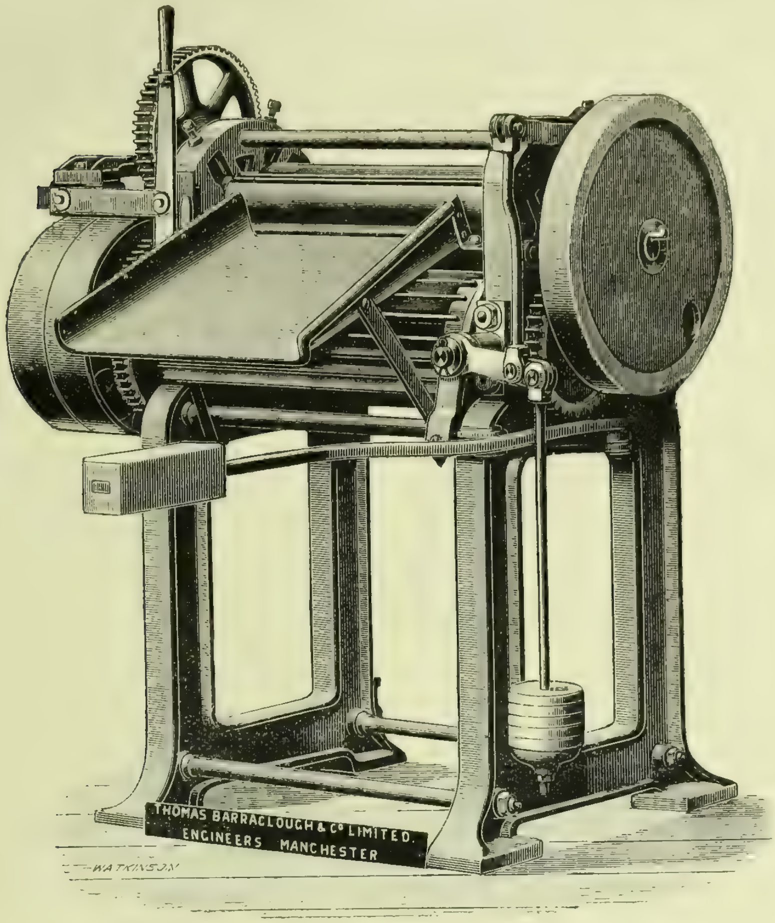


Fig. 1.

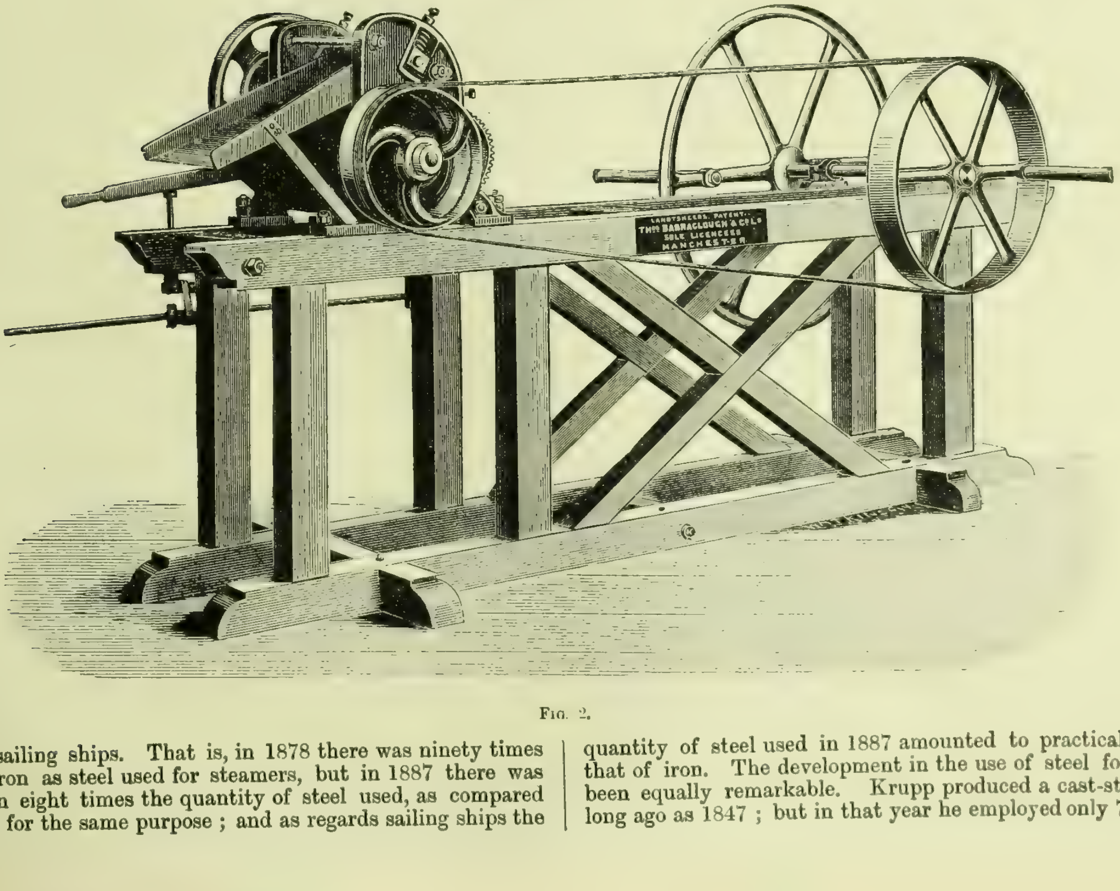


Fig. 2.

tons for sailing ships. That is, in 1878 there was ninety times as much iron as steel used for steamers, but in 1887 there was more than eight times the quantity of steel used, as compared with iron, for the same purpose; and as regards sailing ships the quantity of steel used in 1887 amounted to practically one-half that of iron. The development in the use of steel for guns has been equally remarkable. Krupp produced a cast-steel gun as long ago as 1847; but in that year he employed only 72 men. At the time of his death, which occurred in July, 1887, 12,600 men and officials were employed in the Essen and affiliated works, while the number of those engaged in mining and other operations connected with the firm completed a grand total of 20,000, making the establishment the largest in the world. After discussing steel rails and steel boilers, the writer goes on to mention, among the lesser-known uses of steel, its employment for railway axles. Following the recommendation of Major Marindin, after the Penistone accident in 1884, a Board of Trade return of engine axles for the year 1883 was prepared. From this we gather that of a total of 14,848 locomotive driving-axles in the kingdom, 7,422 were of steel. Cast steel is also being employed for anchors. One of the latest uses to which steel is being put is that of replacing cast iron as a material for water pipes. Messrs. Pigott, of Birmingham, commenced making steel pipes in 1880. It is not long since the first pipes of this material used in Great Britain were made for carrying water over the Tay Bridge. Steel pipes convey the water under the rivers Vyrnwy and Mersey for the new Liverpool water supply. Steel laths for ceilings are largely used in America. Recently a company has been formed at West Hartlepool to manufacture these articles. Steel plates are used in America for the foundations of buildings. In 1876 the total make of Bessemer steel in the United Kingdom was 400,000 tons; that of open-hearth steel, 128,000 tons. In 1888 the United Kingdom produced 2,012,794 tons of Bessemer steel ingots, and 1,392,742 tons of open-hearth ingots. The production of Bessemer steel in the eight chief iron and steel producing countries of the world, in 1887, amounted to 7,269,767 tons. The yield of open-hearth steel in the same counties in 1887 was 1,672,340 tons, against 1,221,921 tons in the previous year. We do not monopolise the steel trade of the world. The annual production of Bessemer steel in the United States already exceeds our own, amounting to 2,936,033 tons. Decidedly we live in "The Age of Steel."

EXPLOSION OF A COPPER PIPE AT DEPTFORD.

(Continued from page 605.)

THE arrangement of piping has been already explained, the pipes dipping through a considerable distance in passing from the boilers to the "receiver," and rising again through a somewhat greater distance to the cylinders. It is stated by Mr. de Ferranti that the pipes were placed in the only position available for them; and if they had been led directly from the boiler drum to the cylinders they would have interfered with the working of the traveller. With regard to the arrangement Mr. Inglis writes :—

"With reference to our conversation about overhead and underground steam pipes, although our practice is to use the former arrangement by preference, still it is quite common to have the steam brought into the engine-house below the engine-room level. Indeed, some makers of mill engines follow this practice altogether. We exhibited one of our Corliss engines at the Inventions Exhibition, London, and also at the Manchester Exhibition, and in both cases we received our steam supply from underground mains. At the Manchester Exhibition there was a large main from 10 boilers (each 30ft. long, 8ft. diameter), 100lb. pressure. At Deptford, I think, any other arrangement would not come in so well, considering the number of engineers there will be, and there should be no difficulty about it.

"About the expansion joints on the line of pipes from the steam receiver to the pipe which burst, I feel quite sure the arrangement adopted of taking the expansion by bends in the pipe, which is our universal practice now, was perfectly good. A stuffing-box joint in the line of pipe would have meant a force of about nine tons, tending to separate the pipes, which of course for safety would have to be prevented by lock or safety bolts on the expansion joint, making it practically same as the solid pipe."

While the arrangement adopted was probably, to some extent, unavoidable, it necessitated particular attention being paid to the means of draining water from the very long range of piping introduced, and I do not think it can be claimed that fitting the two $\frac{3}{4}$in. pipes to the bottom of the "receiver" and connecting them to traps was sufficient precaution to ensure that the steam pipes were free from water in view of condensation, possible priming, &c., which might have been expected to occur. The pipes, &c., were uncovered; the condensation was therefore greater in amount than will result when the work is completed; still, I am of opinion that the drain fittings were inadequate, and that it is necessary to make further provision to satisfactorily meet the case. The "receiver" fulfilled to some extent the office of a "separator," but there were no means provided to enable the quantity of water lying in it to be ascertained; and there was no doubt a considerable quantity carried from the boilers with the steam.

The defective condition of the pipe rendered it quite unfit to be employed as a steam pipe for any considerable pressure, and I think its failure, under favouring circumstances, was only a question of time. The greatest steam pressure known to have been upon it was 152lb. per square inch, while the boiler safety valves are to be loaded to 200lb. per square inch. The cold water pressure to which it is said to have been subjected is 360lb. per square inch, and the nominal factor of safety was intended to be ten. If the actual factor had approached this, the pipe would have experienced no harm had it been tested to a much higher pressure, and I would consider this to have been a prudent course to have adopted, seeing that the stress set upon the bend by the expansion of the remainder of the piping would add greatly to that due to internal pressure, and that the tensile strength of copper is materially reduced at the temperature corresponding to the intended working pressure in this case. With regard to the factor, however, it should be remembered that, in brazing on the flanges, the end portions of the pipe are annealed, and cannot afterwards be planished. In addition, the elastic stress of annealed copper is seldom more than one-fourth of the ultimate, which for purposes of calculation it is advisable not to assume higher than about 24,000lb. per square inch at ordinary temperatures.

When the explosion occurred, the engine stop valve was being opened by Shorrocks, who, as a most experienced man, would have exercised all the care that could be taken with the existing fittings. The pipe was completely destroyed; this, and other circumstances, point to the probability of some water being in the pipe, and that the explosion was immediately due to its presence. The extent to which water was present cannot be ascertained. It would appear improbable from collateral circumstances that the pipe would have given way had it been sound, but this cannot now be well determined.

Since writing the above the remaining bends were subjected to hydraulic pressure in my presence at Messrs. Hick, Hargreaves, and Co.'s works. The following were the results :—

Bend G (corresponding in position to that which burst, see fig. 1) failed at 670lb. per square inch. The fracture was $2\frac{1}{4}$in. long and about $\frac{1}{8}$in. open at widest part, and ran parallel to the seam, $1\frac{5}{8}$in. from the edge of the outside lap and $10\frac{1}{2}$in. from the flange. The fracture was discoloured for about three-fourths of its depth at the middle part. It had the appearance and was ascribed to the presence of a flaw in the original sheet, such as is occasionally met with. While it is probable that the low pressure at which this bend failed was due to the cause referred to, although the fracture occurred at a part of the elbow where a considerable amount of work had been put upon it, still an incipient crack might have been produced by the hammer and subsequently been developed by internal pressure, such as destroyed the bend which is the subject of this report.

Bend F ultimately gave way at a pressure of 1,100lb. per square inch. The fracture followed the outside seam for a length of $8\frac{1}{2}$in., commencing $\frac{3}{4}$in. from the flange which was further from the elbow. The opening was $\frac{13}{16}$in. at the widest part, and the flange was drawn in $\frac{5}{16}$in. at the circumference of the pipe. The fracture was partly discoloured, the bright portion at the thinnest place being about $\frac{1}{8}$in. thick. The seam had evidently "drawn," and it gave way through part of the lap where it had been thinned down. The brazing of the flanges to bends F and G did not appear to be perfect, but resembled that of the flange left upon the exploded pipe.

The remaining bend H withstood an hydraulic pressure of 1,200lb. per square inch without appearance of distress, except the drawing of the flanges, owing to the pressure on the blank ends, which were unstayed. This caused the joints to give trouble, and the test was temporarily abandoned. I have since learnt that the bend gave way when the pressure reached 1,300lb. per square inch, close to the flange of the short end, the length of fracture being $1\frac{7}{8}$in., and the widest opening $\frac{1}{8}$in.

The positions of all the fractures are, for convenience, shown on one sketch (fig. 1).

These pressures, had the pipe been cylindrical and of the thickness intended, would have produced stresses of 12,060lb., 19,800lb., and 23,400lb. respectively in the metal of which the pipes were formed, and the apparent factors of safety in the three cases would have been 3·7, 6·1, and 7·2 when the internal pressure was 180lb. It would therefore seem probable that the bend which exploded possessed a very low factor of safety originally.

The difference between the expected and the actual resistance of these bends can be seen from the table given below.

Bend.	Hydraulic Pressure producing Rupture.	Stress due to this Pressure in Cylindrical Pipe of same diameter and of $\frac{1}{4}$in. uniform thickness.	Apparent Factor of Safety (taking Working Pressure at 180lb.).	Remarks.
	Lbs. per sq. in.	Lbs. per sq. in.		
E	—	—	—	Exploded bend: steam pressure at the time about 150lb. per sq. in.
G	670	12,060	3·7	Corresponding bend to E on No. 1 engine.
F	1,100	19,800	6·1	
H	1,300	23,400	7 2	
Designed	1,800	32,400	10·0	

(To be continued.)

LITERATURE.

The Tabor Indicator. Manchester: Abel Heywood and Son. London: Simpkin, Marshall, and Co.

This book contains a very large amount of useful information with regard to the indicator and its uses, and is profusely illustrated with indicator diagrams and sketches of apparatus used in indicating steam engines. The first chapter consists of a description of the Tabor indicator, an American invention which has been recently introduced into this country by Messrs. John Musgrave and Sons, Limited, of Globe Ironworks, Bolton. The succeeding chapters are devoted to the management and care of the Tabor indicator,—the essential features of indicator diagrams, the uses to which indicators may be applied, methods of indicating, &c. Various methods of calculating indicator diagrams are referred to, and several modes of comparing the actual expansion curve with the hyperbolic curve are graphically shown. There are also many useful tables for engineers, on pressures and temperatures of steam, piston constants, properties of saturated steam, areas and circumferences, &c., &c. It will be seen from the above that the work is by no means of so narrow a scope as its title would indicate, and we can conscientiously recommend it to all steam users and draughtsmen as a very handy and complete work. It is handsomely printed on highly-glazed tinted paper, and reflects great credit upon both author and printer.

Practical, Plane, and Solid Geometry, &c. By J. S. Rawle, F.S.A. 127 pages. London: Simpkin, Marshall and Co.

This little work treats, in a comprehensive manner, all the questions likely to be dealt with by a student entering for the examinations of the Science and Art Department, and for other examinations where questions in practical geometry are given. We are pleased to see the chapter on scale drawing and working to scale is written in a manner which clearly indicates the familiarity of the writer with the actual use of such scales, and we are not surprised that the work has reached a fifteenth edition. The examples given for the student's practice are not the usual and well-known old friends of our younger days, but are chosen with care, and new methods of construction are in many instances given. The chapter on geometrical pattern-drawing, apart from its usefulness as an exercise of constructive geometry, has some value for those engaged in metal-plate cutting. The twenty-one pages devoted to solid geometry are necessarily full of the usual elementary problems, involving the drawing and projection of simple figures on different planes.

Practical Handbook on Direct-acting Pumping Engine. By P. R. Björling. 123 pages. London: E. and F. N. Spon.

The writer of any work which professes to be practical should do his best to give modern practice and recent experience in the actual workshops engaged in producing the pumps or other machines upon which he is supposed to be giving information. Bearing this in mind, we entered into the study of the "Practical Handbook on Direct-acting Pumping Engine Construction" only to be disappointed, for the seven pages devoted to "rules and formulæ" contain but little in the way of information of an original kind. If there is one name more prominent than another in the construction of direct-acting steam pumping engines, we think it is that of the Worthington Company, and the only illustration given respecting this firm's manufacture is one of a single-acting tappet pump, obtained from the Transactions of the Mechanical Engineers, 1852. We do not imagine such a pump would now be constructed by that company. Again, we notice that a direct-acting steam pump is defined as having the steam admitted into the cylinder during the whole stroke, whereas we only very recently described and illustrated in *The Practical Engineer* the compensating arrangement whereby the steam, in a direct-acting pump, can be employed for any portion of the stroke without the uniformity of pressure in the pump end being interfered with.

It is with regret that we feel constrained to pass an unfavourable opinion upon this book, as the illustrations and the printing of the work are done in Messrs. Spon's well-known excellent style.

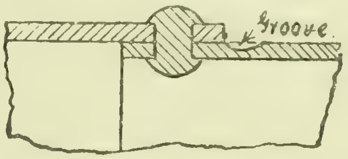
CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

PECULIAR INTERNAL CORROSION.

To the Editor of "The Practical Engineer."

Sir,—I find some of the boilers under my charge are suffering from internal corrosion, or what would, perhaps, be better described as corrosive channelling, in a somewhat peculiar manner. The boilers are of Lancashire type, and the crown plates in both furnaces are grooving along the edges of the overlaps at the first and second circular seams, something like as shown in rough sketch herewith. This peculiar furrowing has been going on for some time, and has extended until it now appears to be something more than half way through the plate, or in worst places about ¼in. deep, and it extends round, as near as may be, one third the circumference of the furnace tube on the upper side.



The water supplied to the boilers, so far as I am aware, is not of a corrosive character, as there are only a few isolated pittings of corrosion in other parts of the boiler.

As I have not heard previously of any boilers having suffered similarly, and it seems to me the channelling must be due to mechanical more than chemical action, I should be glad of the opinion of some of your readers who are boiler experts on the matter. Possibly "Chalkline," or some other of your practical contributors, can throw some light on the matter. As the boiler insurance company is urging renewal of the furnaces, or at least of the upper plates, on account of this grooving, probably something could be done when carrying out the repairs to prevent a recurrence of this apparently unique form of deterioration.—Yours, &c.,

Works Manager.

QUERIES AND REPLIES.

81. Bolts for Flange.—In making a flanged joint fluid tight by means of bolts and nuts, what considerations should be taken into account in estimating size, number, and strength of bolts to be used? The fluid pressure being 100lb. per square inch, total amount of separating force due to pressure 10 tons, and length of flange measured along pitch line of bolts being 6ft., what should be the diameter and number of bolts?—C. P. W.

Answer.—The first consideration to be observed is an absolutely tight joint; next, the correct diameter and pitch of bolts to attain that end. An iron bolt or stud, except in exceptional circumstances, should never be subject to a greater stress at the bottom of the thread than 9,000lb. per square inch of area, and not to exceed 13,000lb. in the case of steel. The force necessary to keep a tight joint is not the only one to be considered in determining the diameter of bolts to be used, as there is a severe stress due to screwing up, producing as it does an unknown twisting movement, the most serious in the whole case. If you allow a stress of 3,000lb. to 5,000lb. per square inch of bolt at the bottom of the thread, it will be in accordance with most good practice, but the question must at all times be well considered for each individual requirement. In the particular case you give there is a stress of $10 \times 2{,}240 = 22{,}400$lb. To resist this stress, allowing the minimum value of 3,000lb., we should require a total area at the bottom of the threads $= \frac{22{,}400}{3{,}000} = 7{\cdot}466$ sq. in. Assuming ¾in. bolts are to be used $= 3{,}045$ area of one bolt at bottom of thread, and $\frac{7{\cdot}466}{{\cdot}3045} = 24{\cdot}5$, say 25 bolts in number. Length in direction of pitch $= 6 \times 12 - 72$in., and $\frac{72}{25} = 2{\cdot}88$ in pitch of bolts, or pitch $= 3{\cdot}8 \times$ diam., a very convenient pitch for high pressures.

Answer.—The size and number of bolts must be arranged so that the stress per unit area of bolt section due to the internal pressure does not exceed the safe working stress per unit area of the material; experience must, however, decide whether the bolts so determined would secure tightness, practical considerations often necessitating modifications. The strain upon the bolts is not due to tension only, as a torsional strain is set up, owing to the obliquity of the bearing surface of the screw; in addition to this, the bolts are strained during the process of screwing up the joint. The formula is deduced in the following manner:—

Let D = the diameter of cylinder in inches
d = the diameter of pitch circle in inches
d_1 = diameter of bolts at bottom of thread in inches
P = the internal pressure in pounds per square inch
f = safe stress per square inch of bolt section, say 3,500lb.
k = pitch of bolts in terms of d_1

then number of bolts $= \frac{d\pi}{\lambda d_1}$

the internal resistance due to pressure $= \frac{D^2 \pi P}{4}$ (1)

resistance of bolts $= d_1^2 \frac{\pi}{4} \cdot \frac{d\pi}{\lambda d_1} \cdot f$ (2)

Now, 1 and 2 must be equal, that is $\frac{D^2 \pi P}{4} = d_1^2 \frac{\pi}{4} \cdot \frac{d\pi}{\lambda d_1} \cdot f$

By transposition and reduction we get $d_1 = \frac{\cdot318 \lambda D^2 P}{df}$

In order to allow for the strains not easily ascertainable, as mentioned above, the formula is generally stated, $d_1 = \frac{\cdot4 \lambda D^2 P}{df}$

Now, in the query, D = say 23, and d = say 5

$\therefore d_1 = \frac{\cdot4 \times 5 \times 17^2 \times 100}{3{,}500 \times 23} =$ 1in. or 1¼in. bolts, at 5in. pitch.—Orion.

83. **Stern-tube Bearing.**—What should be the diameter of the stern-tube bearing for engine of 4,000 horse power, making 90 revolutions per minute?—C. P. W.

Answer.—The diameter of propeller shafts of marine engines is made the same as the crank shaft, and assuming the engines in question are of the tri-compound type, with high pressure of 36in. diameter (D), low pressure 96in. diameter (d), stroke 4ft. 6in. (L), boiler pressure 160lb. per square inch, or 175lb. absolute (P), then by Board of Trade formula we have diameter of shaft

$$= \sqrt[3]{\frac{L \times P \times d^2}{2 \times 1110 \times \left(2 + \frac{d^2}{D^2}\right)}}$$

$$= \sqrt[3]{\frac{54 \times 175 \times 96^2}{2 \times 1110 \times 9\cdot11}} = 16\cdot29\text{in.}$$

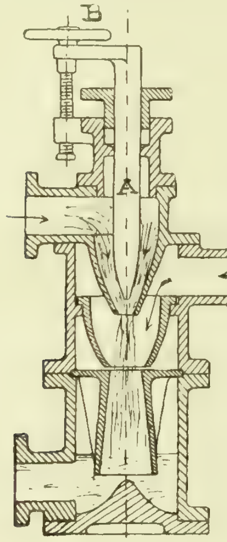
Lloyd's formula gives diameter

$$= \sqrt[3]{\frac{54 \times 175 \times 96^2}{18800}} = 16\cdot67\text{in.}$$

About half an inch is generally allowed on the diameter as found above, to compensate for keyways, &c. The bearing should be about three and a half times the diameter in length. The above sizes are for wrought iron, steel not being acknowledged, although it is now usually employed.—Orion.

85. **Morton's Ejector Condenser.**—Can any of your readers give me a description of Morton's ejector condenser, with a sketch, if possible?—Crankum.

Answer.—Below is a sketch of Morton's ejector condenser, as fitted to a stationary engine, the great advantage being that it dispenses with an air pump, and is very rapid and efficient in its action, a vacuum being produced within five or six seconds of the time of starting the condenser, to do which the central spindle A is raised by turning the handwheel B, and a jet of injection water is discharged through the centre current of exhaust steam entering from the engine at C, which steam becomes condensed and produces a vacuum in the condenser. The velocity of the entering water is that due to the difference of the external atmospheric pressure, and the pressure in the condenser corresponding with the degree of vacuum attained, given by the hydraulic formula $V = 12\cdot19 \sqrt{P}$, when V = velocity in feet per second. P = the difference of presssure, as above, in lbs. per square inch. To this must be added the velocity due to the head of injection water, or $V = 8 \sqrt{H}$, when H = the head in feet. The water jet rushing through the combining nozzle of the ejector and the discharge tube at this velocity carries with it any air that may be mixed with the exhaust steam, and issues into the atmosphere in a continuous stream.—Condensador.



87. **Diameter of Piston Rings before Cutting.**—In the case of cast-iron piston rings of equal thickness, *i.e.*, where the inside and outside circumferences are concentric, could you give me the diameter of the ring before being split, in terms of the diameter of the cylinder? Also, where the ring is ⅛in. thicker in the middle than at the split ends, what would be the diameter of the ring before being split? A text-book I have says $\frac{1}{10}$ larger diameter than the cylinder, but this seems to me excessive.—H. V.

Answer.—A very good rule for the diameter of cast-iron piston rings is to turn them ⅛in. larger than the cylinder for every foot in diameter of the cylinder; thus, for a cylinder 5ft. in diameter, the ring would be turned 60⅝in. outside, and a piece (60·625 − 60) × 3·1415 = 1·963in. long would have to be cut out of the circumference to make it fit the cylinder exactly. In cases where the ring is thicker in the middle than at the ends, somewhat less than the above.—Piston.

88. **Hughes' Patent Packing.**—I am anxious to know the principle of Hughes' patent packing for piston rods. A sketch would much oblige.—Athalia.

Answer.—Hughes' patent packing consists in forming the filling of the stuffing box of a series of metallic or other rings, with grooves turned out of each at their junctions, and in placing segmental or other spring packing in these grooves. The object of forming the filling of a series of rings solidly fitting against each other (see fig. 1), but with grooves turned out for spring packing, is to form a solid abutment for the screw pressure of the gland screws to bear against, and prevent that pressure from wedging the spring packings tight, so that they cannot "give" or float in their grooves, as it is only by this freedom that they become of service, as, if wedged tight, the spring becomes useless. The packing is sometimes fitted as at fig. 2, in which Ramsbottom rings are used, and these having an elastic nature, the springs are unnecessary. Fig. 1 shows the application with the Camerons rings. Care must be taken that the casing is made steam-tight on the bottom of the stuffing box, and held tightly in place by the pressure produced by screwing up the gland, and it is usual to add a turn or two of Tuck's or other packing in the cap between the solid framework of the packing and the gland.—Piston.

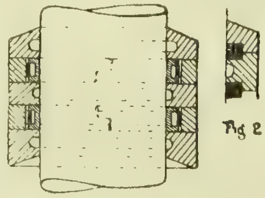


Fig 2

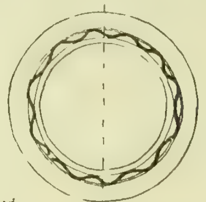


Fig 1

89. **Cement for Joints of Iron Pipe.**—Will some reader kindly state the best kind of cement for the joints of iron pipe in connection with a stove? Putty has been used, but with very unsatisfactory results.—Ignoramus.

Answer.—Has "Ignoramus" tried asbestos putty? if not, I should advise him to do so. It can be obtained, ready for use, of Messrs. Bell and Co., of Southwark Street, London, S.E.—G. B.

90. **Heating Feed Water.**—If feed water is heated up to 190 deg. F., what is the percentage saving over feeding with water at ordinary temperature?—T.

Answer.—In practice, the saving varies from 10 to 15 per cent. Theoretically, it varies much with the type of engine.

80. **Book on Locomotives.**—Can any of your readers inform me of the best book on railway locomotives—chiefly Midland Railway locomotives?—W. B.

82. **Oscillating Engine.**—If CP be the crank and PQ the piston rod of an oscillating engine, find the velocity ratio of P to Q, and set out result in diagram. Find also the angular velocity ratio of CP and PQ at any point of stroke.—C. P. W.

84. **Brake Straps on Cranes.**—What is the usual method of calculating the breadth of brake straps on ordinary cranes?—W. R.

86. **Working Drawing of Crane.**—Will you kindly permit me to ask any of your readers if they could give me information as to where I could get a working drawing of a crane; also, if there is a book published on shading?—J. H.

91. **Aluminium and Steel Castings.**—I see from an American contemporary that steel castings are now produced which can be worked like the best wrought iron, and yet tempered by the use of a flux containing aluminium. Can any reader inform me how steel castings can be produced, capable of being easily worked and tempered, or case-hardened, and possessing great breaking and elastic strength? Is there any work on this subject?—C. H. B.

92. **Tannate of Soda.**—What is tannate of soda, and how is it prepared? Will it prevent a boiler feed-pipe from choking up if injected with feed water? Is there any composition which will do this?—Engine-driver.

93. **Launch.**—Will anyone inform me what kind of engines I should get for an ordinary boat 25ft. by 5ft., but having 2ft. 2in. mean draught? It was originally built for an auxiliary sailing boat. I want speed of 9 miles per hour. I would like to know something of petroleum engines, if they would suit, also the sizes of cylinders, stroke, propeller, &c.—J. M. S.

TO CORRESPONDENTS.

J. S. S., Glasgow.—You can enter any science and art examination as a private student by payment of a small fee, 2s. 6d. we believe, to the local secretary of science and art classes, provided you apply before the end of March. You will get full information in Glasgow from any science teacher.

Engine-driver, Limehouse.—If a feed-water containing lime salts is heated to 150 deg., or so, before being pumped into the boiler, it is less liable to cause the interior of the feed-pipe to choke up. This is due to the fact that a portion of the lime will be deposited in the interior of the feed-water heater.

Thistle, Chester.—If you read our article, "Lap and Travel of a Slide Valve," in *The Practical Engineer* of Feb. 1st, this year, p. 77, you will find full particulars of cut-off, and tables to show the portion of the stroke at which cut-off takes place. This table gives full figures for various proportions of lap.

MISCELLANEA.

Greece has now 367 miles of railroad, all but six miles built within a few years past. The longest line extends from Athens to the Peloponnesus, 190 miles. There are also 207 miles under construction.

A private company has just been formed and has obtained the necessary capital for the construction of an electric railway from the town of Lanark to Hamilton. The motive power is to be obtained from Stonebyres, one of the Falls of the Clyde.

It is stated that Sir Edward Watkin was so much struck with the water railway at Paris that he has determined to further its introduction into this country, and has accordingly offered to the French company a piece of ground near Gravesend, where they may conveniently set up their works within hail of London.

Shipbuilding on the Clyde.—During August, twenty-three vessels, aggregating 36,103 tons, were launched from the shipbuilding yards on the Clyde. Of these, nineteen were steamers, three yachts, and one a sailing ship. The output is the best of any month in the year, and with the exceptions of October, 1888, and August, 1887, is the largest for the past four or five years. The contracts booked during the month amount to 20,000 tons.

It has been resolved to use the Tivoli waterfalls as a motive power for the electric lighting of the city of Rome. Two thousand horse power will be derived from this means, and led to Rome, a distance of 30 kilometres, on the systems of Zipernowsky, Dèri, and Blathy; and, according to the *Pester Lloyd*, this is the greatest distance yet compassed by any similar arrangement. A Pesth firm, Ganz and Co., have undertaken to complete the work.

Boiler-makers and Iron Shipbuilders.—Mr. Knight's report for the past month is a rosy one. The Clyde strike, however, has cost the society about £5,000; but despite this, it appears that in the quarter the society has added £8,600 to its accumulated funds, which now amount to £73,534. The total membership is now 31,407, the highest known. The society has all the promise of a good year for the current one; but the large tonnage launched may make work scarcer for next year.

Firing a Monster Gun.—The 111-ton gun was fired at Shoeburyness on Saturday, and a few results may be interesting. Six rounds, each costing £108, were fired, and projectiles weighing 18cwt. fired by 960lb. of pebble powder were sent 12 miles. The approximate initial velocity was 1,850ft. per second The gun was fired by electricity. The concussion broke many windows in the barracks and houses in the village, which is more than half a mile from the battery. A large number of well-known artillerists were on the ground.

Strike at Keighley.—No concession having been offered to the mechanics at Keighley, near Bradford, who gave notice for 10 per cent advance all round a week ago, the men came out on strike on Thursday and Friday last. The whole of those engaged in the iron foundries and machine and tool shops, numbering fully 3,500, and comprising the bulk of the male population, are now out and firm in their determination to obtain the advance. They claim that they get lower wages than men similarly employed in any part of the country. Their behaviour is perfectly orderly.

The New Liverpool Waterworks.—On Saturday, August 17th, an important conference was held at Shrewsbury of delegates from the County Councils of Shropshire and Montgomeryshire, and also of the Town Councils of Shrewsbury, Oswestry, and Bridgnorth, and Madeley Local Board; and it was unanimously resolved to request the Board of Trade to have all embankments of reservoirs of Liverpool waterworks in Montgomeryshire and Shropshire inspected periodically by an independent and thoroughly skilled engineer. It was also agreed that other local authorities interested should be requested to pass similar resolutions. The meeting was addressed by the chairmen of the County Councils and Mayors of Shrewsbury, Bridgnorth, and Oswestry.

A New Method of Heating Houses.—The London correspondent of the *Manchester Guardian* says a movement is on foot to establish a house-to-house heating supply similar to that of gas and water. The system consists in the constant circulation of water at a high temperature and pressure (viz., at 400 deg. Fah. and 250lb. on the square inch) from the batteries of boilers at a central station through the supply mains and back to the boilers by return mains, the circulation being maintained by means of pumps. The loss of heat by radiation has been reduced to a minimum by covering the mains with a non-conducting material. Service boxes sufficient to heat three houses would be placed under the footpaths. From these boxes the house supply would be taken by means of copper pipes. At the end of the copper pipe and inside the house is fixed a vessel called a "converter," which permits the water to resolve itself into steam, the pressure of which is controlled by a reducing valve fixed on the copper pipe before it enters the "converter." From this "converter" the house service would be taken.

A Monster Casting.—Recently, at Messrs. Beardmore and Company's Parkhead Forge, Glasgow, the casting took place of an unusually large shaft for a dynamo machine. Over seventy tons of metal were run into the mould, which was sunk more than twenty feet into the ground. The casting was of Siemens steel, and when cold will be hollowed to a diameter of twelve inches. When finished the shaft will weigh about thirty-two tons. The dynamo for which the shaft is intended is being constructed to the order of the London Electrical Supply Corporation, and will be the largest in the world. The casting was in every way successful. It will take fully a week for the metal to cool.

Some Facts about the Telephone.—Contrary to what might be expected, telephonic communication is not used to the same extent in Great Britain as it is in some other countries. In the United States 739 towns are provided with telephone stations, to which there are altogether 158,712 subscribers. Turning to Europe, we find that Germany has about 33,000 subscribers to the telephone stations, distributed among 164 towns. In Great Britain, which ranks next, there are only 20,426 subscribers, or nearly one for 200 inhabitants, and London barely 4,600 subscribers. As regards the messages conveyed daily, they average 162,000 in Berlin and about 500,000 in all Germany. The other European countries which make use of the telephone are France, Austria, Belgium, Italy, and Norway.

Making Nails from Tinplate Scrap.—A New York correspondent says that besides the clippings resulting from the manufacture of various articles, an immense amount of tinplate scrap is wasted every year in the form of empty tins and other similar objects. Many processes have been devised for utilising the scrap by separating the tin from the sheet iron, but they all failed more or less, either from a technical or a commercial point of view. An American inventor has hit upon the idea of converting the tinplate scrap into nails; and, although considerable difficulties had to be overcome at the outset, it is stated that the machinery has now been so greatly improved that it enables a boy to produce nearly 1cwt. of nails in a day, the cost of the scrap in America being at present about 9d. per cwt.

The Iron and Steel Institute Paris Meeting.—The arrangements for the meeting of the Iron and Steel Institute in Paris, on the 24th and following day of September, are making satisfactory progress. A large and influential committee has been formed in Paris under the presidency of M. Eiffel (of Eiffel Tower celebrity), which will receive and entertain the Institute during its session. The Institute will be the guests of the French Society of Civil Engineers, by whom they will be entertained at breakfast on Eiffel Tower. A number of interesting papers have been promised for the meeting, including one on the mining and metallurgical exhibits at Paris, by Professor Jordan. Excursions are being organised in Paris to all the leading centres of the iron and steel industry in France, including especially the ironworks of the Loire and St. Etienne, and of the Nord. There will also be excursions to Luxembourg and the great works of Schneider, at Creusot. A large attendance is expected.

Uranium.—A few days ago the Devon and Cornish papers reported a very rich find of the rare and precious metal known as uranium. It now transpires that the discovery is of even greater importance than was at first thought. A continuous lode of this mineral has been opened, a thing perfectly unique in its history since the mineral was first discovered by Klaproth, a German chemist, exactly 100 years ago. Klaproth isolated from a dark coloured material known as pitchblende a yellow oxide which he, after testing, declared to be the oxide of a new metal, to which he gave the name of uranium, in honour of the planet Uranus which Herschel, the astronomer, had then recently discovered. Different varieties of uranium were shortly afterwards discovered in districts of Bohemia and Saxony, and after the lapse of several years traces of the precious ore were found in Cornwall. Curiously enough the enormous find of uranium at Grampound Road in Cornwall has taken place in the centenary year of the original discovery, hitherto this mineral has only been found in pockets and patches. The discovery at Grampound Road is what is known as a true fissure vein, and the ore contains an average of 12 per cent of the pure metal, going up as high in many places as 30 per cent. The importance of the discovery will be understood when it is stated that the market price of the pure metal is £2,400 per ton.

A New Development in Naval Architecture.—An attempt is being made by Mr. A. H. Lucas, St. Louis, Missouri, to construct a vessel which can be utilised alike for river and ocean navigation. With this view he has designed a ship with an adjustable keel, which can be raised or lowered according as the depth of water varies. According to Mr. Lucas, the Mississippi river is too shallow to accommodate ocean steamers of ordinary construction, and it is the purpose of the adjustable keel to overcome this difficulty. To this end a raft has been designed by him, combining a river steamboat and an ocean steamship. The ship has two hulls, united at their forward end by a solid bulkhead, and having an open space between them towards the stern. These hulls are intended as holds for the cargo, and will also afford space for the accommodation of part of the machinery used in propelling the vessel. Each hull will have a stationary keel. Between these hulls will be an adjustable keel which can be lowered and raised at pleasure, the adjustable keel being the old principle of the centre board applied to sea-going ships of considerable tonnage. Supposing the ordinary draught of a 1,000 ton ship is 7ft., under these conditions she could run up a river like the Mississippi as far as St. Louis at nearly all ordinary stages of water. When she should be called upon to go to sea, her false keel can be lowered to 14ft. below the line of her normal draught, giving her a total practical immersion of 21ft., with corresponding resistance to storm or wind pressure above. When in use, the upper part of the drop keel is held firmly in place by stout steel braces, constructed along the entire length of the inner sides of the two hulls. The mechanism for raising and lowering the drop keel will be mounted in connection with the engine shaft of the vessel. From the bow to a point over the forward end of this keel the ship is to be built solid, with water-tight compartments. Her engines are to be of the triple-expansion type, and her motive power the twin screw. If the new system of propulsion proposed should be found practicable, an extraordinary rate of speed (25 miles an hour) is said to be assured, the construction of the ship affording facilities for the use of auxiliary twin screws, placed near the stern of each hull. An experimental vessel, to be called the St. Louis, is to be constructed by Messrs. Cramp and Sons, Philadelphia.—*Iron.*

A New Patent Fire Detector.—A large company of gentlemen travelled by special train from London Road Station, Manchester, to Newton, on Thursday afternoon, August 29th, for the purpose of witnessing a test exhibition of a new patent fire detector and alarm which had been temporarily fitted up in the mills of Messrs. F. W. Ashton and Co., Hyde. Mr. W. E. Smith was present at the demonstration on behalf of the patentees, and explained that the apparatus was a development of a Polish invention in which the actuating power was electricity. He claimed that the new detector is equally suitable for buildings of any extent, for vessels, for railway trains, and for collieries. The apparatus, which is worked solely by pneumatic agency, consists of a box or air chamber, hermetically sealed, and an arrangement of flexible discs connected with the box by piping of any desired length. The air chamber is fixed on the ceiling of any room, and the piping may be carried to a convenient centre for raising the alarm, where it is connected with a "tell-tale" mechanism, comprising an arrangement of levers and weights which set the alarm bell in motion, while automatic labels indicate the exact locality of the outbreak. The piping and the ceiling chamber together form the air storage, and the patentees claim that should a fire of the smallest extent take place in a room provided with the detector the heated temperature will at once expand the air in the chamber, and the expansion will extend throughout the length of the piping till is reaches the discs, when the alarm will ring. An important detail in the working of the apparatus is that the air chamber may be regulated to act at any of temperature, thus obviating the risk and inconvenience of raising a false alarm. The test on Thursday afternoon was almost needlessly severe, the ceiling of the room in which the "detector" was exhibited being divided into a series of arches, the formation of which militated against the distribution of heat. Notwithstanding this disadvantage, however, the apparatus responded rapidly to the influence of each one of several small fires kindled near the centre of the room, the only failure which was experienced being when currents of fresh air from open windows displaced the heated atmosphere, and left the air chamber unaffected.

A New Fireproof Non-conductor for Pipe and Boiler Coverings.—In all non-conductors the endeavour is to provide as large a number of air cells within a given space as possible, in a material that is itself very light, such materials having been found by experience to best confine the heat. The lightness, porosity, and elasticity of the common sponge, composed as it is of fine flexible, tenacious fibres, interwoven in the form of cells and meshes, constitute the ideal structural qualities for a perfect non-conductor. Taking advantage of this fact, Mr. H. W. Johns, of New York, has succeeded in perfecting a new article of manufacture styled asbestos sponge, which has been patented in this country and Europe, and has been but recently put on the market by the H. W. Johns Manufacturing Company in various practical forms as a non-conductor, notably as a covering for steam pipes and boilers. The tentacle-like barbs of the sponge, as prepared in the manufacture, are so intertwined with the fine silky fibre of the asbestos as to make a material at once very elastic and highly porous, while at the same time it is so light that a barrel of it, in the form of filling, barely weighs 50lb. And this, too, is effected with the use of so small a percentage of sponge that the material is practically fireproof. A sample of this filling which was in practical use for several months as a covering for a steam pipe in which a pressure of 100lb. was constantly carried, on being taken off and examined showed the same vitality and "spring" which it had when put in place, the sponge portion of the compound not being at all affected, while, of course, it was impossible for the heat to touch the asbestos. The new material is stated to have double the bulk or covering capacity of the same weight of hair felt, and more than three times that of pure asbestos, making it cost, as stated, less than that of any other material employed for similar purposes. It is also supplied in the form of an asbesto-sponge felt and an asbesto-sponge lined felt, furnished in rolls of varying thickness, as well as in an asbesto-sponge cement felting. This latter composition partakes of the nature of a felt and a cement, and is put up dry in barrels to be mixed with water to the consistency of mortar, for applying to steam pipes, boilers, &c., while heated; also coming extensively into use for covering locomotive boilers.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

June 17th, 1888.

9898A	Dampers, J. Keith, Glasgow.*

August 13th, 1889.

12753	Heating Water, E. Brasier, London.
12754	Conduits, F. H. Lloyd, Middlesex.
12764	Lubricators, H. H. Lake, London. (J. Powell, United States.)*
12783	Centering Tool, J. E. Berkley, London.
12786	Reciprocating Engines, E. G. M. Donnithorne, London.
12790	Stamping Metal Plates, D. Edwards, London.
12793	Cleaning Tubes, W. French and A. P. French, London.

August 14th.

12811	Casting Metal, T. Hydes and S. W. Wilkinson, Sheffield.
12815	Electro-motors, F. V. Andersen and J. O. Girdlestone, Manchester.*
12835	Gauges, W. Gordon, London.
12840	Valves, D. Halpin and I. A. Timmis, London.
12851	Motor, E. Wortmann, London.
12855	Furnaces, T. Cain and T. A. Cain, London.
12863	Drying Apparatus, V. F. L. Smidth, London.
12864	Buffers, W. Somers, Middlesex.

August 15th.

12872	Gas Governor, W. J. Gordon, Liverpool.
12885	Air Superheater, M. Miller, Glasgow.
12889	Cement, T. Smith and R. B. Wager-Tayler, London.
12892	Liquid Meters, S. Gillson, London.
12900	Railway Ties, T. R. Dunning, London.*
12905	Liquid Meters, R. Jewell, London.
12907	Motor Engines, O. Imray, London. (J. C. Grabner and H. Ruperti, Germany.)*
12915	Gas Lamps, J. Lewis, London.
12917	Propulsion of Ships, R. Stone, London.

August 16th.

12927	Hydraulic Jacks, D. T. Young and H. W. Young, Birmingham.
12944	Lubricators, P. M. Sharples, Reading, Pennsylvania, United States.*
12945	Casting Metals, H. E. Cooper, London.
12946	Lubricator, C. H. Sims, Leeds.
12947	Safety Bars, T. P. O'Donnell and I. A. Timmis, London.
12950	Gas Engines, H. P. Ibotson, London.
12958	Fire Escapes, S. H. Sprague, London.
12969	Pulleys, G. A. Wilkins, London.
12970	Telegraph Instruments, J. E. Wright and J. Moore, London.

August 17th.

12987	Doubling Machines, W. T. Glover, Manchester.
12988	Carding Engines, G. Ashworth and E. Ashworth, Manchester.
12995	Buffers, S. S. Miller, London.
12999	Hot-air Engines, C. Wells, London.
13005	Boilers, J. E. L. Ogden and J. Daglish, London.
13011	Lamps, F. Sperling, London.
13014	Drilling Metal, G. Butler and T. Kendrick, London.
13016	Mineral Oils, J. Dewar and B. Redwood, London.
13019	Propeller, H. Barcroft, London.
13024	Dredgers, R. Wright, London.

August 19th.

13037	Scutchers, J. Adamson, London.
13038	Governors, J. Whitehouse, Birmingham.
13045	Aqueduct, E. Birch, W. Hallam, and J. Scott, Manchester.
13047	Arc Lamps, J. H. Rider, Halifax.
13049	Ball Valve, J. W. Turnpenney, Wood Green.
13058	Evaporating Apparatus, C. W. Guy, London.
13062	Printing Machines, J. Foster, F. Foster, J. Y. Foster, and A. F. Battey, London.*
13064	Condenser, H. S. Maxim, London.
13070	Brakes, L. Soulerin, London.
13073	Buffer, J. Brown, T. H. Jones, and J. C, Oakman, London.

August 20th.

13086	Consuming Smoke, W. Burns, Glasgow.
13107	Steam Boilers, G. Lentz, London.
13117	Couplings, J. H. Smith, J. F. Knuth, G. Thompson, and J. Ewald, London.
13118	Moulding Planes, A. M. Clarke, London. (D. Babbitt, United States.
13122	Safety Devices, J. B. Torr, London.
13124	Pulley Blocks, E. H. James, jun., London.
13125	Printing Machines, J. Foster, F. Foster, and J. Y. Foster, London.*
13130	Steam Engines, P. W. Willans and M. H. Robinson, London
13148	Electric Motors, T. Parker, J. H. Woodward, and E. S. G. Rees, London.
13150	Looms, R. B. Loynd, London.*

August 21st.

13159	Safety Lamps, F. Mori and O. Y. Rhodes, Halifax.*
13169	Packing, W. M. Crawford, Bristol.
13171	Slide Valves. H. W. Houlden, Doncaster.
13172	Conduits, F. V. Andersen, London.*
13174	Driving Belts, W. Horn, London.*
13183	Lighting Railway Carriages, J. Radcliffe, East Retford, Nottingham.
13189	Utilising the Rise of Tides, W. Brindle, Liverpool.
13195	Coal Gas, W. F. K. Stock, London.
13205	Lock Nuts, W. R. M. Thomson, Glasgow. (A. K. Leitch, Ceylon.)
13211	Moulding Machines, A. L. Teetor, London.*
12213	Motor Engines, H. Fussner, London.
13222	Steam Generators, G. Dürr, London.*

August 22nd.

13229	Wind Engines, J. Adams, Kent.
13239	Blowers and Exhausters, W. A. Carlile, Birmingham.
13240	Valve Gear, M. Wilson, Glasgow.
13248	Wrench, S. Buckley, Guide Bridge.

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of Nos. 1 to 10 can be obtained at either of our Offices in London or Manchester, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., can be obtained by order from any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of the amount by postal order or stamps.

Vol. II. (bound), price 7s. 6d., is now ready, and may be obtained as above.

Cases for binding Vol. II., price 1s. 6d., are now ready, and may be obtained through any Newsagent, or will be forwarded direct from our Manchester Office on receipt of the amount in postage stamps.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Editorial Notices.

All communications for the Editor of this Journal should be addressed to 6, Victoria Station Approach, Manchester.

Communications intended for insertion in the current week's issue should reach us not later than by first post on Tuesday.

We cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped and directed envelope.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

To Advertisers.

Advertisements intended for insertion in the current issue should reach our Manchester Office by first post on Tuesday.

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THE
PRACTICAL ENGINEER,

SEPTEMBER 13TH, 1889.

COMPARATIVE STEAM-RAISING EFFICIENCY OF LANCASHIRE AND WATER TUBE BOILERS.

THE report of the chief engineer, Mr. Michael Longridge, of the Engine, Boiler, and Employers' Liability Insurance Company for 1888, has just been published, and it contains, among other interesting notes, in Mr. Longridge's usual careful and complete style, tests of the evaporative efficiency of two Lancashire boilers with economiser, and also tests of a water-tube boiler of the best type. In view of the prominence which the water-tube type of boiler takes on the Continent, at the Paris Exhibition, where its almost universal adoption would lead us to believe in its use, exclusive of all other types, and the great improvements which have been made in its details through the past decade, it will interest our readers to examine carefully the results which are here published. According to some engineers, the great increase in boiler pressures which has been steadily going on for years, and so far shows no signs of having attained finality, will compel us to abandon the leading types at present prevailing, and adopt the water-tube type in preference to the Lancashire, locomotive, or marine types. It is argued, and with great show of reason, that for very high pressures the safest system is that which dispenses with vessels of large diameter, and confines steam under the pressures required in tubes of small dimensions, which offer facilities for a great margin of safety. It is also urged by the advocates of the water-tube system that Lancashire boilers can only be made economical by the use of economisers, and that heating surface is best obtained in the boiler itself without adventitious aid from additional tubes.

There is, doubtless, considerable truth in this position, and the fact that the water-tube system is adopted so extensively throughout the world, under some circumstances, makes it impossible for us to adopt the standpoint of some of our correspondents in a recent discussion in our columns on the subject. Considerable progress must have been made in overcoming practical difficulties, and they must suit many circumstances admirably, to secure the position which they have done in Britain, America, and on the Continent. Still, the Lancashire type is undoubtedly the favourite with us at present, whatever may be in store for us in the future; and where there is space enough, and there is no difficulty in the transport of heavy weights, it is exceedingly efficient, and from the point of economical consumption of fuel it is difficult to rival, especially when combined with an economiser. The two Lancashire boilers tested by Mr. Longridge were 30ft. by 7ft. diameter, with internal flues of 2ft. 9in. diameter, having five Galloway tubes in each. The fire-grates were 6ft. long. The economiser consisted of 80 pipes, in 16 rows, and it had been at work since 1866, but the quantity of deposit within the pipes was unknown. Trials were made on the 9th and 10th October, 1888. On the first day the weight of air passed through the furnaces was 20·71b. per pound of coal, and the efficiency of the boilers was 62·86 per cent—that is, 62·86 per cent of all the heat which could be evolved by the combustion of the fuel was actually applied to its intended work within the boiler itself. On the second day the weight of air passed was 14·81b. per pound of coal, and the boiler efficiency rose to 71·57 per cent, which demonstrates emphatically the great loss occasioned by using an undue excess of air. In both cases the economiser was measured separately, and the combined efficiencies of boilers and economisers for the two days were respectively 70·96 and 78·38 per cent.

These results are most interesting, not as proving any previously unexampled economy, but as showing what a Lancashire boiler with economiser can do when in ordinary repair and working condition. The boilers were cleaned and the flues swept three days before the trial, but the economiser had been in use for no less than 22 years, and yet the united heat absorbing effect was such that out of 100 heat units, supplied in the form of fuel, in the best test, nearly 78·4 per cent, was actually applied to the work of evaporation, and only 21 6 per cent passed away in hot gases up the chimney, and by all other sources, such as imperfect combustion, radiation, and so forth. Better results have been obtained with new boilers and feed-water heaters or economisers, specially got up for trial, even with small engines, as in the case of the Society of Arts motor trials, when the Davey-Paxman locomotive boiler gave an evaporative efficiency of 82 per cent; and if we remember aright, Mr. Longridge has had previous trials with other Lancashire boilers and economisers giving nearly 85 per cent efficiency. There can be no doubt at all that the Lancashire boiler, with proper economiser, can be made to give the maximum economy possible from any type of boiler, and on that point it does not appear the least likely that it will ever be superseded. Notwithstanding this, it might be that, in pursuit of greater engine economy, steam pressures may rise beyond those suitable for large cylindrical boilers, and it might be advisable to adopt a boiler slightly inferior in economy in order to use very high pressures, and so get a greater gain in engine efficiency than is lost in boiler efficiency. If, however, the change of type necessitated too great a loss in boiler efficiency the increased engine economy would be unable to compensate for that loss. Perkins, and most of the early advocates of very high-pressure steam, preferred the water-tube type, but so far that type does not seem to be used for higher pressures than others. Mr. Longridge's trials of the best water boilers are valuable as showing the relative economy of such boilers, and in a test in April of last year the best test out of three showed an evaporative efficiency of only 54·36 per cent, and it appeared from the measurements made that only 22·6 per cent passed away in the burned gases, so that but little could have been recovered by using an economiser. Nearly 5 per cent was lost by imperfect combustion, and another 5 by unburned carbon falling through the firebars. The remaining 13 per cent was lost by radiation and transmission through brickwork.

The radiation loss is far heavier than that due to the same cause in Lancashire boilers, and this is due to the fact of the high temperature flame playing on the interior of the brickwork and heating it up. If the furnace could be enclosed in walls of water tube, as in Thorneycroft's boiler, this loss could doubtless be greatly diminished. Comparing the efficiency of this water-tube boiler with the first trial we have mentioned of the Lancashire boiler alone, it stands 54·36 per cent against 62·86, so that it is almost eight per cent worse; but it must be remembered that that water tube is a much smaller boiler than either of the Lancashire, so that while they consume between them some 1,200lb. weight of fuel per hour, the water tube only consumes 271lb. per hour. This of course places the latter at a great disadvantage, as a small boiler must necessarily lose more heat by radiation and conduction than a large one. It is true that Mr. Longridge found a similar result in 1887 with a boiler burning about 905lb. of fuel per hour, but that fact would seem to prove a distinct advance either in construction or care in handling, otherwise the smaller boiler would undoubtedly prove the least instead of the most economical.

In our opinion, the water-tube boilers may yet equal the Lancashire in economy, and still retain the advantages peculiar to themselves of light weight, easy transport, and small tubes, and the makers of such boilers cannot do better than study Mr. Longridge's careful determinations to aid them in their work. We do not think that any type of boiler can ever surpass the Lancashire in its best form for economy, as many boilers are as nearly perfect as necessary practical loss will allow. The heat lost in chimney gases is only about 10 per cent, for example, and it would be difficult to imagine less so long as we depend upon their temperature to produce the necessary draught, and 6 per cent seems little for radiation, conduction, and so forth, when we think of the extent of the surfaces exposed.

There are two points in the report to which we would call Mr. Longridge's attention. In our opinion, it is needless to use the second place of decimals in stating percentages, as the error of experiment far exceeds any correction furnished by that figure, and the statement of furnace temperatures as 2,574 deg. F. and 3,491 deg. F. are plainly erroneous in view of the experiments of Mallard and Le Chatelier, in France, and Clerk, in this country. The true average temperatures probably but little exceed half those numbers. However, those figures do not affect the result, except in giving erroneous ideas as to the temperatures existing.

EXPLOSION AND PETROLEUM FIRE AT ANTWERP.

On Friday last about 2,000 tons of cartridges exploded in an ammunition factory at Antwerp, producing an effect resembling an earthquake throughout the city. Many buildings were seriously damaged, and all the glass windows within miles of the scene of the explosion have been broken by the concussion. By some almost incredible folly not only was the cartridge factory within the boundaries of the city, but it was close by the great petroleum stores, and the explosion was immediately followed by a stupendous fire. The oil-fed flames rose to great heights and filled the whole city with dense fumes and smoke; it was impossible to subdue them, and all that could be done was to prevent their spreading to other buildings. The oil flowed into the cartridge factory and burned upon the ground where cartridges were buried, so that for the two days the fire continued smaller explosions were constantly taking place, and many persons were killed by the bullets. It is estimated that over 200 have been killed and 400 injured.

We are pleased to feel that the law in Britain is much more strict upon the storage and manufacture of explosives than it is upon the Continent, and such an enormous accumulation as 2,000 tons of explosives would not be permitted within our city boundaries. The provisions, too, for isolating dangerous processes of manufacture, to limit explosions as much as possible, have effectually prevented really extended explosions among ourselves. Still the dangers of petroleum storage are forcibly seen from this catastrophe, and it is to be hoped that great care will be taken to completely isolate the great petroleum tanks which are becoming common at our seaports. In view of the increasing tendency to store oil in bulk by pumping directly from the numerous tank steamers now running, it is to be feared that we shall not learn all the precautions necessary till we experience some catastrophe ourselves.

ELECTRICAL TREATMENT OF SEWAGE AT ROUEN.

Experiments have been concluded at Rouen upon the treatment of sewage by electrolysis, which are said to be successful. The details are different from Mr. Webster's process, tested here. He, our readers will remember, uses iron electrodes and a dynamo. In Rouen zinc is used for the negative electrode and platinum for the positive, and common salt is added to the solution. We suppose that under the circumstances chlorine will be evolved if the water be slightly acid, and this will attack the organic matter. But zinc must be dissolved, and we fear the expense must prove an insuperable obstacle. It is not at all difficult to purify sewage to complete satisfaction on the laboratory scale, but it is entirely different when commercial considerations step in.

THE DOCK LABOURERS' STRIKE.

Notwithstanding the intervention of the Lord Mayor of London, the Bishop of London, and Cardinal Manning as intermediaries between the men and the dock directors, the strike still continues. The dock directors, through their chairman, Mr. Norwood, on Saturday last offered to concede a portion of the demands of the men by increasing the rate from 5d. per hour to 6d. per hour, but as they postponed the operation of the advance till January, and made no mention of overtime, the men considered that they were being trifled with, and decided to reject the compromise. We cannot blame them for this decision. Mr. Norwood's letter was a most artful one, which would be certain to lead to misunderstanding if its terms were accepted.

It is disappointing to find both sides still firm, but the present strain cannot last long now, and must end very shortly. We hope that this will have occurred before this reaches our readers.

FRENCH TELEPHONE LINES.

The Parisian and departmental telephone lines were taken possession of by the State on Monday, September 2, but as no arrangements had been concluded with the telephone companies, their officials objected, and only yielded to formal force. It is said that the French Government require the lines mainly to inform themselves of what goes on during the forthcoming elections.

ELECTRIC LIGHT ON RIVER STEAMERS.

The Thames river steamers Alexandria, Glen Rosa, Duke of Edinburgh, and Cardinal Wolsey have been fitted with the electric light instead of the time-honoured but inconvenient oil lamps. On board the Alexandria thirty 16-candle incandescent lamps have been fitted, the dynamo being driven by a Tangye steam engine, running at 230 revolutions per minute. The other vessels are similarly fitted, and some have Hindley and others Tangye steam engines. In all cases the engines are supplied from the main boilers.

The lighting is very satisfactory, and is greatly appreciated by the passengers.

AN AMERICAN AUTOMATIC CUT-OFF GEAR.

We are indebted to our transatlantic contemporary, the *American Engineer*, for particulars of an interesting form of cut-off gear, used upon the steam engine constructed by the Providence Steam Engine Company, which we illustrate at figs. 1 and 2. The valve gear is instructive as an example of automatic variable cut-off, adapted for use with slide valves, in which the use of springs is entirely obviated. In the Greene engine, as it is called, all the valves are of the slide type—two inlet and two exhaust valves being required. The inlet slides are opened to admit steam by a sliding bar, driven from an eccentric, which slide carries movable tappets, whose position is varied by the governor. The governor used is of the standard Porter type.

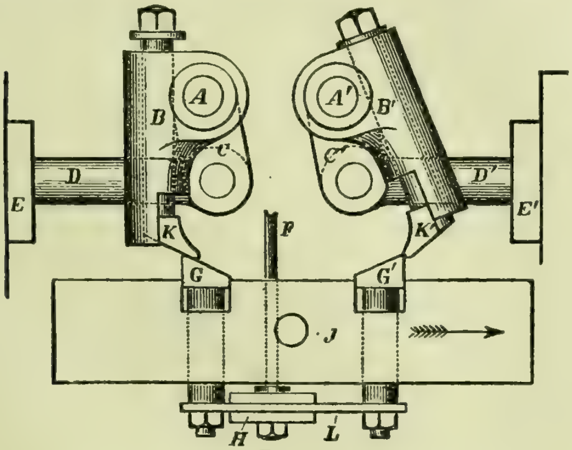


Fig. 1.

Referring to our illustrations, fig. 1 is a diagrammatic elevation, and illustrates the action. A, A^1 are rocking shafts, carrying levers C, C^1 and B, B^1 at their respective extremities, and connected to the slide valve stem D, D^1, so that when the levers B, B^1 are moved the valves are opened. The sliding bar J is driven to and fro from an eccentric, and carries with it the adjustable tappets G, G^1, which may be moved up or down by the governor from the rod F, by the sliding piece H and the plate upon which it slides L. When the sliding bar moves in the direction of the arrow the valve attached to the stem D^1 is opening, but as the tappet G^1 is moving in a straight line, while K^1 must describe an arc, being attached to the rock shaft A^1, it follows that at a certain position G^1 will slip K^1, and the valve will be free to be closed. Immediately this occurs the slide valve at once closes under the influence of a weight and the steam pressure upon the valve D^1.

Fig. 2 is a perspective view of the gear. The rod hanging down in the front from the end of the lever attached to the rocking shaft is attached to the weight, and tends to close the valve immediately the tappet is released. The action at the other end of the slide bar by the tappet G upon K is the same upon the valve stem D. Upon the return stroke, after letting go each tappet G, G^1 slips under K, K^1 lifting them up and allowing them to fall after passing in order to take a fresh hold. The governor controls the positions of G and G^1 vertically, so that they rise or fall simultaneously. When full up, the steam is carried well on in the stroke, as the levers must move through a great arc before tripping and releasing the valve. When the engine runs too fast, the tappets G, G^1 are pulled down, and the valve is liberated early, and so cuts off early.

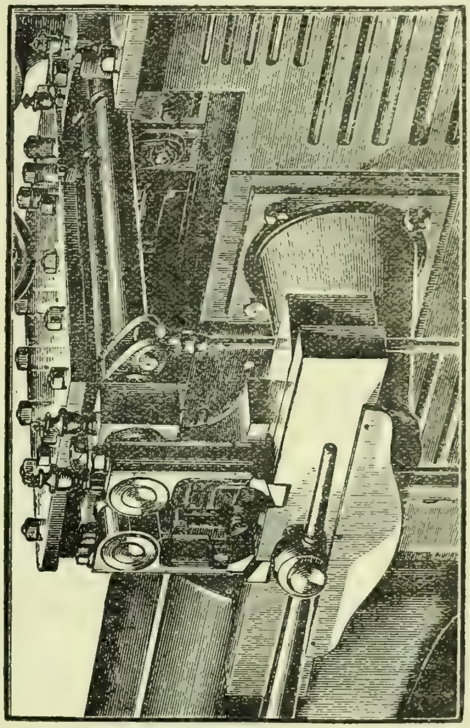


Fig. 2.

The gear is ingenious and simple, but we should think that the point of cut-off will be apt to vary considerably with the condition of the advance edges of the tappets. It also appears to us that the governor has a good deal to do in order to hold the tappets up against the depressing action of the rocking levers, where the angle is considerable. The gear, we are informed, is widely applied in America, and is exceedingly efficient.

A Portable Telephone.—It is the invention of an Austrian railway servant, and by the reports of it to hand it promises to be an instrument of great usefulness in railway working. By it a railway train, no matter where stopping, may be put in communication with the nearest station. The railway authorities are now experimenting with the instrument.

BENDING STRESSES IN FRAMEWORK.

By Francis Campin, C.E.

In designing the framing of machinery it is always desirable so to arrange its component parts that the stresses upon them shall be, as far as practicable, of a direct character—simple tension, compression, or shearing; but this cannot always be done, and there are many positions in which bending stress is unavoidable. With this class of stress as affecting framework we shall deal in the present article.

In the matter under consideration the equilibrium between external moments of stress and internal moments of resistance requires to be examined in regard to the conditions under which it can exist. The external moments being the simplest to treat, we will in the first place dispose of those. As the expression "moment of force" is not in itself very explicit, it may be as well to define it. It is, then, the amount or intensity of a force multiplied by the least distance of its direction from a point about which it acts. In fig. 1 let P be a force acting in the direction of the arrow about a point a; produce the line of direction to c some point beyond a, and upon the line so produced, from a draw the perpendicular $a\ b$; then $a\ b$ will be the shortest distance from a to the direction of the force P, and the moment of that force about a will be $M = P \times (a\ b)$. Thus, if P = 120lb. and $a\ b$ = 29in., $M = 120 \times 29 = 3480$ inch-lbs. The form of the attachment through which the force has to be transmitted does not in any way affect the value of the moment at a given point if there is no intermediate connection with any other supporting point. Thus, if a weight W be supported by a curved arm or cantilever $e\ k\ f$, and the lines $e\ g$ and $k\ i$ are drawn at right angles to the vertical line $f\ m$, which is the direction in which the weight W acts, the moment at e will be $M = W \times e\ g$, and that at k $M = W \times k\ i$. If a bar be supported at both ends, as shown at A B, l being equal to the distance between the supports, and x the distance from one of the supports to the point at which a force P acts upon the bar at right angles to its length, the moment is found as follows: The pressure P is equilibrated by the re-actions of the supports A and B, and by the principle of the lever the action upon B, and, therefore, its re-action, which must be equal and opposite, will be $R = \frac{P \times (l-x)}{l}$, and the moment of this force about the point at which P acts will be—

$$M = R \times x = \frac{P\ (l-x)\ x}{l} = P\ x = \frac{P\ x^2}{l}.$$

The moment at any point between this and the support B will be equal to R multiplied by the distance of the point from B. The moments on the other side towards A can, of course, be similarly determined. If, however, the force does not act at right angles to the bar A B, let it act in the direction of P^1, and let y equal a line drawn from A at right angles to this direction; then the re-action at B will become $R = \frac{P\ y}{l}$, and this value must be inserted in the formula $M = R\ x$. Next, let there be a bar C D carrying a uniformly distributed load equal to w lbs. per foot of length, the total weight will be $w\ l$, and half of this will be carried on each point of support; therefore, the re-action of each support will be $\frac{w\ l}{2}$, acting upwards; at another point distant x from the support the moment of this re-action will be $\frac{w\ l\ x}{2}$. There is also another weight acting about the same point, but downwards. The amount of this is that part of the load between the support and the point at which the moment is required, and is $w\ x$; this may be regarded as concentrated at its centre of gravity, which is its centre of length; its distance then from the given point is $\frac{x}{2}$, and its moment $w\ x \times \frac{x}{2} = \frac{w\ x^2}{2}$. These moments acting in opposite directions, their difference must be taken for the resultant moment, and

$$M = \frac{w\ l\ x}{2} - \frac{w\ x^2}{2} = \frac{w}{2}\left\{l\ x\ \ x^2\right\}.$$

When the bars are fixed, instead of only being supported at the ends, the results will be different; but in treating of this case reference must be made to the moment of resistance; hence it will be deferred until they have been determined. When two equal forces P and P^1 act in opposite directions on a clamp-shaped piece $o\ r\ n$, the maximum moment will be at $r = P \times (q\ r)$.

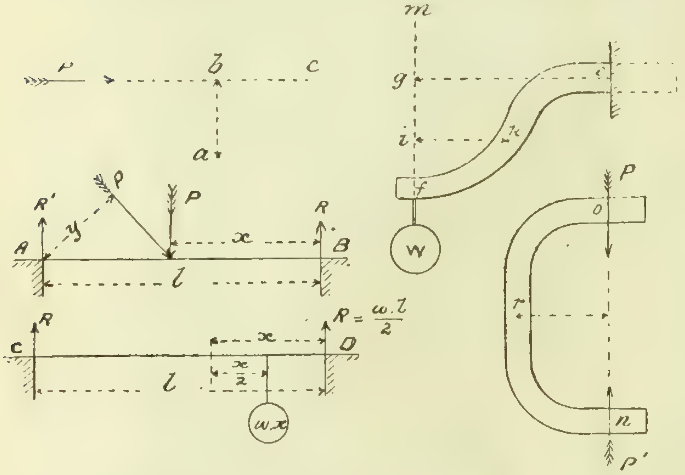


Fig. 1.

The moments of resistance to bending will be determined from an examination of the behaviour of elastic beams under bending forces, and this we shall now make in the simplest manner. In the first place, it is assumed that so long as the elasticity of the material is not injured—that is to say, that no permanent extension or compression is caused—the extensions and compressions are in direct ratio to the forces producing them.

In fig. 2, AB represents a part of a beam of rectangular section, unacted upon by any external stress, and A^1B^1 shows the same when the beam is deflected by some external moment of stress. In order that equilibrium may exist, the external and internal moments of force must be equal in intensity and opposite in direction.

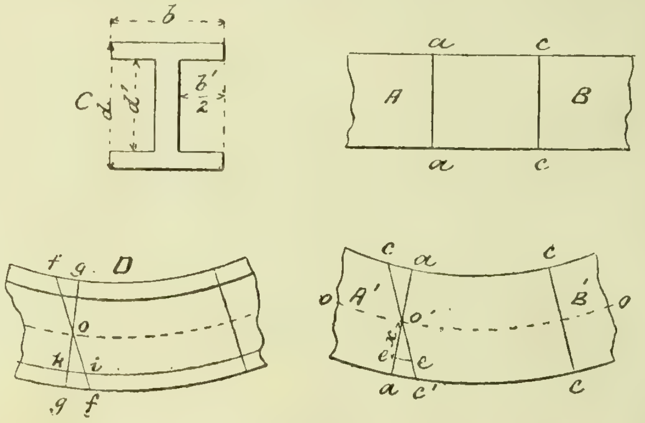


Fig. 2.

On the part AB, while unstrained, let there be drawn at right angles to its length the parallel lines ac and cc; these will represent edges of imaginary sections traversing the beam at right angles to its axis. When the beam is bent, as shown at A^1B^1, these lines will no longer be parallel, but inclined to each other, as appears in the diagram; the fibres of the material will be compressed on the concave surface, and extended on the convex surface of the beam. This being the case, there must exist within the beam some surface between the extended and the compressed fibres where there is no stress at all, and this is called the neutral axis, or, more properly, the neutral surface. Its position is indicated by the dotted line $o\ o_1\ o$. Through the point o^1, where the line aa cuts the neutral surface oo^1o, draw cc^1 parallel to the straight line co; then the distances cut off between c^1a and ac^1, measured parallel to oo, will be the compressions and extensions of the fibres in a length originally equal to ac. From this it will be observed that the extension of any fibre or layer of fibres ee will be to that of the external layer as their distances from the neutral surface—that is, as x is to h. If s equals the resistance of the external layer of fibres per sectional square inch, that of the layer ee will be $\frac{sx}{h}$; and if b breadth and t equals thickness of layer in inches, its direct resistance will be $s.\ b.\ t.\ \frac{x}{h}$, and the moment of its resistance about o_1 will be $s.\ b.\ t.\ \frac{x}{h}.\ x = s.\ b.\ t.\ \frac{x^2}{h}$. We cannot imagine a layer with the thickness t so small that the stress will be equal on both surfaces, but the surface ao^1c^1 represents the sum of all the resistances between the neutral and external surfaces of the beam, and the centre of action of these forces will be the centre of gravity of the triangular surface ao^1c^1, and h being the height of the triangle, this point will be distant from o by $\frac{2h}{3}$. The sum of the resistances will be $= b \times \frac{sh}{2} = \frac{sbh}{l}$, and the moment of resistance for the lower part of the beam

$$= \frac{sbh}{2} \times \frac{2h}{3} = \frac{sbh^2}{3}.$$

If the elasticity is the same in compression as extension, and $d =$ depth of beam in inches, then the whole moment of resistance of the section is—

$$M = \frac{2 \,.\, sbh^2}{3} = \frac{2sb}{3} \times \frac{d^2}{4} = \frac{3bd^2}{6};$$

because $h = \frac{d}{2}$. As the moment of resistance must be equal to that of stress, the formula for each case is found for solid rectangular bars by equating this value of M with that obtained above.

In figure 1, for the bent bracket $M = W \times eg = \frac{sbd^2}{6}$; therefore $bd^2 = \frac{6\,W \times eg}{S}$; s is the maximum stress per sectional square inch allowed, and this, calculated from experiments on transverse strength of cast iron, will be 48,000lb. for the best, or 40,000lb. for average metal, divided by a factor of safety. Now, considering the jar and vibration to which machine frames are subject, the factor of safety should not be less than 6 ; therefore the working strength for average cast iron will be 6,666lb. Then

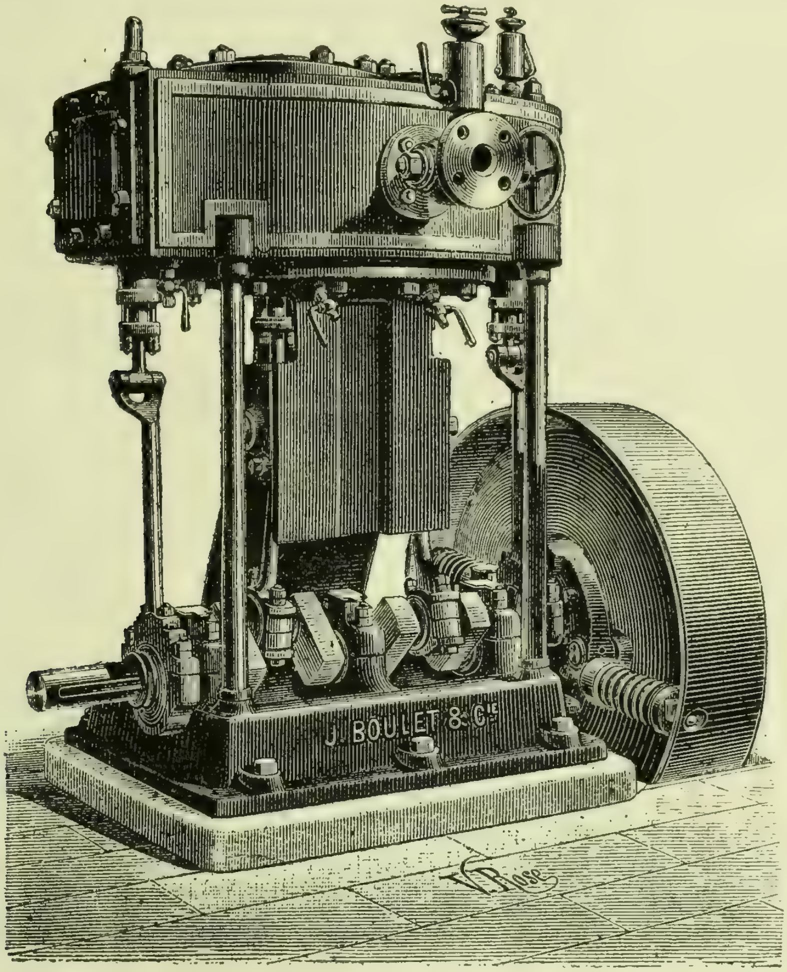
$$bd = \frac{6\,W \times eg}{6666} = \frac{W \times eg}{1000};$$

from which, either the breadth or depth being given, the remaining dimension can be determined. The strength of solid rectangular wrought-iron bars is half as much again, so for that material $bd^2 = \frac{W \times eg}{1500}$, all dimensions being in inches, and weights in pounds. The point in the section (such as k) must always be taken in the neutral surface, which will lie in the centre of gravity of the section.

(To be continued.)

COMPOUND VERTICAL ENGINE AT THE PARIS EXHIBITION.

Messrs. J. Boulet et Cie., engineers, Paris, exhibit largely at the exhibition, and among other engines they show the very neat compound vertical engine we illustrate here. This type of engine is made in sizes of from twelve to two hundred and fifty horse, and the makers claim great compactness and power by adopting what is materially the marine type of engine. The steam supply first enters the cylinder jackets, and then passes by a piston valve to the high-pressure cylinder, from which it enters an intermediate receiver. From this receiver it is admitted to the low-pressure cylinder by "trick" or gridiron slide. The governor consists of two heavy hinged weights placed within the flywheel, which also serves as the driving pulley, and resisted by springs seen in the illustration. It acts upon the piston valve eccentric, and alters the point of cut-off, but does not affect the low-pressure valve.



COMPOUND VERTICAL ENGINE AT THE PARIS EXHIBITION.

When it is used as a condensing engine, the condenser and air pump are placed at the end of the shaft, and below the foundation, and the air pump is driven from a disc crank. The piston rods, crank shaft, connecting rods, &c., of the engine are of forged steel, and the rubbing surfaces are tempered.

The inverted cylinder type of engine is well represented in the Machinery Hall, and it appears that in France this variety is much more common for land work than it is with us. There are several points which we cannot altogether approve, such as taking the steam supply entirely into the jackets, and the style of governor cannot be as sensitive as those mostly used in this country. Still the engine is very simple and neat in design.

STEAM PLANTS FOR ELECTRICAL SERVICE.*

Few industries of modern years have shown the wonderful growth that has characterised the manufacture and use of the various forms of dynamo electric machinery. Less than ten years ago the arc electric light was just becoming known, and the incandescent lamp was scarcely more than a curiosity, while the electrical transmission of power was hardly thought of. To-day there are few towns of 3,000 inhabitants but boast their arc or incandescent electric lighting plants, and many smaller places are fully as progressive. In the large towns and cities the great business houses have their own plants, and central stations whose capacities are measured by the thousands of horse power are not uncommon. Add to these the electric railway, which has now demonstrated its success, and we get an idea of the vast possibilities of this field of energy, which is still in its infancy. While many of the earlier stations did not prove as successful financially as was anticipated, the test of continuous and regular service has pointed out the weak places, and they have been remedied. When careful business sagacity and caution are exercised—as they must be in any successful venture—the electrical industries to-day offer excellent returns to the capitalists. Perhaps the best evidence of this lies in the gross capacity of plants now in operation, estimated at 750,000 horse power, and fast nearing one million.

The world waits impatiently for that immortal inventor whose genius shall show us how to produce electricity direct from coal. We must take things as we find them, however. Our boilers and furnaces give back in steam less than 80 per cent of the energy of the coal burned. This steam does work in a wofully imperfect engine, utilising less than 15 per cent of the heat units. This engine, in turn, drives the dynamos by which the electric current is generated. After distribution, the current re-appears in the form of the electric light—there being a further loss of say 10 per cent in each of the last steps. It is evident, therefore, that in the best plants less than 10 per cent of the energy in the coal consumed is reproduced in the form of light. The poor plants, which are far more common, do not reach 5 per cent.

And yet within these appallingly low figures there is abundant room for study. The conversion of fuel into electric energy has caused the development of steam plants adapted specially for this service. The business of these stations is, in fact, the selling of power, and the steam plant is, therefore, of prime importance. It is not too much to say that permanent commercial success is conditional, first of all, upon a properly designed steam plant. Many companies have found, to their sorrow, that a cheap outfit has proved wonderfully costly to operate and maintain. Others have shown that a somewhat higher first cost has been fully justified by reduced expense of operation and greater reliability. The furnishing of electric light and power may now be regarded as a permanent industry, and the installation of plants presents a broad field of usefulness to the engineer.

Too often the selection of the motive power is left to some one wholly inexperienced, who bases his conclusions upon considerations which are far from being the ones of first importance. The results are as might be expected. We see on every hand instances of mistakes which are costing thousands of dollars unnecessarily in fuel bills, repairs, power wasted, &c. Machinery is now built capable of maintaining one horse power one hour on one and one-half pounds of good coal. When we remember that in most plants five to six pounds are required—and instances are not uncommon where it reaches ten and even fifteen—we see that great improvements are possible. The wonder is, not that electric lighting has sometimes proved unremunerative, but that it has ever paid, under such conditions. The inevitable conclusion is that the fierce competition which now exists, and which bids fair to continue, will result in the "survival of the fittest" only. That electrical station which builds its steam plant in strict accordance with the best principles of modern engineering has already won more than half the battle, and will surely distance the one in which those principles are considered of minor importance.

Some further explanation of the percentages given above may not be out of place. A boiler efficiency of 80 per cent is the best attainable under ordinary working conditions. The purposes of combustion necessitate a good draught. This is proportional to the difference in temperature between the chimney gases and the outside air. (See formula later on). It is, therefore, necessary to discharge the gases at a temperature considerably above that of the steam in the boiler.

Nor is the case of the engine as bad as appears at first sight. Its efficiency also is limited by the range of working temperatures. The higher the initial temperature of the steam, and the colder it is when finally discharged, the higher will be the efficiency. This is best shown by the well-known formula $E = \frac{T_1 - T^3}{T_1}$, where T_1 is the initial and T_3 the final temperature of the steam, both measured from the absolute zero.

Practical conditions, however, confine us to narrow limits. High initial temperatures mean greater pressures, more costly plant, increased liability to accident, and difficulty of maintenance and repairs. The lowest temperatures which can be reached in practice are far above the absolute zero. These losses are inherent in the theory of the steam engine, and but little increase of efficiency is possible. As a matter of fact, that engine which can furnish one horse power with 13 pounds of water evaporated per hour is very close to the highest that is possible under the best conditions of modern practice.

Economy of fuel, however, is not always the most important consideration. Conditions frequently arise which render a sacrifice of fuel necessary to secure other and more desirable ends. The work required of an electrical station differs in important respects from other plants in public service. Gas and water works have their storage reservoirs, enabling their work to be done under conditions favourable to high economy. Electrical plants, however, must supply the current directly needed. Every increase or decrease in the number or burning power of the lamps burning must be instantaneously met by a corresponding change at the dynamos and steam plant. This state of affairs must continue until some of the many storage batteries now being exploited are shown to be sufficiently efficient, durable, and cheap to justify their general adoption. Until then, those plants which do commercial lighting must necessarily, at times of greatest output, be forced to their utmost capacity, and at other times do little or nothing. Under such conditions economy of steam is out of the question. The *real* efficiency must be measured from the plant as a whole, and is a problem of considerable complication. To ascertain the actual cost per lamp per hour, the items of fuel, salaries, oil and other supplies, lamps or carbons, interest, depreciation, repairs, losses due to poor service, interruptions, &c., must be given due weight. In the designing of a new station, it is of even greater importance to give each element of cost its proper consideration. No general rules can be laid down for guidance in studying a problem as complicated as this one. Some of the more important factors may, however, be mentioned.

Whatever the general design of the plant, whether arc or incandescent lighting, or power, whether high or low tension, large or small, whether fuel is high or cheap, space costly or not, the one condition to which all others are secondary is complete *reliability* under severe and continuous service. The public has a right to demand, and does demand, that the lights be always ready, and maintained to their full candle power. An interruption means, not only a loss which cannot be regained, but an injury to the standing and record of the enterprise which months of steady running cannot counteract. Reliability can be secured by using only the best of machinery, as simple in construction as possible, cared for by good men. The plant should be divided into such units that in case of accident to any part of it, that part may be thrown out of service, and the work assumed by the remaining apparatus, without straining the machinery or interrupting the output. This means a reserve sufficiently large to carry the work of any unit of the plant.

The particular electric system in use is the consideration of next importance. The cost of conductors, space required, closeness of regulation necessary, capacity and number of dynamos, all affect the steam plant. Low tension systems require costly conductors, and must be located close to the centre of maximum lighting. Ground is here very valuable, and the most important requirement is to get the plant into the least number of cubic feet. High-duty engines occupy too much space, and water for condensing is usually not available. On the other hand, high-tension systems are less affected by distance, and should be located where land is cheap, and, if possible, where cars loaded with fuel can be switched alongside the boilers, and where an abundance of water may be had for condensers, or, best of all, where water power is available.

The cost of the ground occupied, therefore, affects the arrangement of the plant and type of machinery.

The cost of fuel, as compared with its heat value, is of scarcely less importance than the system itself. If fuel is cheap, costly and complicated machinery to economise it is not justified. If high, it should be adopted as far as other conditions will permit.

The cost and quality of the water supply are important in selecting the type of boiler, heater, &c., and deciding the question of condensers.

The distribution of the load through the hours of the night is worthy of careful consideration. High fuel economy is attainable only under certain fixed and favourable conditions. Among these the most important is the point of cut-off in the engine at which its efficiency is a maximum. The best authorities place this at between $\frac{1}{5}$ and $\frac{1}{4}$ for single-cylinder engines, working with initial pressures of from 80 to 100 pounds above the atmosphere. Both earlier and later cut-offs mean more fuel per horse power. In the latter case we exhaust the steam at too high a pressure, and in the former the cylinder condensation increases so rapidly as to nullify gains from higher expansion. It does not pay, therefore, to use large engines when the load is at times small. The units of power should be so selected as to enable the engines to be run close to the point of cut-off maximum efficiency. As the load changes, engines may be started or shut down, so that at most only one small engine is worked at a disadvantage. Having selected the size of engine best adapted for the work, there are advantages in the way of simplifying the attendance, care, repairs, and general arrangement by re-duplication of parts throughout the plant.

Other conditions, which, while of minor importance, must not be lost sight of, are: The nature of the plant, whether permanent or temporary; the amount of capital available, which, however promising the returns, can not always be secured to carry out plans in the best manner; and provision for growth. This latter is too frequently overlooked. No industry is capable of greater expansion by means of good service and reasonable charges. It often happens that after only short service the demand becomes such as to require extensive enlargements. If this necessitates the remodelling of the entire station, it can only be done at greatly increased expense, and sometimes with serious interruptions to the service.

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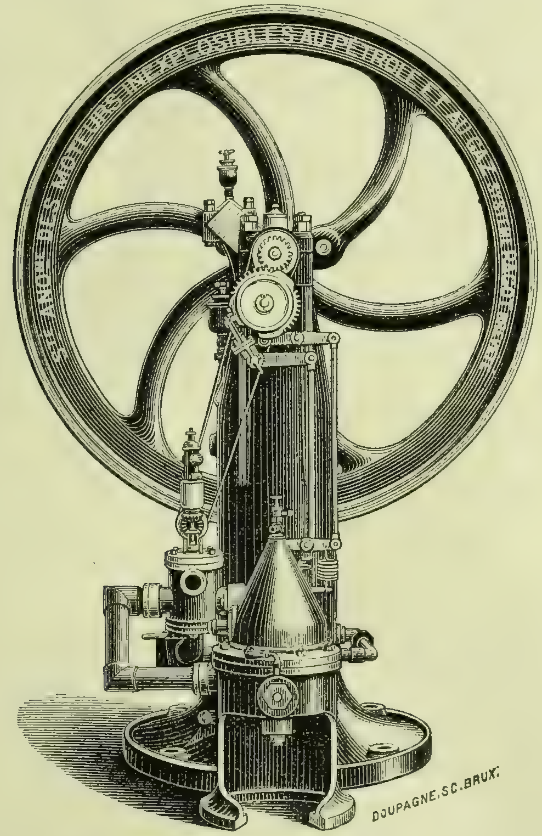
* Paper by Mr. W. H Bryan, Journal of the Association of Engineers' Societies, U.S.A., read before the Engineers' Club, St. Louis.

All the large steam plants in this country are arranged on one of two general plans, which differ in essential characteristics. One school advocates the use of large slow-speed engines, belted to counter shafts, which run at increased speeds, and on which are placed friction-clutch pulleys and clutches, enabling any dynamo or engine to be thrown in or out of service at any time. To get the full benefit of this system the engines must be large and few in number. In practice two engines are generally used, belted to opposite ends of the counter shaft. The other school prefers smaller, independent engines, of the high-speed type, belted direct to the dynamos. Each plan has its warm advocates, and arguments are not lacking on either side. Which of these plans to adopt is the question which confronts us at the outset. The answer in any given case involves a careful study of the points I have discussed, and presents a problem of no small magnitude.

(To be continued.)

THE RAGOT PETROLEUM ENGINE.

THIS engine is one of the many petroleum engines at the Paris Exhibition, in which the well-known Otto or Beau de Rochas cycle is adopted, but it differs from the majority in vaporising heavy oil. Such engines are, in our opinion, more valuable than those merely using the volatile gasoline. We here illustrate its external appearance. The vaporiser is shown in front of the engine, and it consists of a conical vessel enclosing a second cone and forming an annular conical space. The exhaust gases from the engine pass through one cone and heat the petroleum contained in the space. It is then vaporised by air, and drawn into the cylinder to mix with fresh air in order to make the mixture explosive. The cones heat the air supply as well as the oil, so that on entering the engine there is no danger of deposition upon the sides of the cylinder.


DOUPAGNE, SC. BRUX.

The inlet and exhaust valves are operated by cams, and inflammable vapour is obtained for starting by placing a lamp under the cones in the open space shown in front. After the engine is started, this lamp may be extinguished. The inlet and exhaust valves are actuated by levers and cams, as seen in the illustration, from the second wheel spindle, and the ignition is accomplished by the electric spark, which is produced by battery and induction coil. We watched the engine at work for some considerable time, and its action was then very smooth and satisfactory. Developing 3 H.P. on the brake, its cylinder is about 6¼in. diameter, and its stroke about 11in. It is stated to consume about 0·85lb. of petroleum per brake H.P. per hour.

FORTH BRIDGE.

THE half-yearly general meeting of the Forth Bridge Railway Company was held a few days ago in Edinburgh. Lord Colville (chairman) presided, and there was a good attendance. The report by the directors, which was submitted, included a statement of the account for the half-year ended 30th June last, the engineers' report of the progress of the works during the past half-year, and the reports of the 24th and 25th quarterly inspections of the works by Major-General Hutchinson and Major Marindin, on behalf of the Board of Trade.

The Chairman said: I am happy to say that the Forth Bridge is rapidly approaching completion. The great cantilevers are practically finished, and the central girders are now being put into their position. We hope to be able to walk across the bridge in the month of October, and if the two approach lines to the north and south ends are sufficiently advanced, I dare say we shall be able to make use of the bridge for goods and minerals before the close of the year, and open it for public traffic early in 1890. Considering the difficulties which have arisen in the construction of a work of such exceptional novelty and magnitude, I think it may be considered that great credit to all concerned will be due if the bridge should be finished within the period of seven years. I now beg to move that the report and accounts be approved of.

Mr. Matthew William Thompson (deputy-chairman) seconded the motion, which was carried unanimously.

The statement of accounts showed that the total amount received during the half-year was £192,740 5s. 9d., which, added to the amount already received, made a total of £2,780,078 1s. 11d. The sum expended during the half-year was £191,931 17s. 2d., making a gross total expenditure of £3,014,437 1s. 2d. The report by the engineers (Messrs. John Fowler and B. Baker) on the progress of the works during the past half-year is as follows: Forth Bridge—The three great double cantilevers, including the viaducts within them on which the railway is supported, are now practically completed. During the past six months 1,360ft. in aggregate length have been erected. The only portions of the superstructure remaining are the central girders spanning the two openings between the cantilevers. These girders are now nearly all fitted up in the yards at Queensferry. The whole of the work has been carried out in a thoroughly satisfactory manner. Railway approaches to the bridge—North approach: 272,000 cubic yards, or about five-sixths of the total quantity, have been excavated and carried to embankment. The headings of the tunnels are completed, and more than half of their length is enlarged to full size. With the exception of one, all the bridges are completed. South approach: 62,000 cubic yards, or about nine-tenths of the total quantity of excavation, have been carried to embankment. The bridge at Rosshill is approaching completion, and the public road bridge near Dalmeny Station is commenced. The Forth Bridge Station at Rosshill is also commenced. The bridge will be completed at the end of October, and all the approach works forming the Forth Bridge Railway will be ready for public traffic on any day after the 31st December of this year.

BIRMINGHAM AND LIVERPOOL SHIP CANAL.

THE scheme for constructing the ship canal between Birmingham and the Mersey is being actively pushed forward, the survey having been just completed, and the estimates prepared. An entirely new canal will be constructed from Birmingham, permeating the principal iron and coal centres of Staffordshire and Potteries, and uniting with the Weaver Navigation, at Winsford, finally communicating with the Manchester Ship Canal and the Mersey. The change of levels will be overcome by hydraulic lifts. It has been decided to increase the proposed width of the canal from 60ft. to 72ft., rendering it equal to navigation by vessels of 500 tons burden, as compared with 300 as originally proposed. As now estimated, the capital outlay will be nearly £3,000,000; £250,000 being required for the hydraulic lifts. Instead of traffic of 2,000,000 tons per annum, however, the promoters believe it will approach 10,000,000. The committee are obtaining the assent of landowners, and are also supported by the Weaver Navigation Company, the Manchester Ship Canal Company, and the Mersey Dock Board. A bill empowering the construction of the canal will be promoted in Parliament.

PROPOSED RAIL SECTIONS.*

When I had the honour of presenting to the Institute at the Buffalo meeting in October, 1888, my paper on "Steel Rails and Specifications for their Manufacture," I expressed my hesitancy in submitting my ideal rail sections. Since then, continued residence in Chicago, perhaps, or greater intercourse with railroad officials, has either given me more courage or has taught me that so little is really known on the subject that one is safe in expressing one's views, let them be never so erroneous. As a further personal excuse, I may remind you that "fools rush in," &c. At all events, I would now call attention to certain rail sections which I believe to be good. I do not say they are the best, but I feel sure they have more merit than the majority of the adopted heavier-sectioned rails.

In determining the proper form for a rail, the subject should be considered from two points; first, and most important, the duty required; second, and of almost equal importance, the influence of existing details of manufacture upon the character of the finished product.

It is perfectly proper that all the strains to which the rail will be subjected should be considered and calculated. But its ability to resist them will depend quite as much upon the character of the metal as upon the form of its section. That which would be the realisation of the ideal with *good* steel would be disappointment with poorer metal. Therefore, the railroad engineer should always have in mind and pay due respect to what the metal worker *may* give him—the *may* being the factor of danger to be covered by his factor of safety, and possessing greater importance than any formula laid down by never so eminent authorities. It is well known how positive is my conviction that high heat during manufacture and good rails cannot go together; hence, if we insist upon the avoidance of this evil by railmakers, we must give them sections which can be made at low temperatures with commercial as well as technical success.

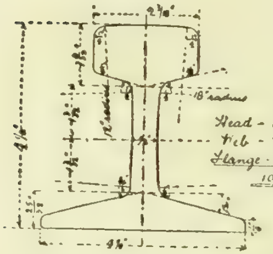


Fig 1 60 lbs

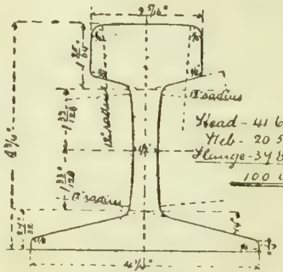


Fig 3 70 lbs

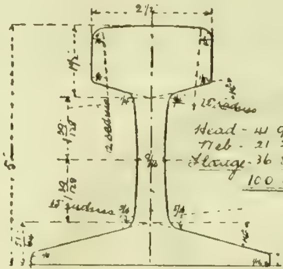


Fig 5 75 lbs

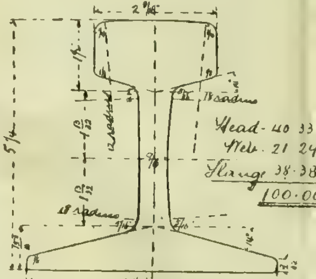


Fig 7 85 lbs

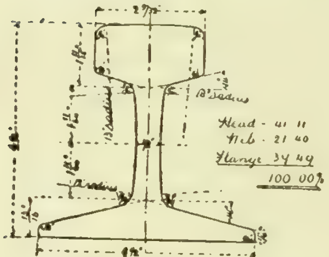


Fig 2 65 lbs

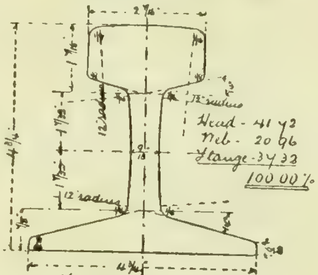


Fig 4 75 lbs.

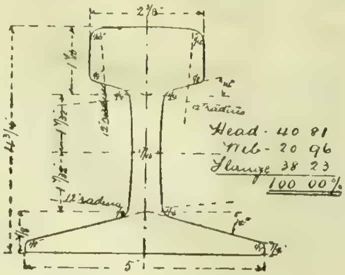


Fig 6 80 lbs.

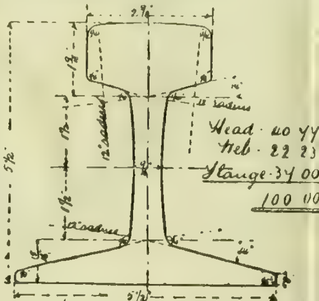


Fig 8 90 lbs.

The market price for rails controls the practice of makers, and, indirectly, the specifications of buyers also. Of course railroad managers want the best possible article, but they must also have it, or its semblance at least, as cheaply as their neighbours. Great reforms are generally inaugurated by bold spirits, who disregard the controlling influences. In this case, I do not think any fanaticism or martyrdom is required, but believe all necessary and practicable perfection can be obtained without seriously antagonising or disturbing existing commercial conditions.

In my former paper I quoted Mr. O. Chanute to demonstrate how great has been the increase of wheel pressures. Since then Mr. D. J. Whittemore, chief engineer of the Chicago, Milwaukee, and St. Paul Railroad, has presented an able paper to the American Society of Civil Engineers, in which he further elaborates that point. I presume all authorities agree that the necessity exists for stiffer-sectioned or heavier rails. In other words, there is a demand for heavier rails, because the weight of wheel pressure requires a stronger beam to support it. The railroad engineer naturally desires to secure this with the smallest outlay, and hence with the lightest practical section. This can be designed, assuming, as before intimated, that the metal in it possess certain physical properties. But if the calculation is to be of value, these assumed properties must be present.

The metal commonly known as steel is almost as sensitive to treatment as woman. It will stand any amount of punishment if administered by judicious bands, and unexpectedly rebel if a less amount is given with indifference. Now, we cannot always control the judgments, or rather the actions, of the irresponsible steel operatives; therefore sound policy dictates that we give them a section to which they can do the least injury.

The earlier rails which gave such satisfactory results, and which have been so constantly presented to railmakers as representing that which *they* ought to do, were all of light sections. They were made of steel which had never been heated to the utmost limit of its endurance, and in mills in which the roll pressures penetrated well through the rail heads. In rolling later rails, the steel has been almost always worked at a higher temperature; and, as the sections have been increased, the penetration of the roll pressures has decreased.

It was supposed that the chemical character of the steel in the earlier rails accounted for their superior wear. Among the makers of these rails, Sir John Brown and Co., of Sheffield' England, sent to this country those which, from their most excellent service, were considered by railroad engineers as the type of what rails should be. Accepting the chemical theory, railmakers expected that the analyses of these celebrated rails would present steel of exceptionable uniformity and purity. The contrary has proved to be the case. I have examined the analyses of numbers of these rails which had been removed from the track after many years of good wear, and had been selected as representing ideal rails. When we consider that the carbon varied from 0·24 to 0·70 per cent, the silicon from 0·032 to 0·306 per cent, the phosphorus from 0·077 to 0·156 per cent, the sulphur from 0·050 to 0·181 per cent, and the manganese from 0·312 to 1·046 per cent, we are forced to the conclusion that their chemical composition was not the controlling influence in their good character. I am therefore strengthened in my belief that the sections and physical treatment of the steel during manufacture must account for the results obtained. As I have stated on previous occasions, the early steelmakers did not know so much more than the later ones as might be inferred from the frequent praise bestowed upon their work. On the contrary, they had much less knowledge, and in consequence were afraid to depart radically from the existing traditions of steel-making.

I do not claim originality in advocating broader-headed rail sections. The present well-known standard 80lb. rail of the New

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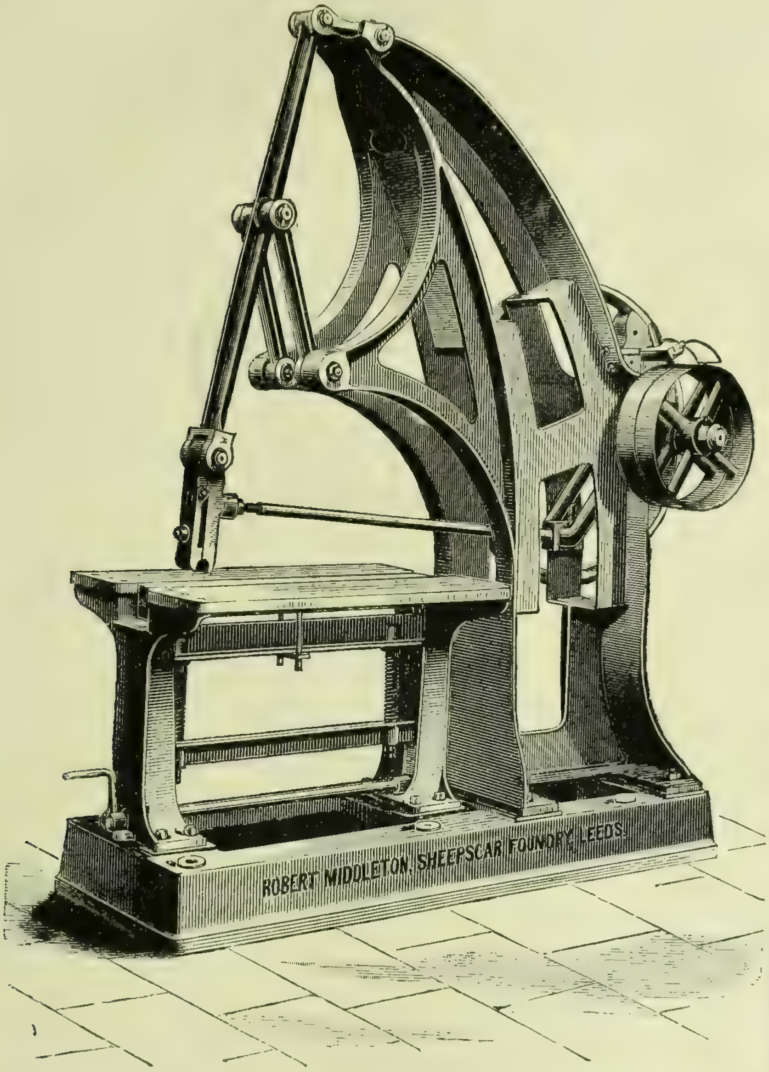
* Trans. Am. Inst. Mining Engineers, by Mr. R. W. Hunt.

LEATHER GLAZING MACHINE.

CONSTRUCTED BY ROBERT MIDDLETON, SHEEPSCAR FOUNDRY, LEEDS.

(For description see page 634.)


ROBERT MIDDLETON SHEEPSCAR FOUNDRY LEEDS

PARKINSON'S PERFECT VICE.

(For description see page 634.)

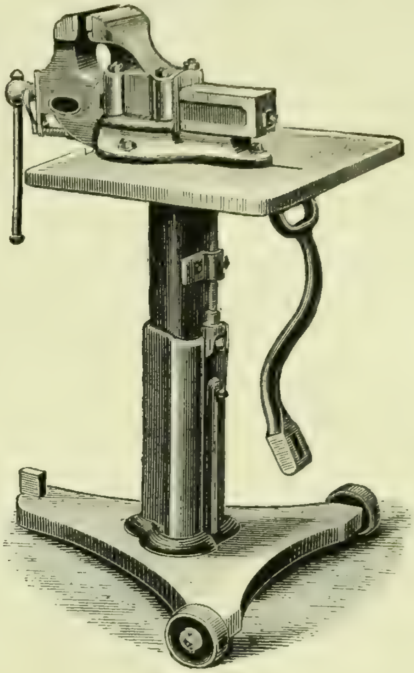


Fig. 1.

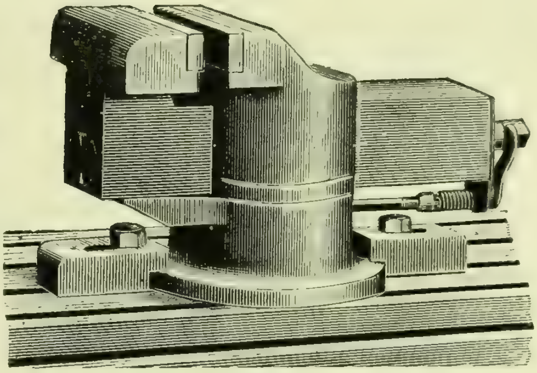


Fig. 2

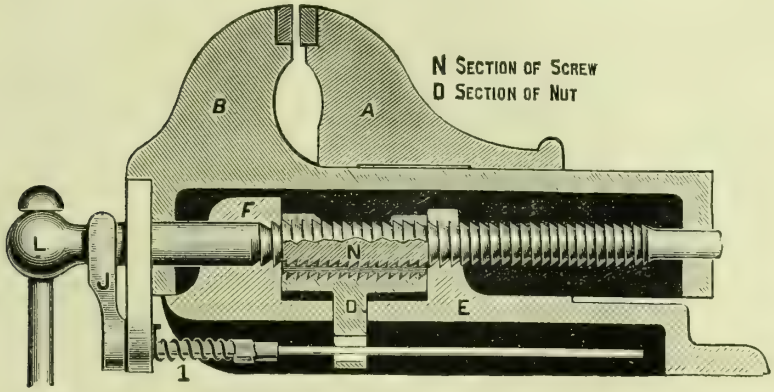


Fig. 3.

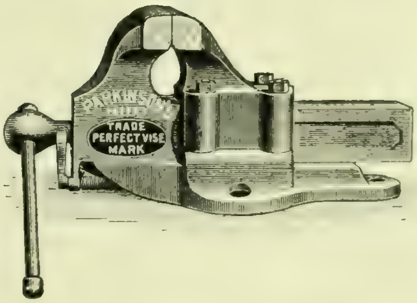


Fig. 4.

York Central and Hudson River Railroad was designed by our fellow-member, Mr. P. H. Dudley, in April, 1883. I filled an order at the Troy works in 1884 for 1,000 tons of this section. The rails were laid through the Fourth Avenue tunnel of the Hudson River Road, extending to the junction with the Harlem Road. Rails of other and lighter sections had given unsatisfactory results in this locality. After one year's experience, the company above named adopted the Dudley section as its standard 80lb. rail, and since then has put down several thousand tons each year. In fact, it is relaying the whole Hudson River division with this section.

As is well known, Mr. Dudley was the first to use the dynagraph car in determining the condition of road beds, and has devoted himself to that branch of his profession for many years. His paper on "Railway Resistances," read before the Institute at Washington, in February, 1876, was the product of much experience already obtained in the use of his ingenious invention, and has been followed by extensive and continuous applications of it, with results of the greatest value to our railroad engineers. His observations convinced him that, to meet successfully the tremendously increased wheel pressure, rails must present a broader head surface. As a result we have his 80lb. rail. As will be seen upon examining my 80lb. section, I have not adhered to the Dudley rail, but have approached more closely to the one adopted for the Michigan Central Railroad by Chief Engineer J. D. Hawks. In designing all my sections I have kept in view the controlling circumstances of their manufacture, adopting wide and comparatively shallow heads, strong webs, and flanges with thick edges. I have tried to distribute the metal so as to avoid cooling strains, and give rails which will require the minimum of cold straightening.

As at present conducted (and mechanical talent has as yet failed to find a better way), cold straightening is the enemy of a perfect rail. It is generally accepted that the hardness of the steel must be increased to improve its wearing qualities. But this augments the danger of the breaking of cold-straightened rails at the "gag-marks." And if, in seeking to avoid such a consequence, the straightening is performed while the steel is too hot, "lumpy" or "wavy" rails will be the result.

Figs. 1 to 8 inclusive present my designs for 60, 65, 70, 75, 80, 85, and 90lb. sections. There are two 75lb. rails (fig. 4 and 5), the first with a 4¾in., and the other with a 5in. base. The latter is intended to meet the views of those engineers who, because they are compelled to use soft wood ties, or for other reasons, require that width of base.

These sections are all designed to be used with fish-plates. When the time comes, as I believe it ought to come, and will, that joints affording a base support are used, we can discuss a very different rail. To meet the conditions which will prevail until then, I respectfully submit these suggested forms.

LEATHER GLAZING MACHINE.

Mr. Robert Middleton, Sheepscar Foundry, Leeds, has constructed an improved leather glazing machine, which he is now introducing. It is compact in design, and occupies but little floor space; whilst its adjustments are easy and accurate. The hinged roller is of improved form, and will take any size of agate, and the bed can be adjusted by side thumb screws to be in level with the agate, so as to secure uniform pressure upon the whole surface of the leather. The machine is constructed with bent crank and balance wheel, and the springs under the bed are adjustable.

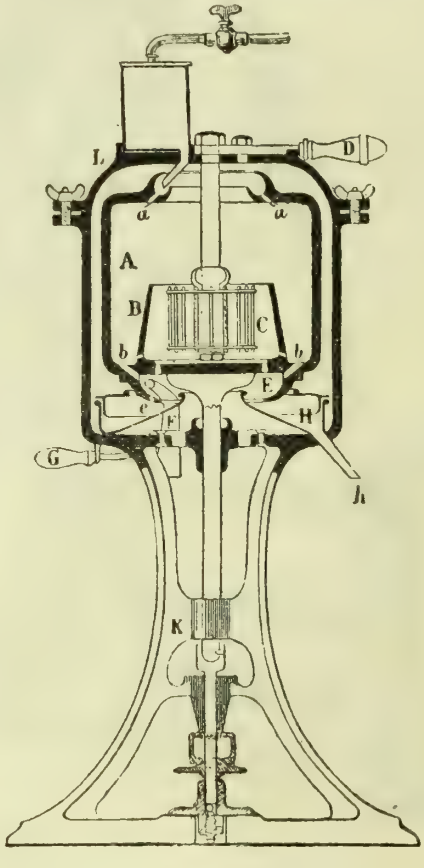
Our illustration, p. 633, shows that it is well made, and of convenient form for its purpose.

PARKINSON'S PERFECT VICE.

Mr. J. Parkinson, of Bradford, exhibits a very ingenious and useful vice at the Paris Exhibition, which we illustrate at figs. 1, 2, 3, and 4, p. 633. Fig. 3 is a longitudinal section, and fig. 1 a general view, as attached to a table. Its inner jaw A is bolted to the table, and through it passes the slide of the exterior jaw B, which connects to the stationary jaw by the screw N, and the projections E, F. The lever J, when moved, liberates the screw from the nut D, and allows B to be pushed up to the work, or drawn out freely, but when J is let go the nut engages, and the work can be at once secured by the tightening handle L. The screw is of peculiar form, to "buttress" against the nut thread in the direction of strain. The section is so clear that further explanation is unnecessary. It is evident that the vice is very simple, and as its working parts are well protected, it is not liable to go out of order. Figs. 2 and 4 show the external appearance of the vice, which is exceedingly solid and satisfactory. Fig. 2 shows its application to a shaping machine.

THE DIRECT BUTTER EXTRACTOR.

The Aylesbury Dairy Company, of London, have recently introduced an interesting apparatus, which is a development of the principle of the well-known centrifugal cream separator. It performs its work most efficiently, and so rapidly that the size commonly used will extract all the butter from 150 gallons of milk in an hour. This result is obtained in the following manner: The milk is fed into the drum of a centrifugal separator, and under the action of the centrifugal force the butter globules, with a small amount of skim milk, assume a vertical position nearer the centre of the drum than the bulk of the heavier constituent, the skim milk. It now only remains necessary to remove the last traces of skim milk from the butter globules to enable the latter to coalesce and form a perfectly pure butter. Upon referring to our sectional illustration, the appliance and its mode of working are clearly illustrated. The milk to be separated flows into the drum A through a feed regulator. This drum, revolving at 6,000 revolutions per minute, separates the whole milk into cream and skim milk; the former, having the lowest specific gravity, remains nearest the centre of the drum, whilst the latter attains the periphery, and thence escapes through the passages *b*. The cream, however, gradually collects in the drum, and eventually flows into the inner chamber B. In this chamber is a wheel C, furnished with small spokes round its periphery, and free to rotate on a spindle depending from the cover of the separator. This wheel can, by means of the handle D on the top of the separator, be introduced into or withdrawn from the cream in the drum. As soon as it is introduced into the cream it begins to rotate, until it reaches the same speed as the drum A. The spokes fitted on the wheel keep parting the cream, and thus enable the skim milk that was in the cream to escape therefrom, leaving only pure butter globules, which coalesce somewhat together, and are drawn off from the drum by the spout F.



The machine is very ingenious, and should be widely applied, as the butter formed is undoubtedly fresher and purer than that obtained in the usual way.

Steel Rivetless Tramway and Railway Sleeper.—A case of some importance to colliery owners and railway companies was settled last week in regard to a new rivetless steel sleeper patented some time ago by Hipkins and Bickley, of the Patent Rivetless Sleeper Works, Walsall. It appears that Messrs. W. G. Bagnall Limited, of Stafford, had applied in March of this year for a patent (No. 4,255), also for a steel rivetless sleeper, and advertised for sale such sleepers. Messrs. Hipkins and Bickley entered an opposition to the grant of this application, and the case was heard at the Royal Courts of Justice, London, by the Comptroller-General. At the hearing the application was supported on behalf of Messrs. Bagnall by Mr. Boult, of London; the opposition on behalf of Messrs. Hipkins and Bickley being conducted by Mr. Barker, of Birmingham, who argued that Hipkins' patent entirely covered the alleged subsequent invention by Bagnall. The comptroller took several weeks to consider the case, and eventually gave his decision entirely in favour of the opposition, and refused to grant a patent to the applicants.

A TRIP WITH THE FLYING SCOTCHMAN.*

On August 10, while visiting Mr. Worsdell at Gateshead, it was the writer's fortune to receive an invitation to ride on the locomotive hauling the fastest train in Great Britain. This is the Flying Scotchman, which leaves Newcastle at 3-39 p.m. and reaches Edinburgh at 6-20, two hours and forty-one minutes, with one stop. The distance is 124½ miles, and the speed, including the stop, is, therefore, 46·4 miles per hour. Such an opportunity to see the working of a fast compound locomotive is not often obtained. It was 3-45 p.m. before the signal was received to depart, and the start was, therefore, made six minutes behind time.

Standing in the station the train looks rather formidable, the ten coaches are crowded, and the passengers discussing priority of claims to the desirable seats. The luggage vans are filled to the roof. The locomotive, painted a pretty green colour, rather towers above the cars. It is a fine looking piece of machinery, with only one pair of driving wheels, to which sand is fed by a steam jet of the Gresham and Craven pattern. The cylinders are compound—that is, one is used at high-pressure and the other at low-pressure. The finish of the locomotive is of the best, and harmonises well with the general outfit of one of the fastest trains in the world. The dome casing is so thin and well formed that, as it gradually expands at the base and blends with the jacket of the boiler, the joint between the two is almost imperceptible. The smoke stack and safety valve casing accords in style with the dome casing, and these harmonise with the shape of the cab roof and the remaining exterior trimming; thus the whole contour and colour of the locomotive being arranged in good artistic taste, great power and speed are suggested. As the eye reaches the large wheel covers that surround the 7ft. 6in. drivers, the suggestion of high speed is considerably increased.

When the signal to depart reaches the engineer he at once starts the steam sand jet by moving the handle of a small valve, not unlike a Westinghouse engineer's air-brake valve in appearance. This movement causes a small jet of sand to be blown between the driver and the rail. Then a small button is pulled, which is attached to a rod leading from the cab sheet directly in front of the engineer to a small valve at the smoke box, which admits high-pressure steam into the low-pressure cylinder. The throttle is now opened and at once the wheels grind on the sand, the train commences to move. As soon as the high-pressure exhaust has reached the same amount as that in the low-pressure cylinder, or nearly that amount, the button on the steam-valve handle moves forward automatically, and direct steam is shut off from the large cylinder and the engine is working compound. In getting under weigh the train accelerates rapidly, but at no time is the throttle fully opened. The cylinder power is great enough to slip the wheels at all times, even when the sand is applied to the rails.

There are a few grades on the line and these are not heavy ones. The track is quite crooked, and in two places makes a turn of nearly a semicircle. When the locomotive, at a speed of 50 miles an hour, strikes these places, the lateral shock in the cab is considerable. On one of these curves, before the track was reduced in curvature, a locomotive drawing the Scotch express was overturned. The driver was buried for three hours under his engine in a hole made by the steam and water escaping from the boiler. He was not seriously injured, and except a few marks on his face is as sound as ever. It was with him that the writer rode on Aug. 10. The fireman is an old hand, and manages the fire easily as he smokes and calls attention to the old castles, the sea, rocks, and other interesting objects along the line. The comfort of the enginemen is well cared for on these engines. On each side is a comfortable wooden seat, but without cushions. Good tight clothes boxes are provided, and all of the finished parts are of forms that are easily cleaned. As the engineman sits in his seat on the right hand side of the locomotive, he can reach all the handles which it is necessary for him to operate, with but little movement of the body. While running, however, he seldom sits down, but keeps his eyes ever on the alert for the signals of the "block system" with which the road is equipped. It occurs to the observer that one of the great advantages of the block system, where the signals are close to each other, is that the engineer is thereby compelled to be ever watchful from the window, fearing he may pass one set against him and thereby be subjected to a penalty.

The boilers of locomotives on English railways are seldom provided with gauge cocks, and these locomotives are no exception. Two water glasses are used to determine the water in the boiler, one being placed upon each side. Automatic cylinder oilers are not in general use, and, instead, the well-known "tallow cup" is mounted upon each side of the cap. The cab is made of steel sheets upon an iron frame, surmounted with a modern roof, which extends well over the whole footplate, and effectually protects both the engineer and fireman from the weather. The front windows are circular and have brass frames hinged to the front of the cab. In order to provide good ventilation there is a series of ¼in. holes punched in the cab front sheet, close up under the roof. The steam gauge is small, about half the dimensions of those used in the United States. During this run the hand of the gauge varied but little from 180lb. per square inch, which is the pressure used on the compound locomotives. To maintain this pressure the fireman seemed to do but little manual labour; however, it may have been the result of some mental exertion. Smoke at times appeared in small quantities at the top of the stack, but during most of the run the jet of vapour issuing from the smoke-box was almost entirely white. The reason for the absence of smoke while soft coal was being used, in this case, was undoubtedly largely the use of a well-arranged brick arch in the fire box, a fire door air supply deflector, and a proper admission of air above the fire through the fire door hole. The fire door is of simple form, and has a sheet iron shield to protect the eyes of the engineer and another to protect his legs. The fireman uses a shovel with a long blade about 22in. × 8in., and with this, and a bent poker to reach under the fire-brick arch, he succeeds in supplying coal evenly to the fire, and keeps it clean and burning freely. During the run he keeps down the coal dust and cleans the deck by the use of a brush dipped in a bucket of water. A sheet iron apron covers the joint between the engine and tender, as is the case with the American locomotive. The valve motion used is the Joy. The cylinders are 20in. × 24in. and 28in. × 24in., and the weight upon the two drivers is about 36,000 to 38,000lbs.

These locomotives make the run from York to Newcastle, 81 miles, in 80 minutes, with a total train-load, including the engine and tender, of 215 tons. On one occasion 5 miles were run in 3¾ minutes. The capacity of the tender is 3,200 gallons, of which 2,900 gallons are used in the run of 124½ miles; the coal used is 26lb. per mile average. At the Gateshead shops, Mr. Worsdell is building several locomotives of the same general pattern, with 7ft. 7½in. drivers, to carry 200lb. boiler pressure. The cylinders are 20in. × 24in. and 28 × 24 in.

So much, then, for the general character of the locomotive and its operators. The line over which the machine is moving deserves attention. It is not hilly, but it is crooked; it does not seem possible, as one views it from the cab, that it could be the same upon which the runs of last season were made. It was then that a speed of 81 miles per hour was attained. This season the races, which were anticipated and prepared for by the North-Eastern, have not taken place, and therefore the average speed is slower than in 1888. The officers of the line state that during the fast runs there was but little, if any more fuel used between terminals than when running at a slower speed. This statement is indeed a "hard nut to crack" for those who have been writing during the past year of the enormous resistance of the air at high speed, and the stupendous wave of deflection which precedes the train, and causes it to be ever climbing up hill. But facts are facts, and these writers will have to find a new wave or a new road bed theory to offset the wave theory, mitigate its evils, and cause the facts to agree with the hypothesis. But let the resistance be what it may, the train moves easily at 65 to 70 miles an hour with but little visible effort on the part of the locomotive. Apparently there is no reason why the speed could not be made 80 miles per hour as well as 70. The engineer, by long experience, is familiar with the line, and only at the one stop between Newcastle and Edinburgh was the air brake used. If it was necessary to slow the train at any point, the engineer was aware of it beforehand, and shut off steam and allowed the train to gradually slacken pace. This, of course, takes more time than to slow the train by means of brakes, but in this case to save time is unnecessary. The road bed of the North-Eastern has broken stone and gravel ballast, but on the North British, which is the line used from Hawick to Edinburgh, the ballast is of large-sized broken stone. The difference in the riding of the locomotive is quite perceptible on these lines. On the North-Eastern the softer road bed and the presence of wooden blocks between the rails, and the cast-iron chairs upon which the rails are carried, reduce the shocks to the locomotive and carriages, while upon the North British the rigid road bed and rail chairs cause the location of the rail joint to be plainly marked by a series of sudden shocks. At high speeds these shocks cause one to think the locomotive is pounding badly. In fact, the condition of the rail joint on all European roads is uncomplimentary to the engineering talent, and while the joints may not be in worse condition than those in the United States, yet the use of carriages without bogie trucks results in the transmission of the shocks directly to the car body, and, therefore, it is far less comfortable to read in a European than in a United States railroad carriage, and to write therein when the train is in motion is impossible. Sometimes the cars are not held steady by the spring buffers, and then they proceed with a sort of snake-like motion that is disagreeable in the extreme. This, however, is seldom noticed, because the majority of the rolling stock is kept in good repair.

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* The *Railroad Gazette*—New York.

On these Scotch expresses all weight is reduced to a minimum, and each car is filled before another is added. As one looks into the window of a compartment holding ten persons, five on each seat, with all their hand luggage and wraps, he cannot avoid a comparison with the New York and Chicago "Limited," with its capacious accommodations for each passenger.

Passengers on the lines in the north of Great Britain are locked in the carriages after they enter, and when the Scotch express stops at the one place in its run, great is the howl of the traveller to be liberated, in order that he may get the sweetbread and drink of whisky—all served from the same counter—before the train starts. Last year the whole run of 124½ miles was made without a stop, and the carriages are unprovided with toilet conveniences. In the south of England and in France and Germany the doors of the compartments are no longer locked, but can be opened from the window by the passengers.

From Newcastle to Hawick, the first and only stop, the train gains three minutes easily, and its operation is most satisfactory; the boiler and grate are small, and the pulsations of the exhaust—only one-half as many as in the case of the single-expansion engine—are but just perceptible. The fire burns brightly; there is but little smoke, in fact none that could in the least inconvenience the passengers in the cars. The locomotives ride so easily that a seat on a smooth board is comfortable at a speed of 65 miles per hour, and the writer's companion, Mr. William Forsyth, mechanical engineer of the "Burlington," seemed to be very well pleased with a stool made up of a towel and a water bucket on the fireman's seat. Dust there is none, and if one puts his head out of the cab window nothing but air rushing past is perceptible.

The counterbalancing is almost perfect, as far as the motion of the locomotive itself is concerned. A careful watch of its motions resulted in a discovery of none that could be attributed to a lack of or a superabundance of balance weights.

The whole trip was so well managed that when arriving in Edinburgh at exactly 6-20, having been running almost continually with the same engine for 2 hours and 35 minutes at an average speed of about 50 miles per hour, the locomotive was in good condition to make the return trip, which she did in a short time thereafter. Much of this success is due to the great attention paid to the details of the locomotive. Each part is carefully arranged so that it can be oiled and cared for while running, and pipes lead from the axle boxes to the foot plate inside of the cab, within easy reach of the fireman's oil cup. This locomotive ride is probably the most instructive of all taken by the rider this summer, not excepting that in Germany on the compound locomotive of the State railroads. D. L. B.

EXPLOSION OF A COPPER PIPE AT DEPTFORD.

(Concluded from page 620.)

With a view of throwing as much light as possible on the cause of failure, a sample of the copper taken from the exploded bend was forwarded by Messrs. Storey and Co. to the Assay Office and Laboratory Mining Offices, Swansea, and was there analysed. It was found to consist of—

	Per cent.
Metallic copper	98·64
,, arsenic	0·50
,, lead	0·15
,, nickel	0·22
,, iron	Trace.
,, bismuth	Trace.

With respect to the quality of copper, I would remark that while, on the one hand it is asserted that "a good ordinary merchantable copper is seldom purer than 98½ per cent," I am informed by Messrs. Storey and Co. that "we have been making inquiries among our other friends in the trade and experts, and find that the general opinion is that sheets, to stand good working, should contain from 99 to 99·25 per per cent of pure copper. The general opinion as to the effect of arsenic seems to be that 0·5 per cent would not cause any serious difference to the metal. The small amount of lead present is less than that usually found."

The following is an extract from a letter written by a firm with regard to samples of the copper which had been cut from the exploded bend:—

"Upon applying our usual tests, we find it gives way much sooner than it ought to. We are not prepared to say definitely whether the copper has been injured in the brazing or not, but we think not.

"It appears to us rather that the copper is weak in itself, and would be not unlikely to give way when being worked by the coppersmith. We imagine that this might not show much at first, although the fibre would be really ruptured, but that pressure from the inside would afterwards develop distinct cracks."

Taking all the circumstances into consideration, it is only reasonable to conclude that the material supplied, in view of the amount of work necessary to produce a bend of such small radius, was not of the superior quality which it is desirable to employ for such purposes.

Notwithstanding the many suggestions which have been made in view of the high pressures now employed, the question of means of obtaining reliable copper steam pipes is, I think, not yet satisfactorily solved.

A firm is, I understand, about to lay down machinery with the intention of producing solid-drawn pipes of considerable diameter; but if copper is liable to inherent defects, it is clear that this method of manufacture alone will not ensure sound pipes being produced, but it must be supplemented by means to ensure that the copper is free from defects before the work is begun, and that none are produced during the process of drawing, &c., and this will, in a great measure, depend upon the quality of the copper used.

Other attempts have been made with a view to give greater confidence in the use of copper pipes, but these have not yet, I think, been subjected to sufficient trial to prove that they will meet the case. Some of the suggestions are, however, of such a nature that they do not appear to be designed to strengthen the pipes, but merely to limit the extent of fracture in the event of an explosion.

The engines and boilers are, in this case, in a spacious building. Had the explosion occurred in a confined space, as on board ship, in all probability no person present at the time of the explosion would have escaped with his life.—I am, &c., William H. Woodthorpe.

Observations of the Engineer Surveyor-in-Chief.

The explosion was caused by the deficiency of strength of the brazed copper bend to resist the pressure brought upon it. The brazing of both seams and flanges was defective, and circumstances make the presence of water in the bend most probable. It is a moot point whether the defective pipe could have stood long even if it had been kept clear of water. It appears, on considering the strength of the corresponding bend on the other engine, that both had a much lower factor of safety than is desirable. The results of the hydraulic tests recorded in the report are interesting, as it will be observed that it is stated in the report that the factor aimed at was ten.

The whole subject of copper pipes requires careful investigation, and the information given in this report will be of value. None of the methods which have been suggested of strengthening copper pipes have been proved to give absolute security.

In this case one man was killed and ten others were injured by the explosion, which, fortunately, took place in a large open building, or the consequences would have been more serious.

Thomas W. Traill.

HEAT ENGINES OTHER THAN STEAM.—II.

(Continued from page 606.)

I have for a long time been considering whether it was not possible to divide the various sorts of "heat engines other than steam" into some two or more great classes, having distinct and well-defined characteristics, but I have found it impossible; and although it is not scientifically correct to speak of hot-air engines, and gas engines, and of petroleum engines, as is popularly done—because, as a fact, these are all hot-air engines, yet, on the whole, I think it is better in our case to follow the popular division, even though it is scientifically incorrect. I propose, therefore, first to consider "Hot-air Engines," then "Gas Engines," and then "Petroleum and other forms of Heat Engine," always using these titles in their popular sense.

One of the earliest successful hot-air engines was that invented and patented by the Rev. J. R. Stirling and his brother in the year 1827.

We have already considered what is the effect produced by increasing the temperature of an enclosed volume of a gas such as air, the volume remaining constant; and I have also shown you the effect of increase of temperature on a volume of air—the pressure remaining constant, but the air expanding as heat was applied; and you will have realised that an ideal heat engine for power purposes would give the greatest efficiency if (among other advantages of which we shall have hereafter to speak) all increases of temperature in the working agent were made with its volume remaining constant (or even, it may be, being lessened), and all decreases of temperature were due to the transformation of heat into work during expansion.

But to construct a hot-air engine such as this, in which a reasonable power might be developed, would require, among other things, enormous cylinders; for the pressure at which the engine would work would practically be extremely low, and the element of time would become of great importance, *i.e.*, the time necessary to impart the large quantity of heat to the air, and to cool it, at each stroke would be considerable, with the result that the speed of the engine would be low. There is a device called a "regenerator" included in the first patent of Stirling, which to some extent meets this difficulty, and which, in other forms, is one of the most important devices in the arts and manufactures.

Let me try to illustrate to you what the principle of the regenerator is, and let me try first to define, pithily, the sense in which the word is here used. A regenerator is really a heat "filter;" that is to say, the heat is filtered out of the hot air or of any hot gas passing through it. The apparatus consists of a series of absorbing surfaces; usually in hot-air engines there is a metal box filled with numerous thin plates, in contact with which the hot air or hot gases are caused to pass, and in doing so they give up the heat they contain to these plates or surfaces, and the hot air or hot gas leaves the further side of the regenerator at a temperature much lower than that which it had on entering it, because it has given up to the surfaces presented to it a portion of the heat which it contains.

Now, if the current of air or of gas be reversed (or if cool air or gas be allowed to pass in the opposite direction, back through the regenerator), it will repick up the heat which had been left behind on the first journey, and will leave the regenerator at almost as high a temperature as that which the hot gas had on first entering it.

Air was supplied to this cylinder or air vessel at a pressure of about 150lb. on the square inch by means of a small pump attached to the engine, which was worked from this cylinder, the pump serving also to make up any loss of air by leakage or otherwise. There were two of these cylinders, each with its own piston or displacer, and with its own regenerator. One was attached to one end of the working cylinder of the engine, and the other to the other end of this cylinder.

Stirling's engine would work in the following way: If one of the displacers was raised it displaced the air above it, between its top and the cylinder cover, sending the air through the regenerator into the space below the displacer, where it would be subjected to the heat of the fire. Thereupon the air, becoming hot, its pressure would rise, and this air of increased pressure would pass along through the passage, which connects with say the top side of the piston of the working cylinder, and would thereupon force this piston down. The second air vessel, which is similar to the one shown, having also a displacer and regenerator, is in connection with the other side of the piston in the working cylinder, and this piston in passing down would transfer the air contained in that end of the working cylinder into the space above the displacer in this second air vessel. Now, if this displacer is moved upwards, the air contained in the space above it will be delivered through the pipe, through its regenerator, and will be heated in the space over the fire in the second air vessel. The pressure of this air will thereupon rise; will be communicated to the lower side of the piston in the working cylinder, and will cause that piston to rise, thus completing one "cycle" or series of operations, and bringing the engine back to the position in which it was when we commenced our description.

In order to start such an engine into motion the fires were lit under the air vessels, and when all was thoroughly hot the displacers were alternately moved up and down by hand. You will see, as we go on, that one of the practical difficulties in connection with almost all heat engines other than steam is involved in this question of starting.

Let me point out to you what are the peculiarities of Stirling's engine. First, the air, by the alternate heating and cooling of which it is worked, has, as I have said, an initial pressure imparted to it of 150lb. on the square inch, and at this pressure it is maintained, as against loss by leakage or otherwise, by means of the small air pump.

You will realise, from that which I have told you as to the laws governing the expansion of gases, that a high initial pressure of the air is of great advantage from the point of view of economy of fuel consumption in a hot-air engine, because it would require a very much less quantity of heat in proportion to raise the pressure of the air by any given amount than would be required if only used initially at the pressure of the atmosphere. As we have learnt, with a given volume or quantity of a gas, the same number of units of heat are required to double the pressure, no matter what that pressure may be. Another peculiarity of this engine is, that the same air is used over and over again; it is not exhausted from the engine at each stroke.

It is certain that no record of the history of hot-air engines would be complete without mention of the name of John Ericsson, who died in America (the country of his adoption) as recently as March the 8th last. He was an engineering genius. To him the invention of the screw propeller is sometimes attributed; he is credited with designing and building the first real ironclad, completing it in 100 days from the laying of the keel-plate. A steamer fitted with a "caloric" engine, as he called it—a hot-air engine really—on his principle, was built and successfully tried. This engine was designed to develop as much as 600 horse power. His patent is dated 1826. From an examination of the patent drawing, you will see that the engine shown here is a mixed air and steam engine.

The atmospheric air, or a portion of it, having first been used for the combustion of solid fuel under a steam boiler, was thereby heated and was afterwards used, together with the hot gases produced by combustion, to act in an ordinary working cylinder, and thus assisting the steam engine. In an alternative engine, described in this patent, the hot products of combustion could be mixed with the steam from the boiler, and the two together could be used in the same cylinder of the engine.

You will realise that the essence of this invention of Ericsson's, as compared with that of Stirling, is that in Ericsson's engine a portion of the air was passed directly through the fire, and the gases of the products of combustion themselves were used directly in the power cylinder, and were exhausted after completing their work, while in Stirling's engine the air was heated, as I have shown you, first by the regenerator and then by being brought into contact with a hot diaphragm or plate of metal, the fire being on one side of this and the air upon the other, the two not coming directly into contact with each other; further, the air was not exhausted at the completion of each stroke, but was used over and over again. Broadly speaking, these two engines represent the two great classes of hot-air engines.

In the one, the air to be used in the power cylinder is passed directly through the fire, and goes, with the gases produced by combustion, into the power cylinder.

In the other class, the air does not come into direct contact with the fuel, but is heated through an intervening plate of metal.

(*To be continued.*)

LITERATURE.

The Prospector's Handbook. By J. W. ANDERSON, M.A., F.R.G.S. 138 pages. London: Crosby Lockwood and Son.

THIS work is written as a handbook for those about to seek their fortunes in a foreign land, and it undoubtedly gives information of a most valuable kind to such persons, while it also aims at imparting knowledge upon every subject connected with mining, minerals, and the nature of rocks and ores. The practical manner in which the tests for the various metals are set forth indicates the personal experience of the author in that direction. The book is a general compendium of most valuable information respecting mines and metals, and the issue of this—the fourth edition—is a proof that the author has been successful in his efforts to popularise a somewhat difficult subject.

The A B C of Electricity. By W. H. MEADOWCROFT. 108 pages. London and Manchester: John Heywood.

WE are not surprised that Mr. Edison has written an endorsement of this excellent little work, as it contains, in the most simple and intelligible language, a complete introduction to electrical knowledge. The fault of most text-books upon electricity is avoided in this work, for Mr. Meadowcroft takes nothing for granted in his descriptions of electrical instruments and results, but instead is most careful to make all his statements clear by bringing into comparison with the new matter which he is explaining some familiar illustration from every-day practice in common life. It is the clearest introductory work we have ever examined. The student and the novice will alike appreciate this work, and its moderate cost will soon bring a large demand from the general reading public.

The Elementary Principles of Electric Lighting. By A. A. CAMPBELL SWINTON. 37 pages. London: Crosby Lockwood and Son.

THIS little work is descriptive of the more common principles and systems employed for generating and supplying electricity for lighting purposes. It does not enter into any very elaborate explanation of the theories of the electrician, but sets out in a plain, simple way the actual results obtained by following certain previously defined electrical systems. There is much information of an elementary form, interesting to the reader who merely wishes to be familiar with the modern system of electric lighting, without having to wade through the technicalities of a general electrical treatise.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

PECULIAR INTERNAL CORROSION.

To the Editor of "The Practical Engineer."

SIR,—Your correspondent, "Works Manager," has experienced the ordinary trouble which, I fear, most practical men conclude to be without remedy. I have distinct recollection of similar corrosions on boilers that I have repaired, and I not only found this corrosion near to the lap of the tubes, but in almost every case where there was a *continuous projection* around the tube. I took out some Bowling rings which were cut away in exactly the same manner, both against the projecting plate or flange of the ring, and at the corner forming the commencement of the hoop. I have also seen the ⊥ rings of the tube joints affected in a similar manner in other boilers. It appears to me that this corrosion is inevitable, for my experience has led me to expect that, given a projection of a continuous kind around a flue tube, then there will, as a result, be corrosion at that part. Perhaps some of your numerous practical readers can give their experience with corrugated flues.—Yours, &c., ENGINEER.

To the Editor of "The Practical Engineer."

SIR,—The corrosive channelling is certainly peculiar, but not unusual, as it is often found as described by "Works Manager," and also occasionally near the edges of T hoops, and at ring seams on shell bottoms. It is due to a mechanical and chemical action of an erratic kind not yet satisfactorily explained. In my opinion, it is due to the circumferential expansion being retarded at the seams, and each ring of plates has a tendency to assume a barrel shape, and, being of iron, are readily injured by the oft-repeated bending and straightening of the material in its weakest direction. Where seams are drawn exceedingly tight I should expect to find this most aggravated. I have never, to my knowledge, found this defect in a definite form in steel plates, or in iron plates plated longitudinally. "Works Manager" is in error in thinking the feed water is not corrosive. The fittings prove most conclusively that it is, and the surface of the plates destroyed by the mechanical action would be readily affected by any corrosive agent, however weak. In the case of new furnaces I should recommend flanged seams, or light steel Bolton hoops.—Yours, &c., CHALKLINE.

QUERIES AND REPLIES.

80. BOOK ON LOCOMOTIVES.—Can any of your readers inform me of the best book on railway locomotives—chiefly Midland Railway locomotives?—W. B.

Answer.—No book treating specially of Midland locomotives; but several examples in the volumes of *Engineering*, &c. The best book on the subject is Zerah Colburn's "Locomotive Engineering and the Mechanism of Railways," but it is rather costly, and eighteen years old; but it is not yet superseded, and is scarcely likely to be. I cannot recommend the cheap elementary books published on the subject.—J. H.

84. BRAKE STRAPS ON CRANES.—What is the usual method of calculating the breadth of brake straps on ordinary cranes?—W. R.

Answer.—The amount of pull or stress on the brake strap in any given case being known, the strength of the strap is proportioned thereto, calculated on the net section between the rivet holes by which it is attached to the anchored end.—J. H.

86. WORKING DRAWING OF CRANE.—Will you kindly permit me to ask any of your readers if they could give me information as to where I could get a working drawing of a crane; also, if there is a book published on shading?—J. H.

Answer.—Consult back volumes of the *Engineer* and *Engineering*, where you will find scaled drawings of different types. There is no useful book on cranes. The only two in existence are Towne's and Glynn's, and both are extremely meagre and far behind present practice. If you will say what kind of crane you want, perhaps I can give you the leading dimensions. The best book on shading that I know of is an old one published by Blackie—"The Engineer's Drawing Book." But you will find cheaper books in Spon's and Lockwood's catalogues.—J. H.

93. LAUNCH.—Will anyone inform me what kind of engines I should get for an ordinary boat 25ft. by 5ft., but having 2ft. 2in. mean draught? It was originally built for an auxiliary sailing boat. I want speed of 9 miles per hour. I would like to know something of petroleum engines, if they would suit, also the sizes of cylinders, stroke, propeller, &c.—J. M. S.

Answer.—"J. M. S." must not be too sanguine about getting a speed of nine miles per hour out of his 25ft. by 5ft. launch. The following is what I should suggest:—

Engines—a pair of high-pressure, direct-acting, inverted cylinder type, having cylinders 4in. diameter by 5in. stroke.

Boiler—horizontal, through tube type, 3ft. diameter by 4ft. long, working pressure 100lb. per square inch.

The engines to be of light construction, carefully balanced, that they may be capable of running at a high speed, say 400 revolutions per minute, at which speed they should indicate about 20 horse power.

Propeller to have two blades, and to be 26in. diameter by 2ft. 6in. pitch.

Screw shaft to be 1⅝in. diameter.

"J. M. S." mentions petroleum engines, and asks if they would be suitable. If by this is meant engines similar to those now being fitted by Messrs. Yarrow and Co. in their zephyr launches—certainly, yes; as to obtain a speed of nine miles the weight of the machinery would have to be reduced as much as possible, and it is claimed by Messrs. Yarrow that, although the engines are of about the same weight per horse power as an ordinary steam engine of the same power, the weight of the generator is not more than one sixth that of the boiler it replaces, which in a small launch is always the most serious item of weight; also the weight of fuel to be carried to travel the same distance is less than with coal.—BATEAU.

Answer.—Answering your correspondent "J. M. S" regarding particulars of engine required for a steam launch 25ft. long by 5ft. beam, I should say that compound steam engines with cylinders about 3¼in. and 6in. diameter by 5in. stroke would be suitable for a speed of about nine miles an hour. The boiler should work at from 100lb. to 120lb. per square inch, and would be about 4ft. diameter by 5ft. long. The propeller would be from 20in. to 24in. diameter. The weight of the above complete, with water in boiler, would perhaps reach as much as four tons. Again, a single cylinder, say 5in. diameter by 6in. stroke, with a boiler 3ft. 6in. to 3ft. 9in. diameter by 5ft. long, working at 130lb. pressure, would be of less weight and cost less. The boiler would have one furnace, and contain about 40 tubes 1½in. diameter. Petroleum engines are as yet a specialty, and will perhaps be dealt with by someone giving these their immediate attention.—W. R.

Answer.—As "J. M. S." desires his boat to obtain a speed of nine miles per hour, the following details would meet the requirements of the case, but I am of opinion the life of such a boat would be very brief indeed, as boats of the class you describe are not constructed to be subject to such a vibrating agent as an engine. The boat would therefore have to be considerably stiffened to make it at all suitable for the purpose you name. As regards petroleum boilers, as far as I can ascertain, petroleum fuel is not yet wholly a commercial success, being more in the experimental stage. I would, therefore, recommend "J. M. S." to obtain a good engine and boiler, arranged to burn coal fuel from some good firm, who would also advise as to the suitability of your boat to receive engine power. Description, single-cylinder vertical engine: Details would be nearly as follows—Diameter of cylinder, 5in.; length of stroke, 5in.; steam pressure in boiler, 75lb.; number of revolutions (probable), 390; indicated horse power, about 10. Propeller: Number of blades, 4; diameter, 2ft. 1in.; mean pitch, 2ft. 2⅜in.; greatest length in line of keel, 3¼in.—J. R.

82. OSCILLATING ENGINE.—If CP be the crank and PQ the piston rod of an oscillating engine, find the velocity ratio of P to Q, and set out result in diagram. Find also the angular velocity ratio of CP and PQ at any point of stroke.—C. P. W.

91. ALUMINIUM AND STEEL CASTINGS.—I see from an American contemporary that steel castings are now produced which can be worked like the best wrought iron, and yet tempered by the use of a flux containing aluminium. Can any reader inform me how steel castings can be produced, capable of being easily worked and tempered, or case-hardened, and possessing great breaking and elastic strength? Is there any work on this subject?—C. H. B.

92. TANNATE OF SODA.—What is tannate of soda, and how is it prepared? Will it prevent a boiler feed-pipe from choking up if injected with feed water? Is there any composition which will do this?—ENGINE-DRIVER.

94. PORTABLE ELECTRIC LAMP.—Is there a portable electric reading lamp in the market, containing its own battery? Any information, with cost and where obtainable, will be appreciated.—STEAM.

95. RAIL CONNECTIONS.—Why are rails connected by fish plates, instead of the ends being laid in chairs on sleepers? It would surely cause less jolting if they were laid in the latter manner. Information will greatly oblige.—YOUNG ENGINEER.

96. STROKE OF HYDRAULIC ENGINE.—What is the advantage derived from making the stroke of a hydraulic engine variable? How is it done? A sketch will oblige.—J. S.

97. CORROSION IN STEAM CYLINDER.—I have recently seen an old steam cylinder in which a deep groove is corroded into the metal of the cylinder at each end of the piston stroke. The groove is so deep and completely round the circumference, that the metal is almost eaten through. Can any reader explain this?—E. H.

PATENTS AND INVENTORS' QUERIES.

1. DELIVERY OF NEW MACHINES NOT PATENTED.—We have just finished a new machine to supply an order which is urgent. We are applying for provisional protection, but have not yet sent in our specification. Can we send off the machine without invalidating the proposed patent?—G. AND T., Birmingham.

Answer.—The machine must not be sent off till your specification has been filed. Even sending it out of the works and delivering it to your customer a day before the date of your patent constitutes publication, and renders your patent void.

2. A NEW INVENTION WITH POINTS OF SIMILARITY TO OLD INVENTION.—I have designed a new tube-corrugating machine, which acts in one point the same as an old form of beading machine. Can I obtain a valid patent?—C. F. G., London.

Answer.—Most new inventions have points of similarity with old ones, but if the older invention was mechanically a failure, and your new invention overcomes the difficulties of practical application, you can obtain a perfectly good patent.

3. A JOINT PATENT.—I have produced a new detail in watches, which is patented in my name and that of another person. Can each work the invention without the consent of the other?—J. F., Coventry.

Answer.—Joint patentees, on the absence of any written agreement between them, have equal rights in the invention patented, and can work it independently. This has been decided repeatedly in the law courts, and recently in the case of an employer and a workman. The workman had an equal right to manufacture with another firm, or for himself, just as he chose.

TO CORRESPONDENTS.

J. S., Hastings.—We shall insert several of your queries. The *Scientific American* is an interesting journal, but is not entirely devoted to engineering. It can be obtained through any newsagent. Thanks for appreciative remarks.

J. D., Glasgow.—We have your letter, and shall deal with it next week

CONSTANT READER, Chigwell.—We expect our correspondents to send name and address when asking for information. Do so, and your query shall be answered.

MISCELLANEA.

Brunnen, a small village on the Lake of Lucerne, is now lighted by the electric light. Power for this purpose is supplied by the spinning mill of Herr Ibach, where water representing 200 horse power over and above the requirements of the mill is available. The surplus water has been utilised in a small central station, from which Brunnen is supplied with electricity.

The total coal consumption of the world is said to amount to upwards of 1,000,000 cwt. per hour. Of this quantity about 240,000 cwt. are required per hour in order to heat the boilers for stationary and marine engines, locomotives, &c. The production of pig iron absorbs 100,000 cwt., and that of other metals 80,000 cwt. per hour. The average hourly consumption of household coal is reckoned at 200,000 cwt., but the total production is estimated at 30,000,000 cwt. to 33,000,000 cwt. per diem, so there is a considerable margin.

Scottish Steel.—The chief of the steel-producing companies in Scotland gave, at its annual meeting, some remarkable figures. Sir Charles Tennant, its chairman, stated that in the financial year just ended there had been made 208,691 tons of steel ingots. This was 13 per cent more than in the previous year. But the products were in value 23 per cent more, price having risen as well as production. This great concern sets an example to others, even to great Durham works, for it is widening the nature of its output, and has put down a tire mill, to make engine and wagon tires.

Measuring Waves.—The Honourable Ralph Abercromby, while on board the steamer Tongariro, succeeded in measuring the height of ocean waves by floating a sensitive aneroid barometer upon the water. The width and velocity of the waves were also obtained by timing their passage with a chronograph. The biggest wave he encountered was in 55° S. latitude and 105° W. longitude. It was 46ft. high, 765ft. from crest to crest, and had a velocity of 47 miles an hour. As the weather was not exceptional for the latitude, Mr Abercromby concludes that waves must occasionally reach a height of 60ft., as has been stated by Admiral Fitzroy.

Boring for Coal at Hart.—We understand that arrangements have been made between Messrs. Casebourne and Bird, of West Hartlepool, and Vivian's Boring and Exploration Company Limited, of Whitehaven, to discover whether workable coal exists between the present known boundary of the South Durham Coalfield and the Hartlepools. The estates on which borings will be made are the properties of Colonel Scurfield and Sir F. Milbank, Bart. Previous attempts have been made to solve this question. One boring was put down at the village of Hart in 1735, and another in 1808, but, owing to the imperfect character of the boring machinery in those days, no definite results were attained. The case is altogether different now, when the diamond boring apparatus is available. The first boring is now being commenced in the immediate neighbourhood of Hart Station, and will probably be completed in about six months. Should its indications be sufficiently favourable, further borings will be made on the large area secured, which extends over about seven square miles.

There is considerable talk about a new invention for which a Chicago man has recently taken out a patent, and which some people believe will revolutionise the tin and steel industry of the world. Patents have also been secured in Europe. It is a process by which molten metal may be rolled into any desired shape, thus saving all intermediate processes. It was invented originally to roll molten solder into thin plates, but the process is pronounced by experts to be equally applicable to iron and steel in the various forms of plates, structural iron, and rails. It is believed that by this process the cost of manufacturing steel rails can be reduced to the extent of 10dols. per ton, and that thin iron plates for tinning can be made much below the cost of production of tin-plates in Wales, thus making a new industry in the States. The molten metal is passed between rollers which are chilled as it passes, the rollers being kept cool by a stream of water which passes through them. Another advantage claimed is that iron and steel so rolled will be much more even and closer in texture than that made by present methods, being free from the air-holes which result from the intermediate processes.

Consumption of Gas in Engines.—Tests recently made in Germany have developed some interesting particulars bearing on the question of gas consumption in gas engines. The tests were instituted because of the general complaints of excessive gas consumption in such engines, and a series of preliminary trials showed that, as a matter of fact, the actual consumption in the case of a one horse power engine exceeded the rated consumption by about 30 per cent. Investigation showed that the gas meter was placed in a room at a temperature of 25 deg. C., with a barometric pressure of 730mm. Reducing the quantity of gas indicated on the meter to a temperature of 12 deg. C. and a barometric pressure of 760mm., the quantity was found to agree much closer with the rated figure, showing very strikingly the importance attached to the position of the meter or the temperature of the surrounding air, and the influence which it exerts on the readings. This circumstance is important, not only where gas is used for power purposes, but also in cases of lighting and heating. For the consumer, therefore, it is worth while to select for the meter, if possible, a cool place, taking precautions, however, against frost.

Expansion in the Eiffel Tower and Forth Bridge. We see it stated that the space allowed for expansion under change of temperature in the immense girders of the Machine Gallery of the Paris Exhibition is 8 centimetres, or 3⅛in. The space allowed for expansion in the Eiffel Tower, as we noted some time ago, is only the half of that (1 9-16in.) The difference of temperature calculated upon in the former case is 50 deg. C.—between 35 deg. above and 15 deg. below zero, or between + 95 and – 5 on Fahrenheit's thermometer. The contrivance, whereby the curvatures *(demiarceaux)* work on swing hinges below and are left free above, is reckoned not the least of the wonders about the Machine Gallery. The whole roof is displaced, rising or falling a little according to change of temperature. But there is a far greater wonder in the way of space allowed for metallic expansion much nearer to us than the *galerie des machines.* In connection with the foregoing, it is worth while recalling that, at the Forth Bridge, a railway is being laid upon a structure that is always shortening and lengthening. There the space allowed for expansion averages an inch per 100ft., being an allowance of nearly 7ft. for the whole bridge, which is 8,098ft. long.

A Pennyworth of Electric Light.—One of the latest novelties in the application of electricity consists of an electric reading-lamp, which is being fitted to the carriages on the main line of the South-Eastern Railway. It is on the principle of the "put a penny in the slot" automatic machines. The apparatus is situated immediately over the passenger's head and under the rack, and is contained in a small box 5in. by 3in. The light is of five candle power, and is obtained by the introduction of a penny at the top of the box, and by a subsequent pressure of the knob, and will last for half an hour, extinguishing itself at the end of that time automatically. If the light be required for an indefinite period, a penny every half-hour will suffice. The light can be extinguished at any moment by means of a second button provided for the purpose. One of the special features of the invention is that if the instrument is out of order, the penny is not lost, as it is in the present machines. It drops right through and comes out at the bottom of the box, so that it can be recovered; and the same result happens in the case of any coin other than a penny. Each carriage is fitted with an accumulator which supplies the electricity.

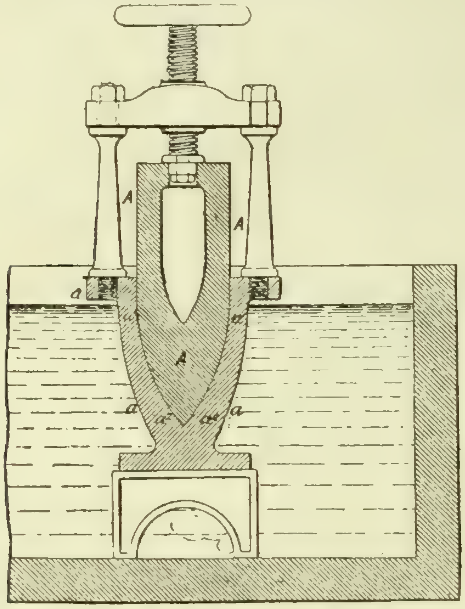
Nitrogen from Coal.—Mr. Mond, the president of the Society of Chemical Industry, at the annual meeting of the society, gave the result of considerable and varied research demonstrating that nitrogen in the form of sulphate of ammonia can be recovered from coal on a profitable commercial basis. He says that the loss in gasifying coal in order to recover ammonia from it amounts to about 20 per cent of the fuel used. From 125 tons of fuel four tons of sulphate of ammonia can be obtained, and beyond that the same result would be obtained from the 125 tons as from 100 tons which had not been treated for the purpose of recovering the nitrogen. That means that 25 tons of fuel are consumed to obtain four tons of sulphate, or six and a quarter tons of coal for one ton of sulphate. In coal districts the six and a quarter tons of fuel would cost about thirty-five shillings, and the total cost of producing the sulphate of ammonia would be about £4 10s. to £5. As the sulphate is worth about £12 a ton, there is an ample margin for profit and contingent expenses. Mr. Mond points out that the process is one which would prove particularly profitable for large consumers of fuel in districts where coal is cheap; and if only one-tenth of the coal used in this country were treated by it a sufficient supply of nitrogenous compound would be provided to meet the requirements of the whole of the Old World. It would afford the means of building up an exceedingly important industry amongst us, which would give employment both to men and capital, and prove a great advantage to the farming industry.

Electric Light on the Midland Railway.—For some months past several of the Midland Railway Company's trains between St. Pancras and Manchester have been furnished with the electric light. After a lengthened trial, during which the great improvement in the ordinary train light has been made manifest, the company have decided to continue the electric luminant, much to the satisfaction of the general public. The lamps are placed either in the centre of the roof of the carriage or at the sides, and in many cases they are arranged that the light shines from behind the traveller, so that he may read with the greatest ease. So satisfied are the company with the success of this effort to further enhance the comfort of the travelling public that they have, with an enterprise which does them great credit, decided to extend the electric light to their local or short distance trains. Already one or two experiments have been made in carriages running between Manchester and Stockport, and on Thursday week a stopping train to Derby and back was brilliantly illuminated with the electric light. The experiments, so far as the local service of trains is concerned, are merely in their initial stage at present, but if they should prove as beneficial as those on the London trains the company anticipate a very considerable extension in the supply of electricity to their carriages, Evidences are not wanting in other directions that the old method of illumination is on the decline, as the London and North-Western Railway Company have for some years past had at least one of their trains running between Manchester and Liverpool fitted with electric lamps.

ILLUSTRATED PATENTS.

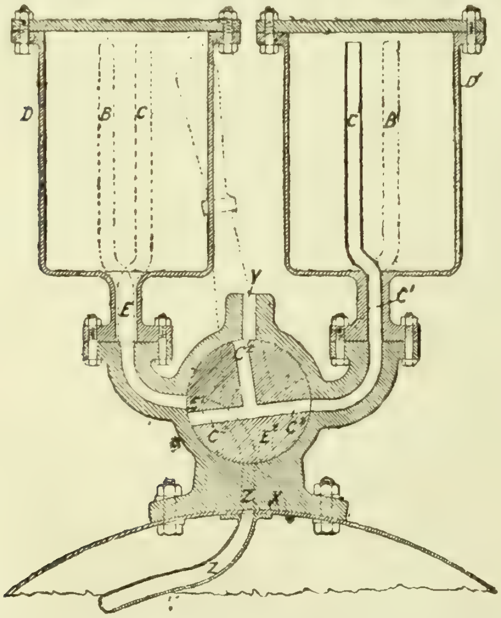
4,433. Projectiles. R. Lowe, Woolwich Arsenal, and H. H. Smith, Plumstead, Kent.

Tempering.—The shell A is heated and inserted into a case a of metal or other material. It is then subjected to pressure to bring its surfaces into contact with the case, and the case is immersed in the cooling liquid. The case may be of uniform thickness, or of varying thickness, as shown at a^1 and a^2.—March 22, 1888. [8½d.]



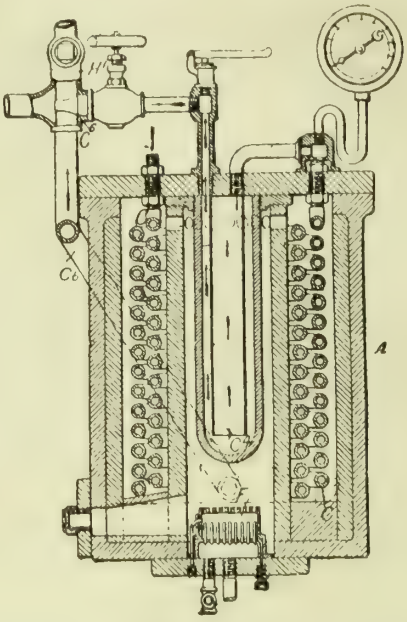
4,500. Boiler-feeding Apparatus, E. W. Jones, Caistor, Great Yarmouth.

Two or more vessels are alternately put in communication with the water reservoir and the boiler, either automatically or by hand. A sectional view of an apparatus, consisting of two vessels operated by hand, is shown. From the top of the vessels D, D^1, pipes B, B^1, and C, C^1 lead down into passages on the casing of the cock, and between these pairs of ports in each case is a passage E in the left-hand vessel, leading from the bottom of the vessel. In the plug are cut-ways, shown by full and dotted lines, by which the vessels are made to communicate with the boiler and water supply Y alternately. When the plug is in the position shown, the left-hand vessel communicates with the water space by E, E^2, and Z, and with the steam space by B, a passage B^2 parallel to E^2 and the pipe X. By this means the water it contains flows into the boiler, at the same time the right-hand vessel D^1 is filled with water from the supply branch Y by C^2 and C^1. When the plug is moved over the vessel D is filled and D^1 is emptied in a corresponding manner. To make the apparatus automatic, the plug is fixed while the vessels and casing rock on it owing to the varying weights of the two sides.—March 24, 1888. [8½d.]



4,531. Fluid-pressure Generators, J. Bourne, Shepherd's Bush, Middlesex.

Consists in arrangements for burning liquid or gaseous fuel, and mixing the products of combustion with the steam generated in the apparatus for use in any convenient fluid-pressure engine. One form of apparatus for carrying out the invention is shown in vertical section. At the lower end of the cylindrical fire-brick lined casing A, the liquid fuel burner F is situated. The burner consists of a trough of pumice stone, or equivalent material, saturated with liquid fuel, and supplied with air under pressure through short tubes passing upwards through the pumice stone. The combustion products, after passing away from the upper grated surface of the burner, pass round the inner tube C^4 and the coiled tube C in which water is heated under great pressure. The water from the coil escaping from a nozzle in the pipe C^6 flashes into steam, and there mixes with the combustion products from the burner as they pass on their way for use in the motor. Arrangements are provided for heating up the apparatus by the burner before using the products in the engine.—March 24, 1888. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq., *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

August 22nd.

13253 Belt Clasps, B. J. B. Mills, London. (P. Coste, France.)
13265 Steam Boilers, J. Laird, Glasgow.
13267 Circular Sawing Machines, J. H. Hamilton, London.
13273 Arc Lamps, C. Julian, London.
13275 Ships, O. T. Hobday, London.
13276 Railway Rolling Stock, J. Walker, London.
13278 Cutting Cork, J. Wiederkehr, London.

August 23rd.

13294 Lubricators, W. James, Chester.
13301 Furnaces, W. Deighton, Leeds, Yorkshire.
13310 Lock Nuts, T. H. Ramsden, Leeds.
13312 Furnaces, D. Colville, jun., Glasgow.
13313 Drawing Wire, J. M. Hunter, Newcastle-upon-Tyne.
13317 Ratchet Drill, T. Daniels, London.
13319 Steam Generators, C. T. Allport, London.
13322 Electric Signals, E. J. P. Mercadier, London.
13324 Oil, J. Deuss, London.
13326 Ventilating Apparatus, W. R. Maguire, London.
13331 Coupling, H. J. Haddan, London. (R. Bossard, Switzerland.)
13338 Spring Motor, W. Barnes, London.
13341 Boiler Tubes, A. Witcomb, London.

August 24th.

13347 Flange Joint, W. J. Ford, Kent.
13351 Knitting Machines, C. Terrot, Bradford, Yorkshire.*
13362 Rotary Motors, R. Alston, Glasgow.
13366 Cranks, O. F. A. Jörgensen, London.*
13367 Rope-spinning Machines, J. Mertens, London.*
13368 Water Gauging Fittings, G. Mock, London.*
13374 Railway Signals, G. G. Byrne and E. F. Gascoine, London.
13379 Ventilating Railway Cars, C. Huelser, London. (B. M. Turnbull and B. W. Taylor, United States.)*
13382 Electric Alarm, M. Beckers, London.*
13392 Bearings, C. Golay, London.

August 26th.

13402 Generating Steam, T. Blandford, Corbridge-on-Tyne, Northumberland.
13418 Plugs, W. Defries and V. I. Feeney, London.
13419 Brake, N. C. Parascho, London.
13420 Aluminium, G. W. Clarke, Birmingham.
13421 Gas Engines, R. Hargraves, London.
13426 Meters, G. Teideman, London.
13428 Feeder, C. N. Hearn, Kent.
13436 Water Heater, P. Tyrer, Surrey, and L. Breeze, Essex.
13437 Centrifugal Fans, W. Sayer, London.*
13441 Compressed Fluids, T. Tubini, London.
13443 Sifting Machines, C. Haggenmacher, London.
13444 Dynamo Machines, F. Reisinger and W. Wenzel, London.
13449 Saws, H. H. Lake, London. (Messrs. Wirth and Co., Germany.)

Publishers' Announcements.

BACK NUMBERS of "The Practical Engineer," from the commencement, with the exception of several of the earlier numbers, can be obtained at either of our Offices, or by order of any Newsagent.

Vol. I. (bound), price 6s. 6d., and Vol. II., price 7s. 6d., can be obtained through any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of postal order or stamps for the amount.

Numerous complaints having been made to us by Subscribers of the difficulty they experience in obtaining copies of *The Practical Engineer* in certain districts, we have to state that the Journal can be obtained by any Newsagent through the ordinary trade channels, and no difficulty should therefore exist in obtaining copies *by order* of any Newsagent.

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

SEPTEMBER 20TH, 1889.

NEW ALLOYS OF NICKEL AND STEEL.

THE ever-increasing demands of the world at large for greater rapidity of locomotion on land and sea, greater economy of fuel, and great motive power in small bulk, has created the necessity for the production of improved materials of construction which engineers can use with confidence and success. Much sustained effort has accordingly been devoted by our metal manufacturers and metallurgists to the examination of the properties of new metals—new, we mean, from a commercial standpoint—and also new alloys or old alloys studied under improved conditions. The many new materials now available for engineering purposes are the results of this work, and it is interesting to note how varied are the properties and capabilities of the newer commercial alloys.

Mr. Nordenfelt's so-called "mitis" metal is intended to meet the demand for wrought-iron castings, or rather castings which have the properties of wrought iron, and yet the free fluidity of cast iron; and it consists of an alloy of iron and aluminium which has most remarkable properties. It casts readily, produces sound castings, which are soft and malleable, and have great tensile strength, without requiring to undergo the tedious process common to ordinary malleable iron castings. Mr. Hadfield's manganese steel also possesses remarkable properties; and alloys of steel with chromium, copper, and other substances are now, perhaps, not in common use, but still they are largely used for various purposes. Aluminium itself, although mostly used as an alloy with copper, yet bids fair, if Sir Henry Roscoe is correct, to come into use as a constructive engineering material. At present its cost forbids this, but no doubt, if the manufacturing difficulty could be overcome, the valuable properties of this metal would be gladly utilised by engineers. According to Sir Henry Roscoe, its breaking strain varies from 12 to 14 tons per square inch; and its specific gravity cast is 2·58, and rolled and hammered 2·68—that is, an equal bulk of iron is rather more than two and a half times as heavy.

This considerable tensile strength, taken in conjunction with its power of entirely resisting corrosion from air or water, would make its use widely extended if it could be sold at a reasonable price. However, if we may judge from a paper read before the Iron and Steel Institute, just published in their journal, steel and its modifications have not by any means attained their full and complete development. Mr. James Riley, whose name is so well known as an authority on all matters pertaining to steel manufacture, and who has had so large a share in the introduction of mild steel for construction and engineering purposes generally, has made a considerable number of experiments upon the influence of nickel upon the properties of steel. These experiments he describes in his interesting paper. Taking a sample of mild steel for example, containing about 0·22 per cent of carbon, when annealed the elastic limit would be reached with a tensile strain of 16 tons per square inch, and the breaking strain would be 30 tons per square inch. The extension of a test piece of eight inches in length would be about 23 per cent, and the contraction of area about 48 per cent. Now, the same composition of steel, to which has been added nickel to be present to the extent of about 4·7 per cent, at once gives a material standing a strain of 28 tons per square inch before reaching the elastic limit, and having, moreover, a breaking strain of 40·6 tons per square inch, without impairing the elongation or contraction of area of the specimen to any marked extent. The elongation of an 8in. test piece is 20 per cent, and the contraction of area about 44·8 per cent, after rolling and annealing, as with the mild steel sample. With 3 per cent of nickel and 0·35 per cent of carbon, the elastic limit is the same, 28 tons per square inch, but the breaking strain is increased to 48·5 tons per square inch. At the same time the extensibility and contraction of area are somewhat reduced.

Steels containing nickel up to 5 per cent can be machined with moderate ease; beyond that they are more difficult to machine, and the alloys poorer in nickel stand punching remarkably well.

Ordinary steel can be prepared of a tensile strength of about 52 tons per square inch, but it is excessively hard; its elastic limit is high, but its ductility is very low. What we require in the workshops is a material of great tensile strength, high elastic limit, but still ductile and soft enough to work easily. This combination of properties seems to be given by nickel steel; the tensile strength seems to be greatly increased without impairing the ductility, and, like ordinary steel, its strength is greatly increased by increasing the proportion of nickel. The strongest sample tested by Mr. Riley gave a breaking strain of 95·6 tons per square inch, an elastic limit of 54 tons per square inch, and an extension, in a 4in. piece, of 9·37 per cent, with contraction area of 49·2 per cent. Two similar pieces tested by Mr. Kirkaldy gave a breaking strain of 94·18 tons and 93·86 tons, elastic limit 52·01 tons and 53·92 tons, extension 7·8 and 8·2 per cent, and contraction of area 52·4 and 50 per cent respectively. These are most remarkable results, and go very far to justify Mr. Riley in his belief that this material will yet be found of very great practical use.

One very important weak point of ordinary steel plates, as compared with wrought iron, is the greater liability of steel to corrosion, and this difficulty is remedied by the use of nickel. Mr. Riley states:—

"In the very important matter of corrodibility, it is with the greatest satisfaction I can state that the steels rich in nickel are practically non-corrodible, and that those poor in nickel are much better than other steels in this respect. Thus, some experiments we have made show that, as compared with mild steel of 0·18 carbon, 5 per cent nickel steel corrodes in the ratio of 10 to 12; and, as compared with steel having 0·40 carbon with 1·6 chromium, in that of 10 to 15. In the case of 25 per cent nickel steel, these ratios are as 10 to 870 and 10 to 1,160 respectively. These results were obtained by immersion of samples of the different steels in Abel's corrosive liquid, and the results confirmed by subsequent immersion in water acidified by hydrochloric acid. Some samples of the richer nickel steels which have been lying exposed to the atmosphere for several weeks still show an untarnished fracture."

This statement is most important, and if the material commercially produced should come up to the high standard of quality attained by the experimental samples, it is quite possible that within the next few years we shall see as great a change as that produced by the substitution of mild steel for iron. In the discussion which followed Mr. Riley's paper, Mr. J. F. Hall corroborated Mr. Riley, and stated that his firm had for several years past been engaged upon nickel steel experiments, and had now quite a large quantity of nickel steel in use for various purposes. Mr. W. H. White, of the Admiralty, also spoke, and seemed to consider it undesirable to attempt any further reduction of scantlings, especially as the strength of a riveted structure necessarily depended upon the material available for rivets, and it was improbable that material could be used of sufficient tensile strength, and at the same time workable and reliable, for riveting. Other speakers, including Mr. Martell and Mr. Parker, both of Lloyd's, warmly commended Mr. Riley's experiments.

There is one further interesting point respecting these alloys which may be of particular interest to the Birmingham metal trades, where deep stamping and metal spinning are largely carried on. Nickel steel containing 25 per cent of nickel has an exceedingly high breaking strain, 42 tons to the square inch, and is yet endowed with an elastic limit as low as 15 tons to the square inch, and an extension of 40 per cent. This means that it is capable of taking an enormous amount of punishment without rupture and distress. This, together with its quality of non-corrodibility, should make it an admirable substitute for brass where light yet strong stamped or spun work is required.

For boiler construction, where high pressures are carried, and for engine and machine construction, where great strength and light weight are necessary, this material, if it approaches, commercially, Mr. Riley's anticipations, will effect quite a revolution, and materially aid the progress of engineering in the direction of economical and safe construction.

THE BRITISH ASSOCIATION.

The Fifty-ninth Annual Meeting of the British Association began at Newcastle-on-Tyne on the 11th inst., by the delivery of the presidential address by Professor Flower, the president for this year. Sir Frederick Bramwell, as the retiring president, opened the proceedings by introducing Professor Flower, and reminding his audience that Professor Flower was one of the first to volunteer to go out to the Crimea during the war to exercise his profession as a medical man. He aided the wounded during the war, and suffered great hardship. He afterwards became famous as an anatomist, and undertook the directorship of the Natural History Branch of the British Museum.

Professor Flower's address was learned and able, as was to be expected from a man of his great reputation, but he dealt mainly with the management of museums, and restricted his range to a much greater extent than has been customary with his distinguished predecessors. We have been so accustomed to hear from the eminent men who address us from the presidential chair, opinions on a wide range of subjects, including our own science—engineering—that we must admit on our own part a sense of disappointment this year. However, any narrowness of range in the address of the President of the British Association was abundantly compensated for by the addresses of the presidents of the sections. That of Mr. William Anderson, of the Mechanical Science Section, was unusually brilliant and interesting, covering as it did the connection of molecular physics with the properties of steel, iron, and alloys, and indicating the probable line of advance in the practical application of the growing knowledge of molecular structure to the daily needs of the engineering world. The petroleum industry and the growing applications of liquid fuel to the purposes of steam-raising, heat engines, and metallurgy were also dealt with. In connection with the world's petroleum and natural gas supply, Mr. Anderson described, in a graphic manner, Mendeleeff's theory of the origin of petroleum and hydrocarbons deep down in the earth, from which he deduced the encouraging assurance that the petroleum and natural gas supply was permanent. If reasonable permanence could be assured, he stated that the applications of liquid fuel to industrial purposes would be widely extended, as at present manufacturers feared to change their plant on account of the probable rise in price of oil fuel by anything like its general adoption. He contended that extended use would tend not to increase prices but to increase the supply. Mr. Anderson's address is well worth careful study, and we purpose considering some parts of it in detail on a future occasion. We give a full abstract in another part of this issue.

The address of Sir Lowthian Bell, Bart., F.R.S., as president of the Chemical Section, was also exceedingly interesting, dealing, as it did mainly, with the chemistry of the iron and steel manufacture.

Mr. A. B. W. Kennedy, F.R.S., gave an interesting paper on the transmission of power by compressed air on the Popp system at Paris. From the central station of this company some six thousand horse power is distributed with great success and a constantly-growing demand. We are interested in examining the proportion of power given by the motor to that developed by the steam engine at the central station. The efficiency is very low. When the air supplied is used in an engine without reheating, only 25 per cent of the power exerted at the central station is obtained by the motor. When heating by coke fires is resorted to, some 50 per cent is obtained. We fear that this result is far from encouraging, so far as our country is concerned, as it means a consumption of at least 8lb. of coal per horse power per hour actually obtained by the user. This, added to the necessarily heavy charge for laying and repairing the pipes carrying the compressed air, makes the power so obtained very expensive. Success in Paris, we fear, by no means indicates the probability of like success here, as the conditions are very different. So far the Birmingham compressed air scheme has not justified the anticipations of its promoters.

The papers placed before the Mechanical Section this year are most valuable and interesting, and include Water Gas, Central Station Heating and Power supply, and the Hopcraft Smokeless Furnace, which subjects we shall consider at another time.

ANOTHER SEWAGE PROCESS.

Yet another system of sewage treatment, professing to solve the troublesome problem. We very much fear that the problem has been so often solved on paper, that when a really successful process appears it may receive scant attention. Mr. E. Harris Reeves has introduced a process which may be successful on the small scale—we do not doubt but that it is—but we can hardly see how success is to be obtained on any considerable scale.

The chemical action occurring between strong sulphuric acid and manganate of soda causes the evolution of sulphurous acid gas and free oxygen, and this action is utilised to fill the sewers and pipes leading from the houses with those gases. They attack the organic matter and decompose sulphuretted hydrogen, and so arrest, for the time being, putrefactive decomposition. We cannot see how this process can be applied on any reasonable scale at a practicable cost, and in our opinion this new scheme is not in advance of well-known older processes.

THE RAISING OF H.M.S. SULTAN.

The methods adopted by the plucky Italian firm of engineers who have succeeded in raising the Sultan and taking her safely into dock, are at present creating great interest. This is due, no doubt, to the alleged impossibility of the undertaking according to many of our naval authorities who considered the matter. Divers were sent down to examine the bottom, and rocks on one side of the vessel jamming her firmly in position were carefully removed. Then the holes in her plating, nine in number, were made good in a temporary way with balks of timber and cement. As the work was all done under water, and under the bottom of the vessel, it was of a most difficult kind. When all was ready, and the decks had been made good, sixteen powerful pumps, constructed by Messrs. Worthington and Messrs. Gwynne, were set in operation, and ejected from the holds some 5,000 tons of water per hour. After one attempt, which failed on account of a leak starting again, the vessel was floated and taken into harbour thirteen miles off. Messrs. Baghino deserve great credit for their able and successful attempts.

COMPARATIVE COST OF GAS AND ELECTRIC LIGHT.

The *Gas and Water Review* has calculated an interesting table which shows the various prices at which the electric current must be supplied per Board of Trade unit in order to compete with gas at different prices per 1,000 cubic feet. The electric current sold at the prices given gives light just equal to that given by the gas. This is the table:—

Gas at per 1,000 Cubic Feet. s.	d.	Corresponding Price per Board of Trade Unit for Electric Light. d.
2	0	$2\frac{3}{8}$
2	3	$2\frac{11}{16}$
2	6	3
2	9	$3\frac{5}{16}$
3	0	$3\frac{5}{8}$
3	3	$3\frac{7}{8}$
3	6	$4\frac{3}{16}$
3	9	$4\frac{1}{2}$
4	0	$4\frac{11}{16}$
5	0	6
6	0	$7\frac{3}{16}$

In London the maximum price allowed to be charged under the Board of Trade rules is 8d. per unit, which corresponds to 6s. 8d. per 1,000 cubic feet of gas. It is generally estimated that the cost to electric lighting companies is $3\frac{3}{4}$d. per unit. It follows that electricity will compete with gas when the price of the gas is above 3s. 3d. per 1,000 cubic feet.

CANAIGRE—A NEW TANNING MATERIAL.

According to Mr. Henry Trimble, of Philadelphia, a new material is now used in a number of American tanneries, which is much cheaper than gambier and resembles it in its action more closely than any other substance yet discovered. The new material is, of course, only new to commerce; it has been long known to chemists, and has been used by the Mexicans for over two centuries. It was first sent to the Agricultural Department, Washington, U.S.A., in 1868, and the sample was analysed and found to contain 32 per cent of tannin. It is a root called canaigre, which consists of heavy globular pieces of from two to six inches long and one to three inches in diameter. When moist it contains about 17 per cent of tannin; dry, it rises to about 30 per cent. The source is said to be almost inexhaustible, and it can be sold in any part of the United States at three cents per pound, so that it is likely to establish itself as quite an important industry.

CLOSE OF THE GREAT LONDON STRIKE.

On Monday morning last the great strike terminated, and the labourers returned to their work, to the intense delight of all concerned. The port of London is all astir again, and bustle and activity reign where stagnation had prevailed for many weeks past. The dock directors have practically conceded the demands of the men, and 6d. per hour is to be paid for day work, 8d. for night work, commencing at the beginning of November next. The other reforms demanded by the men, in altering the system of taking on and discharging casual hands, have also been acceded to, so that the men are triumphant on nearly all points. We trust that the results gained by this strike may materially improve their condition, and lead to other needful reforms in the relations of dock proprietors and shipowners. The men are to be praised for their moderation and law-abiding conduct on the whole, and the strike is a good example of the change in the nature of popular uprisings which has occurred in the last few years. Men are learning that self-control and law-abiding firmness is far more powerful than violence and disorderly conduct.

STEAM ON COMMON ROADS.—II.

(*Continued from page 547.*)

Russell.—Mr. J. Scott Russell (the well-known designer and builder of the Great Eastern) in early life took great interest in steam locomotion. He made a small steam carriage which ran about the neighbourhood of Greenock successfully. In later years, when residing in Edinburgh, he patented a steam locomotive intended for the conveyance of passengers on common roads. Six of these coaches were built under his patents and to his designs by the Grove House Engine-works, Edinburgh, for the Steam Carriage Company of Scotland.

In April, 1834, this company established a line of steam coaches for the conveyance of passengers between Glasgow and Paisley, which plied hourly for many months with the greatest regularity and success. The distance between the two places was a little more than seven miles, and the trip was run in forty to forty-five minutes.

Mr. Russell's coaches were very popular with the travelling part of the community, and were repeatedly overcrowded, thirty to forty persons finding places on a vehicle and its tender, constructed to carry six inside and twenty outside passengers. These carriages have been briefly referred to by two or three writers on this subject, but they have not been illustrated and described in any recent work on steam locomotion; in fact these coaches have been practically ignored by previous writers, and in order to supply this missing link in the history of steam on roads we devote a considerable amount of space to their description.

Mr. Scott Russell, as an experienced engineer, designed his coach with great care. Fig. 4 shows an end view of the engine to an enlarged scale. The general appearance was far superior to many of its competitors, and we are told that "it was fitted up in the style and with all the comfort and elegance of the most costly gentleman's travelling carriage."

The boiler was of the multitubular type, with furnace and return tubes on the same level, and similar to a marine boiler. The improvements introduced by Russell consisted in constructing the boiler in such a manner that it should everywhere consist of opposite and parallel surfaces, or as nearly so as circumstances allowed, and connecting these surfaces together by means of stays of small diameter, placed at distances proportioned to their direct cohesive strength, and to the degree of pressure to be resisted; the plates were much thinner than usual, so that the heat was transmitted quicker; the copper plates were one-tenth of an inch thick. The stays were only one-quarter of an inch in diameter, there being thirteen hundred of them used. Mr. Russell said that the boiler was safe, because he thought the moment the pressure exceeds the maximum, the weakest of the stays will give way; and one rod giving way will instantly let out the whole of the water in the boiler, take off the pressure, extinguish the fire, and prevent all chance of explosion. But we regret to find that Russell's ideas respecting the safety of his boiler were not realised in practice, as we shall see presently. The whole weight of the carriage was supported on springs. The engine had two vertical cylinders, twelve inches diameter and twelve inches stroke. The piston rods worked through the top cylinder covers, and were connected by crossheads to two side connecting rods; the rods from each cylinder worked on to a separate crank shaft, as shown by fig. 3, below. Each cylinder had four ports, which were alternately opened and closed by slide valves, actuated by eccentrics keyed on the crank shafts; one pair of these ports were for the admission of steam, and the other for the exhaust. On each crank axle was fixed a spur pinion gearing into a wheel on the main driving shaft—ratio, two to one; the crank shaft and the driving axle being coupled together by sun and planet straps, which kept the toothed wheels properly in gear. The engine was mounted upon laminated springs, so beautifully arranged that each spring in its flexure described, at a particular point, such a circle as was also described by the main axle of the carriage in its motion round the crank shaft; thus any irregularities in the road in no way interfered with the proper working of the spur gearing. The exhaust steam was turned into the chimney to create a blast. The water and coke were carried on a separate tender on two wheels, coupled to the rear of the engine; at different stations on the road spare tenders were kept in readiness, filled, and were quickly connected to the coach. This tender was mounted upon springs, and provided with seats back and front for passengers. India-rubber tubes conducted the water from the tank to the two brass feed pumps on the engine. Three persons were required to be in attendance—a steersman on the front seat, an engineer on the back seat outside above the engines, the stop valve and cocks being within his reach; he could also tell the height of the water in the boiler, and the amount of steam pressure. The stoker stood on the foot-plate in front of the boiler. These coaches were admirably worked out, and were said to be a "triumphant success" by a Glasgow paper after they had run for four months. Russell's coaches shared the same fate in Scotland that Sir Charles Dance's did in England. They had not been running many months before the road trustees at the Glasgow end, in order to cause an obstruction, put a thick coating of loose stones on the road, but the steam carriages ploughed through it. More men were then employed by the obstructionists to put another thick layer on the top, so that the road was all but impassable. Ordinary road carriages were injured, and heavy carts were obliged to desert the road and go round by a different and much longer route. After the steam coaches had travelled over this accumulation of road material for some time one of the wheels broke, and the carriage was nearly overturned. The whole weight of the vehicle rested on the boiler, which caused it to burst, and five of the passengers were killed.

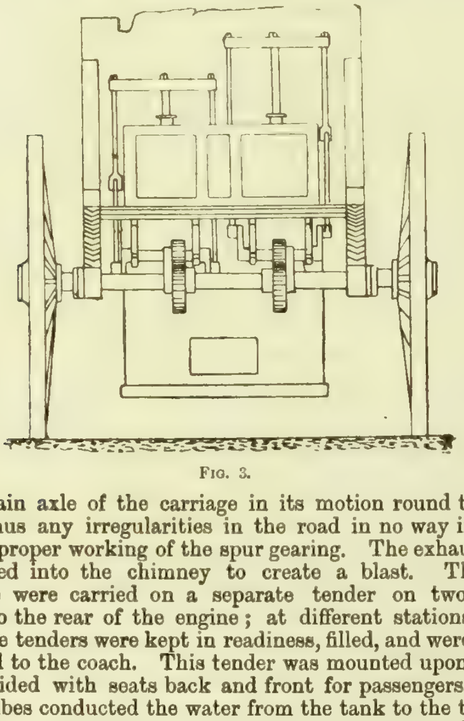


Fig. 3.

The Court of Session, in consequence of this accident, interdicted the whole set of carriages from running, for the time at least. The editor of the *Mechanics' Magazine* said this was a fine specimen of Caledonian wisdom! Why not clear the Clyde of steamers, because accidents happen with steamers as well as carriages? The Steam Carriage Company brought an action for damages against the trustees of the turnpike road for having compelled them to give up the running of the carriages on the Glasgow and Paisley road by "wantonly, wrongfully, and maliciously accumulating masses of metal, stones, and rubbish on the said road, in order to create such annoyance and obstruction as might impede, overturn, or destroy the steam coaches belonging to the plaintiffs."

Russell's steam coaches were no longer used in Scotland, but two of them were sent by steamer to London, and were often engaged in running with passengers between London and Greenwich, or Kew Bridge. Several trips were made to Windsor. They were eventually offered for sale, and to show their powers they started every day at one o'clock from Hyde Park Corner to make a journey to Hammersmith. But they remained unsold, and we hear nothing further respecting them.

Mr. J. Scott Russell, however, was actively employed in shipbuilding, his name being a "household word" in everything pertaining to steam navigation. He was a Fellow of the Royal Society, vice-president of the Institute of Naval Architects, and a Member of Council of the Institute of Civil Engineers. A contemporary, in speaking of Mr. Russell's death, which occurred as recently as 1882, said, respecting the coaches we have illustrated: "The springs of his steam carriages, and the manner in which the machinery adapted itself to the irregularities of the road, were triumphs of engineering."

LENOIR'S AGRICULTURAL PETROLEUM ENGINE.

M. Lenoir, whose name is so well known as the first to introduce a gas engine to the world on anything like a commercial scale, which he did so early as the year 1860, is well represented at the Paris Exhibition. We are pleased to see him in the field once more, and this time with compression, instead of the non-compression principle, as the basis of his engines. We illustrate on page 645 his portable agricultural petroleum engine, as seen at the Exhibition in the hot-air section, close by Pont de Jèna. The engine, like most continental explosive engines, adopts the well-known Otto cycle, but is modified for the use of hydrocarbon vapour instead of gas.

Referring to our illustrations, fig. 1 shows a general view of the engine mounted upon its carriage. Fig. 2 is an end elevation; fig. 3 a section of the cylinder and explosion chamber. Figs. 4, 5, 6 show the mixing valve. Fig. 7 is the carburetter, and figs. 8 and 9 illustrate the governor details. The carburetter E, which is also the petroleum reservoir, is mounted above the engine, as shown (figs. 1 and 2), and communicates by the pipe *c* and the mixing chamber *d* with the inlet mixing valve *e*, from which the gases pass to the explosion space D and cylinder G by the port Y (fig. 3). The tank A carries water for cooling purposes, which is circulated by the small centrifugal pump *m* and the pipe *n* (fig. 1), through the water jacket X (fig. 3). In this engine the explosion chamber D is not water-jacketed, but the heat is allowed to escape by radiating from the projections shown to the air. In this way the chamber is maintained at a higher temperature than usual in such engines, and a considerable saving of heat is thereby effected. The action of the engine is similar to the well-known Beau de Rochas cycle. The exhaust valve seating is shown at H (fig. 3), and L is the spindle hole. M is the bracket carrying the exhaust valve lever. The petroleum vapour and some air enter the valve *e*, and pass by the port Y to the explosion chamber and the cylinder. Upon the return movement of the piston the mixture is compressed into the chamber D, the exhaust valve being meanwhile closed, and when the piston is full in the mixture is ignited by the electric spark, and the engine receives an impulse. Air is drawn through the carburetter from the pipe *c* (fig. 1), and the exhaust gases are discharged from the cylinder by the pipe *f*. B is the engine bed bolting to the tank A, and *g* is a rod actuating the vapour inlet valve as determined by the governor; *h* is the rod actuating the exhaust valve from the cam on the second motion shaft.

M. Tresca has made many experiments upon this engine, and reports that the maximum pressure of the explosion varies from 12 to 13 atmospheres, and the consumption of petroleum spirit was 0·65 litres per horse power per hour. The best result claimed by the makers of the engine, Messrs. Mignon and Rouart, is 0 629 litres gasoline per horse power per hour.

LENOIR'S PETROLEUM AGRICULTURAL MOTOR.

Constructed by Messrs. Rouart Freres, Engineers, Paris.

(For description see page 644.)

Fig. 1

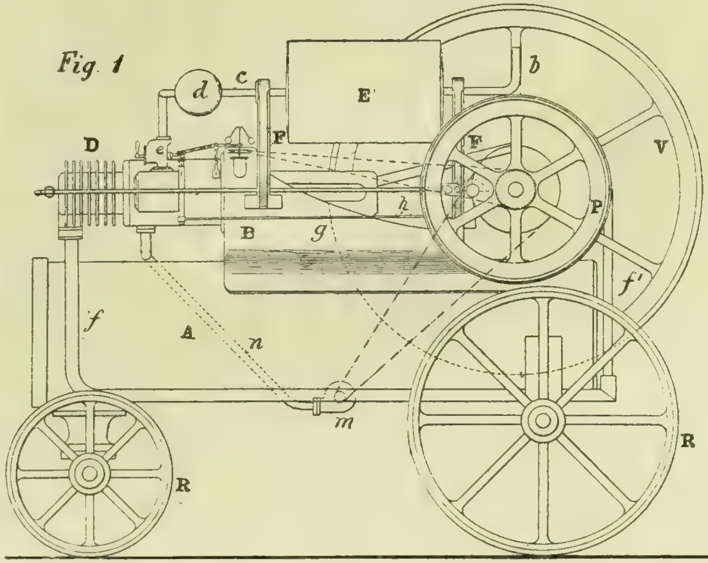


Fig 2

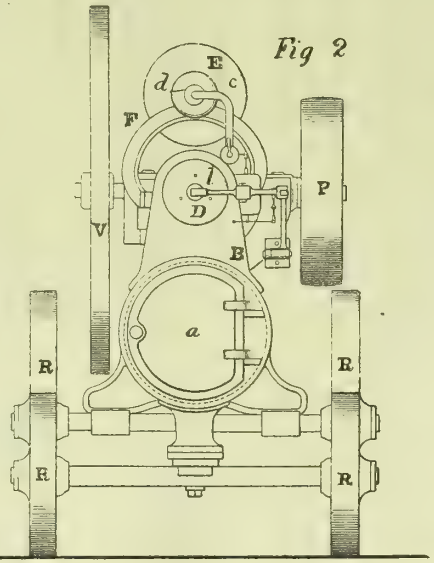


Fig 4

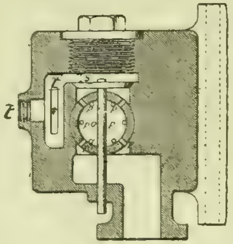


Fig 5

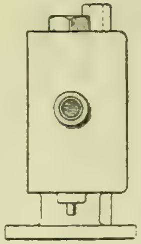


Fig 6

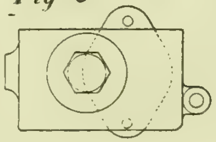


Fig 8

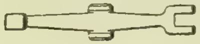


Fig 7

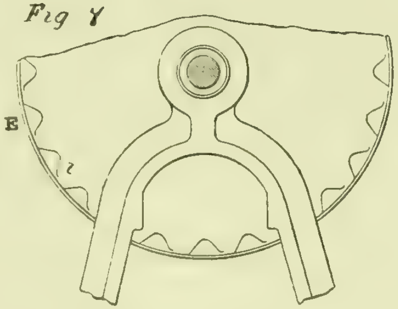


Fig 3

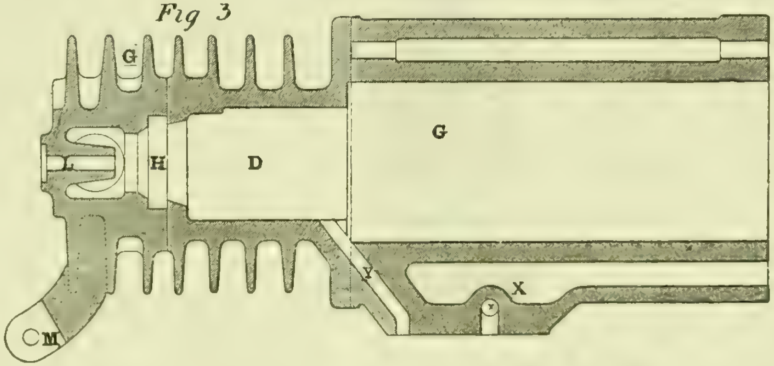
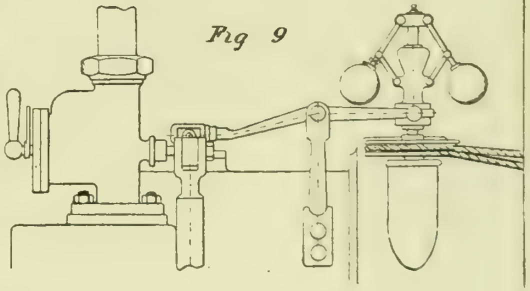


Fig 9



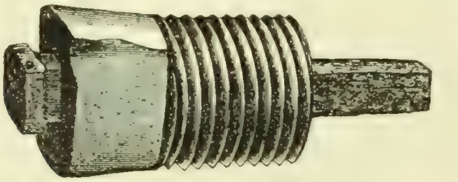
This result, M. Tresca states, is nearly as economical as that attained by the use of coal gas. The numerous engines at work in the Exhibition were all acting admirably at the time of our inspection, and accomplishing their various tasks very satisfactorily indeed. Where the use of gasoline is permitted, they are exceedingly convenient. In this country gasoline has not been used much for the purpose of engine work, and effort is more directed to the construction of engines capable of using heavy petroleum.

ON FUSIBLE PLUGS.*

The fusible plug is one of the most abused appliances to be met with around boiler-rooms. It is so small, and in such an out-of-the-way position, that there is great temptation to let it take care of itself. Again, it is so seldom heard from that a fireman who is not very watchful is liable to forget all about it. Yet when it is properly cared for the fusible plug is a most important safeguard.

In the event of an explosion, too, it often furnishes valuable evidence concerning the immediate cause of the explosion. Thus, after the disastrous explosion at the Park Central Hotel in this city, described and illustrated in the March *Locomotive*, the fusible plug was found intact; and by placing it in a retort, and carefully ascertaining the melting point of the filling, it was easily shown that at the time of the explosion the water in the boiler was several inches over the tubes. That is, direct proof was obtained that the water in the boiler was not lower than it should have been.

The "fusible" plug which we illustrate was found in a boiler in the South. The water in this boiler got low one day, and of course the fusible filling melted out and gave the alarm. The owner not having time to have it refilled, and not having another one on hand, drove a nail into it and went ahead as usual until the water got low a second time; when, as the nail was not any more fusible than the boiler, both got red hot at the same time. Fortunately this caused such a leak around the nail that the escape of steam relieved the pressure somewhat, and the repairs cost only about seventy-five dollars. The boiler was 42in. in diameter and 8ft. long, with an internal flue used as a firebox. The chances are that the owner will not drive any more nails into fusible plugs.



We remember another instance, in which the fireman had driven an iron rivet into the plug in a similar manner. When we remonstrated with him he answered: "By gar, she do be melting out all the time." We told him if he would be more watchful of his waterline that would not happen, but he insisted that the water had never been low since he had been fireman.

In Massachusetts the law concerning safety plugs reads as follows: "No person shall manufacture, set up, use, or cause to be used, a steam boiler, unless it is provided with a fusible safety plug, made of lead or some other equally fusible material, and of a diameter of not less than one half an inch, placed in the roof of the firebox, when a firebox is used, and in all cases in a part of the boiler fully exposed to the action of the fire, and as near the top of the water line as any part of the fire surface of the boiler. . . . Whoever without just and proper cause removes from a boiler the safety plug thereof, or substitutes therefor any material more capable of resisting the action of the fire than the plug so removed, shall be punished by fine not exceeding 1,000 dols. Whoever manufactures, sets up, or knowingly uses or causes to be used for six consecutive days a steam boiler unprovided with a safety fusible plug . . . shall be punished by fine not exceeding 1,000 dols." And it seems to us that it would be wise to have similar laws in all the States.

When fusible alloys are used for filling safety plugs it is found that their melting point is often considerably raised by long exposure to the heat. The exact cause of this rise in the melting point does not appear to be clearly known. It has been suggested that the metals composing the alloys are gradually separated or crystallised out from one another by the prolonged action of heat. However this may be, it is certain that pure Banca tin is a much more reliable material to use for filling. As tin is an element its melting point remains constant, and it is low enough—420 deg. Fah.—to adapt it perfectly for use in fusible plugs.

In order to prevent delay, in case a plug should melt out, all owners of boilers should see to it that extra ones are constantly kept on hand, so that they can be put in place at short notice.

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*From *The Locomotive*.

BENDING STRESSES IN FRAMEWORK.

(Concluded from page 606.)

In the case of the bar AB,

$$M = Px - \frac{Px^2}{l} = \frac{sbd^2}{6} = 1000bd^2;$$

therefore, for cast iron

$$bd^2 = \left\{ Px - \frac{Px^2}{l} \right\} \cdot \frac{1}{1000};$$

and for wrought iron,

$$bd^2 = \left\{ Px - \frac{Px^2}{l} \right\} \cdot \frac{1}{1500}.$$

When there is a weight moving along the bar the maximum stress will occur when it is in the centre of the bar. Then

$$x = \frac{l}{2} \text{ and } M = Px - \frac{Px^2}{l} = P \times \frac{l}{2} P \times \frac{l^2}{4l} = \frac{Pl}{4};$$

then the formulæ become, for cast iron,

$$bd^2 = \frac{Pl}{4} \times \frac{1}{1000} = \frac{Pl}{4000}; \text{ for wrought iron, } bd^2 = \frac{Pl}{6000}.$$

In a similar way we obtain for the bar, loaded as at *cd*, for cast iron, $bd^2 = \frac{w}{2}\frac{(lx - x^2)}{1000}$; and for wrought iron, $bd^2 = \frac{w}{2}\frac{(lx - x^2)}{1500}$; and at the centre, where $x = \frac{l}{2}$ and the stress is at a maximum, $bd^3 = \frac{wl^2}{8 \times 1000} = \frac{wl^3}{8000}$ for cast iron, and $\frac{wl^2}{12000}$ for wrought iron.

If the bars are circular in section, $\frac{sbd^2}{6}$ will be replaced by $0{\cdot}7854\, s r^3$, and, the transpositions being made as above, we have for the moment of resistance in each case, the working strength being taken, $5236 r^3$ for cast iron, and $7854 r^3$ for wrought iron. The expressions for the different cases will then be, for the bracket, $r = c \sqrt[3]{W \times \overline{eg}}$; for bar loaded as AB, $r = c \sqrt[3]{Px - \frac{Px^2}{l}}$; for bar loaded as at CD, $r = c \sqrt[3]{\frac{w}{2}(lx - x^2)}$; for HB when the load is at the centre $r = c \sqrt[3]{\frac{w.l}{4}}$; and at the centre of CD, $r = c \sqrt[3]{\frac{w.l^2}{8}}$.

In all of these c equals, for cast iron 0·0575, for wrought 0·0503. In all cases the expression for the clamp-shaped piece *orn* is the same form as for the bracket, but $(P \times \overline{gr})$ is substituted for $(W \times \overline{eg})$.

Framework.—It will, however, only be for certain classes of work that the parts of the frames will be of solid rectangular section, and in other cases a section of the form shown at C, fig. 2, will be used. Here we have to take the moment of resistance of the whole section shown by the dotted lines, less that of the parts omitted. D is a side view, which shows that the triangle $o\,k\,i$ for part of the breadth has to be deducted from the whole triangle $o\,g\,f$ taken for the whole breadth. Let d=the whole depth and d^1=the depth between the flanges, b=the whole breadth and b^1=the sum of the breadths of the openings. The extension $k\,i$ will be $= g\,f \times \frac{d^1}{d} = s \times \frac{d^1}{d}$, and the moment to be deducted will $= s \times \frac{d^1}{d} \times \frac{d^1}{4} \times \frac{2d^1}{6} \times b^1 = \frac{sb^1d'^3}{12d}$; then the moment of resistance for the lower half of the section is $= \frac{sbd^2}{12} - \frac{sb^1d'^3}{12d}$; and for the whole section $M = \frac{s}{6}\left(\frac{bd^3 - b^1d'^3}{d}\right)$. The expression for any case is found by equating this with the moment of stress, but as this is to be done in exactly the same way as in the previous case, there is no necessity to occupy further space with it here.

When the flanges and web are very thin in proportion to the outside dimensions, the stress on them may be taken as uniform, and then the moment of resistance of one flange will be

$= s \times b \times t \times \frac{d}{2}$, where s = direct resistance per square inch, and t = thickness of flange in inches; if the flanges are alike, the whole moment is $M = s\,b\,t\,d$. $s\,b\,t$ represents the stress on one flange; calling this S, we get $M = S\,d$, so that dividing any of the formulæ for moments of stress by d, we get the direct stress on one flange, to which we can proportion its sectional area. The working value of s is: For wrought iron in tension, 5 tons; for wrought iron in compression, 4 tons; for cast iron in tension, 1·5 tons; for cast iron in compression, 8 tons. We will take an example of a girder loaded as at C D, the area of flanges being required at the centre. Let l = 20ft., and d = 15ft. (the length and depth in these cases being taken in feet), $w = 0{\cdot}3$ ton. Then equating the moments of stress and resistance, $M = \frac{w\,l^2}{8} = S\,d$;

$$\text{therefore } S = \frac{w\,l^2}{8\,d} = \frac{0{\cdot}3 \times 20 \times 20}{8 \times 1{\cdot}5} = 10 \text{ tons.}$$

Then for the top (compression) flange the sectional area $b\,t = \frac{10}{4} = 2{\cdot}5$ square inches, and for the bottom (tension) flange $b\,t = \frac{10}{5} = 2$ square inches. The connecting web is not included in resisting horizontal stress.

It will frequently occur that the carrying parts of frames, being cast in one piece with them, will have fixed ends, in which case the moments of stress will be less than when they are merely supported. If the ends are supported only, the bent beam will assume the form shown at A B, fig. 3, the top surface being compressed throughout its length, and the bottom surface similarly extended; but if the ends are rigidly fixed, the form assumed will be that shown at C D, and each surface will be partly extended and partly compressed, and a moment will be set up in a direction opposite to that acting on A B. Now, if the moments due to the load tend to shorten the top surface, and a moment set up at the points of fixture prevents such shortening, it is evident that the moment at C and D must equal the average of the moments due to the load. If the load or bending force is concentrated at the centre, and equals W, the vertical re-action at C or D will be $\frac{W}{2}$, and the moment of this re-action at any point distant x from the nearest point of support will be $\frac{W}{2} \times x$, the maximum at the centre where $x = L$ being $\frac{W\,l}{4}$. The moments vary also directly as x; therefore the average moment will be half the maximum, or $\frac{W\,l}{8}$, which will be set up at the point of fixture and in the opposite direction to the moment due to the load. Deducting this moment from the former maximum, we have $\frac{W\,l}{4} - \frac{W\,l}{8} = \frac{W\,l}{8}$ for the maximum moment of stress upon the beam. The top surface will be in tension for a quarter of its length from each end, and in compression along its central half, and the stress on the bottom surface will be exactly the reverse of these. If the load is at any other point, the moments at C and D will be half the maximum moment, which occurs directly under the load. From this we see that by fixing the ends of this beam we double its strength, and therefore need only use half the material required for the supported beam.

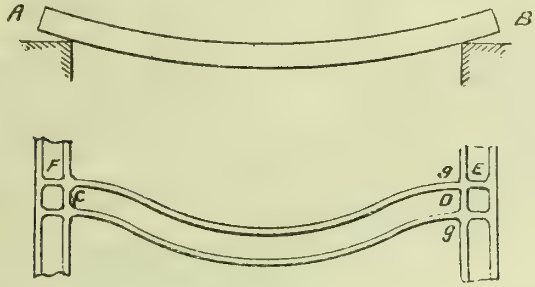


Fig. 3.

When the load is distributed evenly over the length of the beam, the average moment will not be half the maximum, for the moments vary as $(lx - x^2)$, which will give a parabolic curve in which the average ordinate will be two-thirds of the greatest one; therefore the average moment will be—

$$\frac{2}{3} \times \frac{wl^2}{8} = \frac{wl^2}{12},$$

which will be the moment set up at C and D, and this will then be the maximum, as the central moment will be—

$$\frac{wl^2}{8} - \frac{wl^2}{12} = \frac{wl^2}{24}.$$

In this case one-third of the weight is saved by fixing the ends.

The flanges should be carried right across the uprights E and F, as shown, otherwise breakage may occur at $g_1 g$, and it is to be remembered that there will be on the upright a bending moment equal to that at C and D, which produces shearing strains at the ends, where they join the horizontal parts of the framework.

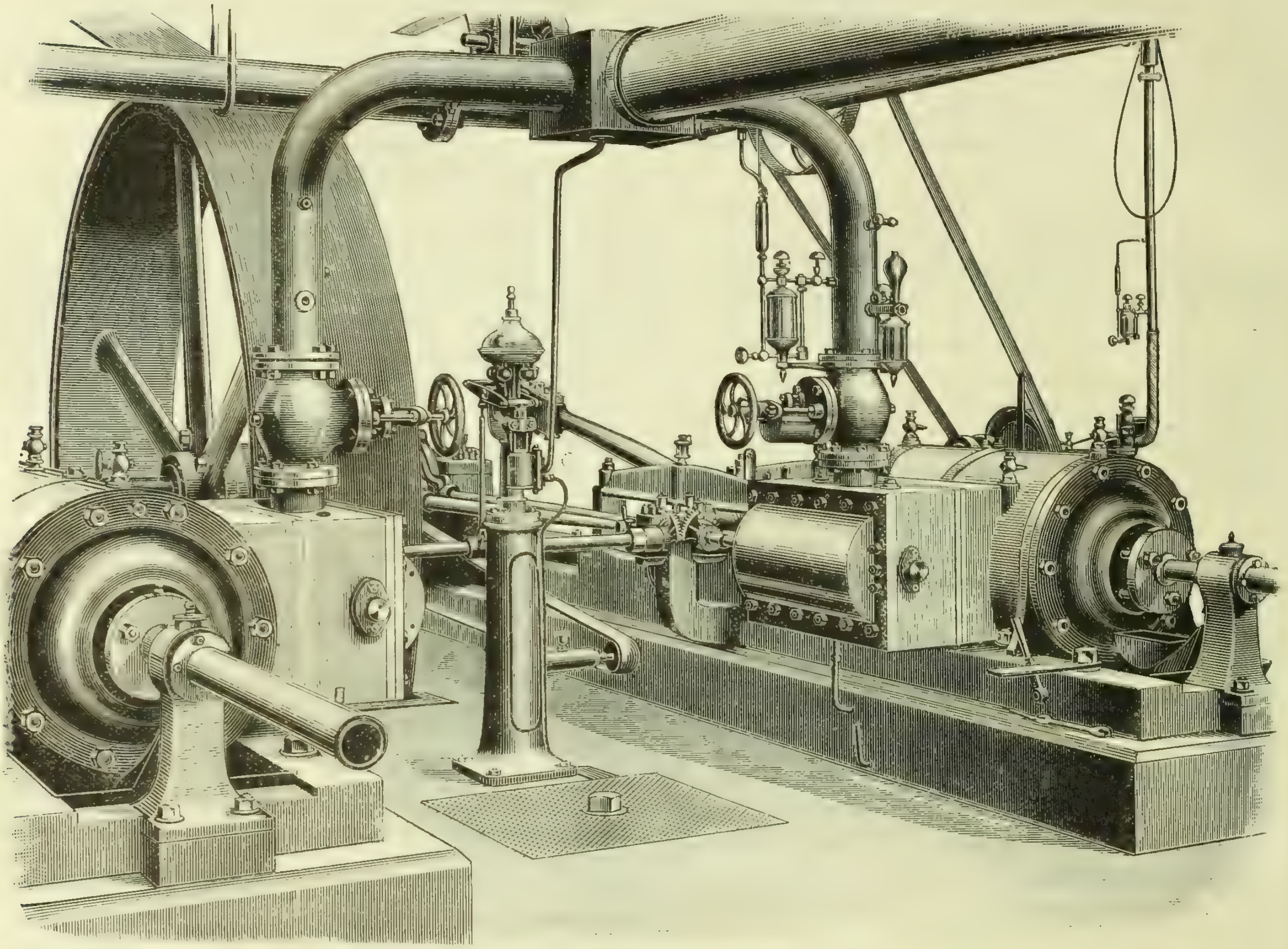
STATE OF THE SKILLED LABOUR MARKET.

The following memorandum has been prepared for the *Journal* by the labour correspondent to the Board of Trade: "The trade reports of the principal unions issuing monthly statements as to the condition of their respective labour markets are the most unsatisfactory that have appeared since March of the present year. The returns do not so much indicate any general falling off in trade as they do an extremely disturbed condition of the relations existing between employers and employed. Indeed strikes would almost appear to have been epidemic during the month, and even trades not in any way directly effected by the questions in dispute, have suffered indirectly from the stoppages of labour in other departments of industry. This inter-dependence of the various branches of labour is most strongly illustrated in the case of the strike of dock labourers at the East End of London, which not only seems to have acted contagiously on other occupations, but has by its stoppage of the transport from the Thames of finished articles, and prevention of delivery of raw material caused the suspension or discharge of workmen in many of the skilled trades. This is noticeable in the East End reports of the chief societies. The engineers and general iron trades are affected by it, and so are the joiners, tin workers, and other classes of workmen who have to do with dock work or shipping. Altogether apart from this there have been many industrial complications. In some districts the coal trade has been in a very disturbed state, and there have been several important stoppages of single collieries. The general strike in the Somersetshire district seems drawing to an end, and some concessions have been offered to the men. Both in the cotton and woollen trades there have been several stoppages; in the former especially trade is most unsatisfactory. The operations of the cotton corner and a general scarcity of raw material have caused a great many mills to close partially or entirely. In the Oldham district the effect of these conditions has been to increase the proportion of unemployed from 3·8 per cent in June to 22 per cent in August, which is a very serious increase indeed. There have been sectional stoppages among the iron shipbuilders, and 3,000 men engaged in the engineering and machine trades of Keighley are out for an advance of wages. The building trades have also been involved in some places, and the strike in the Nottingham lace trade is not yet finally disposed of. The printing trade generally is dull. A little general briskness may have been caused by the issue of the lists of voters, but the closing of the law courts and the end of the parliamentary session have much affected the London trade. The number of societies reporting is twenty, with a total membership of 198,636. Of these, 4,986 are unemployed, as against 3,411 for the previous month, an increase in the unemployed list of 1,575. The percentage of those not in work is thus 2·5 as against 1·7 for last month. This increase is due to the following three trades: Engineers, compositors, and cotton spinners. The percentage of unemployed for the corresponding period of last year was 3·9, and for the year before 8·3."

The Iron Trade on the Continent.—A Paris correspondent writes, notwithstanding the activity which prevails at present among the ironworkers on the Continent, and the high price of pig iron, coal, and coke, there are symptoms that the ironmasters do not possess unbounded confidence in the future prospects of the trade. A sale took place recently in Belgium of 3,500 tons of Vignole and 400 tons of double-headed rails, the bulk of the former being secured for some pig-iron works in Westphalia at 80f. per ton. Some Belgian works, who had paid from 83 to 84 francs at the previous auction, only offered on this occasion 74f. A London firm offered 84f. for the double-headed rails, which was the highest tender, though about 5f. below what they would have fetched a few months ago. A parcel of steel rails was put up, and it positively went at 67f.

THE LÜDE STEAM-POWER GOVERNOR.

CONSTRUCTED BY MESSRS. SCHÄFFER AND BUDENBERG, ENGINEERS, MANCHESTER.



Practical Engineer. FIG. 1.

MESSRS. SCHÄFFER AND BUDENBERG have now had at work for some considerable time a most ingenious form of governor gear, which secures great sensitiveness of governor action, and an almost entire freedom from frictional load. When engine governors have of themselves to perform the actual work of moving the throttle valve, or altering the position of release tappets in a variable cut-off engine, a very slight friction—for example, in the packing of the throttle spindle—causes considerable variation in the speed of the engine, because of the increase in centrifugal force required to produce power enough to move the valve. Many ingenious and valuable contrivances have been devised to minimise friction, and give the governor as little work to do as possible. With all the ingenuity, however, which has been hitherto applied, governors have to be heavy and powerful to act efficiently with the ordinary valve arrangements.

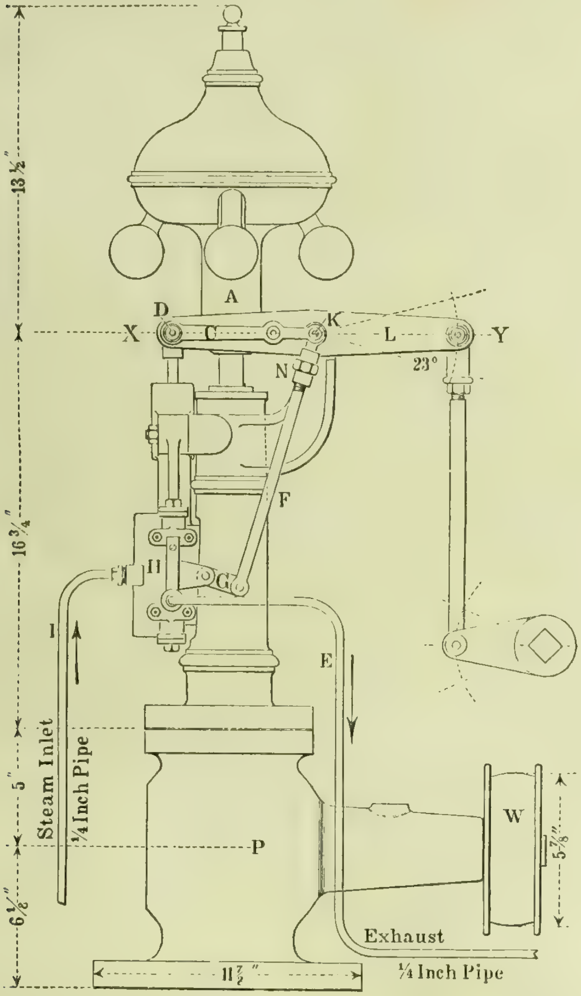
In the Lüde governor, Messrs. Schäffer and Budenberg, in common with the inventor, have made a new departure, and instead of increasing the power of the governor, to make it capable of moving the valves, they have used the governor itself only as a means of opening a small valve which supplies steam to a cylinder whose piston does the real work of moving the throttle. The governor, in fact, is only used to signal that the speed is too high, and bring into operation any desired amount of power to accomplish the work required. There are many difficulties in the way of accomplishing this effectively, and not the least arises from the necessity of moving the throttle valve in proportion to the movement of the governor, so that for each position of the governor there is a corresponding position of the throttle.

It is not difficult to cause a governor to open a small steam valve, supplying steam to a cylinder in such a way that a piston is thrust through its whole stroke, and a throttle valve actuated from it entirely closed, but it is difficult to so move the piston that it follows the governor sleeve or muff as accurately as if it were directly connected up to it. Referring to our illustrations on page 649, fig. 2 is a view of the new governor in elevation and transverse section, and its action will be readily understood from the following description:—

When the speed of the engine changes slightly the balls move out or in, and the motion of the governor muff A is transmitted by means of the double lever B to the lever C, which is pivoted at D in the main lever L. The short arm of the lever C is connected by means of the rod F to a small lever G, which actuates a $\frac{1}{4}$in. equilibrium piston valve arranged in the casing H on one side of the steam cylinder. This valve controls the steam admission and exhaust ports of both cylinder ends, the arrangement being such that both sides of the piston are connected with the exhaust pipe E when the valve occupies its normal central position, while a very small displacement of the valve in either direction permits of steam entering one end of the cylinder. The resulting motion of the main piston and lever L, with connections, causes the piston valve to return to its central position, so as to again open both sides of the piston to the exhaust when the lever L has been turned through an angle corresponding to the displacement of the governor muff. Normally the centre of the joint K corresponds with the turning axis of the lever L. When the governor muff is displaced, the lever C is caused to turn about the centre D, thereby raising or lowering the centre

K. The resulting displacement of the lever L causes the lever C to turn about the centre O, and the centre K is consequently returned into agreement with the axis M of the lever L. It is therefore evident that the motion of the lever L, and connections, will always correspond precisely to the motion of the governor muff, and owing to the high velocity of steam this action is practically instantaneous.

The arrangement whereby the lever C is moved slightly by the muff A independently of the lever L is strikingly ingenious, and this departure of the end K from the central position opposite the main fulcrum M is instantly corrected by the movement of L up or down, which necessarily brings it to the centre again.



Section X-Y.

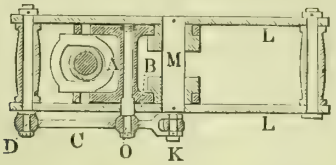


Fig. 2.

The steam pressure is in fact only applied to the steam piston when the centre lines of the levers L and C do not coincide with each other. The steam cylinder is made in three sizes of 1½in., 2in., and 2½in. diameter respectively. For Rider and similar valve gears the smallest size is used, while the two larger sizes are suitable for gears of the Corliss and Meyer class. With a pressure of 75lb. per square inch, the force exerted amounts to 120lb., 230lb., and 320lb., according to the size of the cylinder employed.

Fig. 3 is an illustration showing the external appearance of the gear, and fig. 1 shows its application to engines driving Messrs. Schäffer and Budenberg's own works, where it acts with every possible success.

The whole apparatus is sightly and mechanical in appearance, and is constructed with Messrs. Schäffer and Budenberg's well-known care.

We are informed that the apparatus has been applied with perfect success to many engines of widely-varying types and dimensions, including compound and triple-expansion engines with expansion slides, and Corliss engines. In our opinion, the steam-power governor is most ingenious, and the idea of giving the governor only the work of signalling and controlling the piston valve of a miniature steam engine, whose piston rod is connected to the regulating gear to be moved, is exceedingly fascinating and attractive. The combination lever arrangements are clever, and well worth the careful study of the steam engineer. When extreme accuracy of turning is required, this governor will doubtless find ready use.

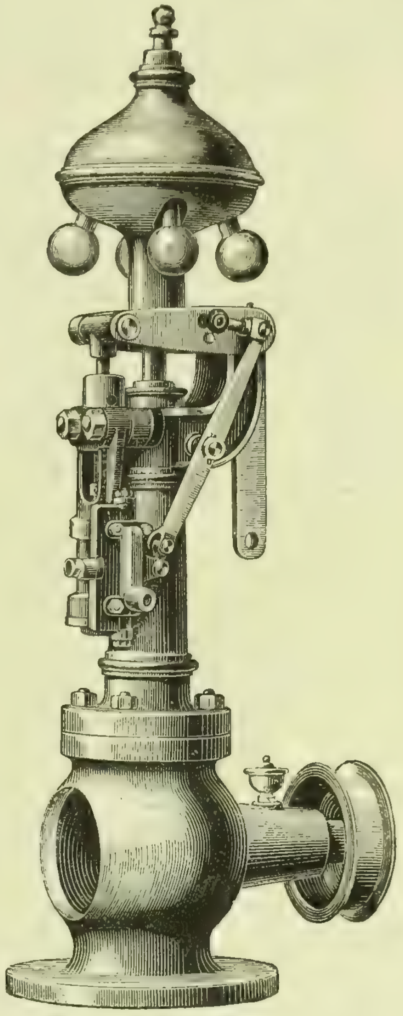


Fig. 3.

BRITISH ASSOCIATION: PRESIDENTIAL ADDRESS.

Mechanical Science Section.

The section for Mechanical Science of the British Association met on Thursday, 12th Sept., in the Presbyterian Church, Barras Bridge, Newcastle-on-Tyne, when Mr. Wm. Anderson, M.I.C.E., the president of the section, delivered a most able and instructive address. Mr. Anderson occupies a distinguished position in the engineering world, is a member of the well-known firm of Easton and Anderson, Erith, and was recently appointed, as announced in our columns, as Director-General of Ordnance Factories. He is a member of the council of the Institute of Civil Engineers, a vice-president of the Institution of Mechanical Engineers, and the author of well-known books on engineering matters. He has made a special study of the molecular nature of matter as bearing on the properties of constructive materials, more especially steel, and his address is of great importance in its bearing upon the molecular structure of steel and alloys. His remarks on tempering of steel, and the theory of tempering,

are most instructive. Owing to pressure on our space, we are unable to give the address in full, but the following is an abridgment which covers the whole ground:—

Five years ago, at Montreal, in his address to the Mathematical Section, Sir William Thomson took for his subject the ultimate constitution of matter, and discussed, in a most suggestive manner, the very structure of the ultimate atoms or molecules. He passed in review the theories extant on the subject, and pointed out the progress which had been made in recent years by the labours of Clausius, of Clerk Maxwell, of Tait, and of others, among whom his own name, I may add, stands in unrivalled prominence. I will not presume to enter into the field of scientific thought and speculation traversed by Sir William Thomson, but I propose to draw attention only to some general considerations, and to point out to what extent they practically interest the members of this section.

Professor Mendeleeff has attempted to show that there existed an analogy between the constitution of the stellar universe and that of matter as we know it on the surface of the earth, and that from the motions of the heavenly bodies down to the minutest interatomic movements in chemical reactions the third law of Newton held good, and that the application of that law afforded a means of explaining those chemical substitutions and isomerisms which are so characteristic, especially of organic chemistry. The total result is complete equilibrium, and, in many cases, a seeming absence of all motion, which is, in reality, the consequence of dynamic equilibrium, and not the repose of immobility or inertness.

The Three States of Matter.

In the case of gases, indeed, it is almost self-evident that they are composed of particles so minute as to be invisible, in a condition of great individual freedom. The rapid penetration of odours to great distances, the ready absorption of vapour and of other gases, and the phenomena connected with diffusion, compression, and expansion seem to demonstrate this. One gas will rapidly penetrate another and blend evenly with it, even if the specific gravities be very different. The particles of gases are, as compared with their own diameters, separated widely from each other; there is plenty of room for additional particles; hence any gas which would, by virtue of its molecular motion, soon diffuse itself uniformly through a vacuum, will also diffuse itself through one or more other gases, and once so diffused, it will never separate again. A notable example of this is the permanence of the constitution of the atmosphere, which is a mere mixture of gases. The oxygen and the nitrogen, as determined by the examination of samples collected all over the world, maintain sensibly the same relative proportions, and even the carbonic acid, though liable to slight local accumulations, preserves, on the whole, a constant ratio, and yet the densities of these gases differ very greatly. Liquids, though to a much less degree than gases, are also composed of particles separated to considerable relative distance from each other, and capable of unlimited motion where no opposing force, such as gravity, interferes; for under such circumstances their energy of motion is not sufficient to overcome the downward attractions of the earth; hence they are constrained to maintain a level surface. The diffusion of liquids takes place not only when they are in actual contact, but even when they are separated by partitions of a porous nature, such as plaster of Paris, unglazed earthenware, vegetable or animal membranes, and colloidal substances, all of which may be perfectly watertight, in the ordinary sense of the term, but yet powerless to prevent the particles of liquids making their way through simultaneously in both directions.

When we come to solid substances the same phenomena appear. The volumes of solids do not differ greatly from the volumes of the liquids from which they are congealed, and the solid volumes are generally greater. The volume of ice, for example, is one-tenth greater than that of the water from which it separates. Solid cast iron just floats on liquid iron, and most metals behave in the same way; consequently, if the liquids be porous the solids formed from them must be so also; hence, as might be expected, solids also occlude gases in a remarkable manner. Not only are gases occluded, but they are also transpired under favourable conditions of temperature and pressure, and even liquids can make their way through. Red-hot iron tubes will permit the passage of gases through their substance with great readiness. Mr. Goodman stated, during a recent discussion at the Institute of Civil Engineers, that petroleum passed through a red-hot boiler plate half-an-inch thick, and it is well known that mercury will penetrate tin and other metals with wonderful rapidity, completely altering their structure, their properties, and even their chemical compositions. The evidence of the mobility of the atoms or molecules of solid bodies is overwhelming.

Cementation and Welding.

At high temperatures the effects are more easily produced on account of the greater energy of motion of the atoms or molecules. In the process of the manufacture of steel by cementation, or in case-hardening, the mere contact of iron with solid substances rich in carbon is sufficient to permit the latter to work its way into the heart of the former, while in the formation of malleable cast-iron the carbon makes its way out of the castings with equal facility, it is a complete case of diffusion of solid substances through each other, but, on account of the inferior and restricted mobility of the particles at ordinary temperatures, a higher degree and longer time are needed than with liquids or gases. Again, when, by the agency of heat, molecular motion is raised to a pitch at which incipient fluidity is obtained, the particles of two pieces will unite into a homogeneous whole, and we can thus grasp the full meaning of the operation known as "welding." By the ordinary coarse methods but few substances unite in this way, because the nature of the operation prevents, or at any rate hinders, the actual contact of the two substances; but when molecular motion is excited to the proper degree by a current of electricity, the faces to be joined can be brought into actual contact, the presence of foreign substances can be excluded, and many metals not hitherto considered weldable, such as steel, copper, and aluminium, are readily welded.

Nature of Explosions.

The behaviour of explosives illustrates in a striking manner the effects of disturbing molecular equilibrium. An explosive is a substance which contains in itself, in a solid or liquid form, all the elements necessary to produce a chemical change by which it is converted into the gaseous state. The application of heat, of pressure, or of impact, causes, as in Professor Spring's experiments, chemical union to take place, first at the spot where the equilibrium is disturbed by the application of external force, and afterwards, with great rapidity, through the mass, the disturbance being propagated either by the air surrounding the particles or by the luminiferous ether, with all the rapidity of light; the chemical reaction is accelerated by the pressure which may arise, for example, if the explosive be confined in the chamber of a gun or in the bore-hole of a blast. High explosives, as they are termed, are comparatively inert to ordinary ignition; but when the molecular equilibrium is suddenly disarranged throughout the mass by the detonation of a percussion fuse, combination takes place instantly throughout, and violent explosion follows. In a similar manner some gases, such as acetylene, cyanogen, and others, can be decomposed by detonation and reduced to their solid constituents. Professor Thorpe has devised a very beautiful lecture experiment, in which carbon disulphide is caused to fall asunder into carbon and sulphur by the detonation of fulminate of mercury fired by an electric spark. In these cases a reverse action takes place, but illustrates equally well the conversion of one form of energy into others, and the consequent disturbance of molecular equilibrium in the substances affected. It seems to me clear, therefore, that the time has come when the conception of dynamic equilibrium in the ultimate particles of matter in all its forms must take the place of the structural system of inert particles.

Molecular Motion Illustrated.

I cannot conceive how the phenomena which I have enumerated can be explained on the supposition that matter is built up of motionless particles—how, for example, a stack of red and yellow bricks could ever change the order of arrangement without being completely pulled asunder and built up again, in which case an intermediate state of chaos would exist; but I can easily comprehend how a dense crowd of people may appear as a compact mass, streaming, it may be, in a definite direction, and yet how each member of that mass is endowed with limited motion, by virtue of which he may push his way through without disturbing the general appearance; how the junction of two crowds would form one whole, though, perchance, altered in character; and how even Professor Spring's experiments may be explained by the supposition that bystanders on the edge of a crowd would be forced, by external pressure, to form part of it and partake of its general movements.

The Hardening of Steel.

When it is conceded that molecular motion pervades matter in all its forms, and that the solid passes, often insensibly, into the fluid, or even direct into the gaseous, it follows, almost of necessity, that there must be a borderland, the limits of which are determined by temperature and pressure, in which substances are constantly changing from one state to another. This is observable in fusion, but to a marked degree in evaporation, where the particles are being incessantly launched into space as gas and return as constantly to the liquid state. If steel be looked upon as a solution of carbon and iron, then the hardening of steel is explained by the theory that dissociation has taken place at the temperature at which it is suddenly cooled, the sudden cooling fixing the molecular motion at such an amptitude or phase that it gives a characteristic structure, one of the properties of which is extreme hardness. In tempering, the gradual communication of heat causes dissociation again to take place, the molecular equilibrium is modified by the increased energy imparted to the particles, and when suddenly cooled at any point there remains again a distinct substance, composed of iron and carbon, partly in various degrees of solution and partly free, and again possessing special mechanical qualities. That steel, and probably other alloys, differ in the nature of their composition according to the way in which they are worked, both with respect to heat and mechanical pressure, has been abundantly proved by many eminent metallurgists, and especially by Sir Frederick Abel, in the extended researches which he has recently carried out, on the hardening of steel, for the Institution of Mechanical Engineers, and it would appear as a natural sequence that the properties of steel would be greatly affected by the manner in which its temperature was changed, as we indeed find that it is when these changes are produced by baths of melted metals, by oil, or by water at different temperatures. The action which takes place may be illustrated by what would happen supposing that a complicated dance, such as the Lancers, were suddenly stopped in various phases of the figures. The component parts would always remain the same, but the relative distribution of the partners would vary continually, and analysis would show that at one time each gentleman was associated with a particular lady; at another, that two ladies were attached to a single gentleman, while a number of gentlemen had no partners at all; and yet, again, at another, that the movements which were once rectilinear have become circular. In each case the groups would assume a totally distinct appearance.

Influence of Small Changes in Chemical Composition.

It may be urged, however, that it is unlikely that alloys or solutions could be affected in a manner so marked merely by small changes at comparatively low temperatures; but I would observe that "great and little" are relative terms, and we have abundant evidence of the immense effects produced by what would be called "little" causes. Sir Frederick Bramwell, in his address last year, drew attention to the importance of the "next to nothing." It is not so very long ago that anyone would have been considered a dreamer for propounding a theory that the fraction of a per cent of carbon, phosphorus, or sulphur would totally alter the character of iron; that the addition of one two-thousandth part of aluminium to molten iron would make the pasty mass as fluid as water; that the presence of the smallest impurity in copper would have a disastrous effect on its powers of conducting electricity; and that the addition of one-thousandth part of antimony would convert the "best selected" copper into the worst conceivable. I need hardly allude to the great part played in nature by microscopic organisms, and how much of the beauty of our seas and rivers is derived from substances so minute that nothing but the electric beam of Professor Tyndall is capable of revealing their presence. There is one more circumstance connected with my subject to which I must draw your attention, because, though its application to the mechanical properties of substances is very recent, it promises to be of great importance. I allude to the Periodic Law of Dr. Mendeleef. According to that law, the elements, arranged in order of their atomic weights, exhibit an evident periodicity of properties, and, as Professor Carnelley has observed, the properties of the compounds of the elements are a periodic function of the atomic weights of their constituent elements. Acting on these views, Professor Roberts Austin has recently devoted much time and labour to testing their exactness with reference to the mechanical properties of metals. The investigation is surrounded by extraordinary difficulties, because one of the essential features of the inquiry is that the metals operated on should be absolutely pure. For chemical researches, a few grains of a substance are all that is needed, and the requisite purity can be obtained at a moderate cost of time and labour; but when mechanical properties have to be determined considerable masses are needed, and the funds necessary for obtaining these are beyond the reach of most private individuals. In view of the difficulty of obtaining metals of sufficient purity, he selected gold as his base, because that metal can be more readily brought to a state of purity than any other, and is not liable to oxidation.

(*To be continued.*)

SOMETHING NEW IN LATHE DRIVERS.*

The ordinary lathe driver, gripping by the point of a set screw, possesses serious faults, which have been put up with for so many years that the faults have come to be looked upon as something really belonging to lathe work. A wrench is required to tighten the driver, and a wrench is required to loosen it. If an extra heavy cut be taken, the wrench must be called into play again, to give the driver an extra tightening. If a slight twisting takes place, the set screw may slacken a little, and the wrench is again called into play. The action of the set screw in an ordinary driver is such that few set screws can stand the work for any length of time. Every latheman knows the result when the set screw begins to upset. If the set screw was at once removed when this occurs, and a new and good one substituted, things would not be so bad, but it seems to be an established law of all shops to keep the old set screw in the dog as long as it can be used at all. Old set screws, when upset, will not screw far enough. When the ends split off the result is sad indeed. The best and most perfect of set screws bruise the work fearfully if heavy cuts be taken, but when the end of the set screw is broken, or otherwise out of order, the damage is increased many fold. The careful latheman fully recognises the merit of coppers under the set screw, but the coppers are a nuisance, and, besides, are slippery on heavy work.

Fig. 2 represents a piece of turning, taken from a photograph, illustrating the grip of what is know as Shartle's bulldog. The word bulldog is not a very nice one, but nothing could more perfectly indicate the extent of the work done. The merit of the dog will be appreciated when it is understood that the set screws are *thumb screws*, and that the bruising of the work, even with this heavy cutting, is so slight as to be ignored, except on the finest finished work.

Fig. 1 represents the Shartle lathe dog. It is shown with two straight tails, but these dogs are in the market with two straight tails, or with one straight tail, or with one straight and one bent tail. This latter form possesses many points of merit, and is illustrated in fig. 3.

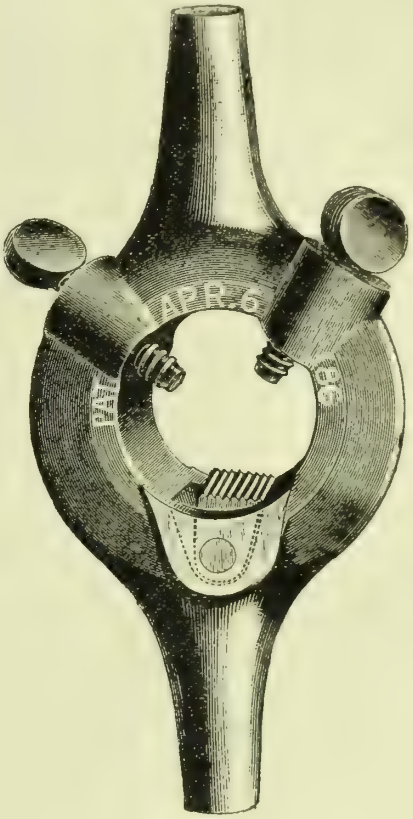
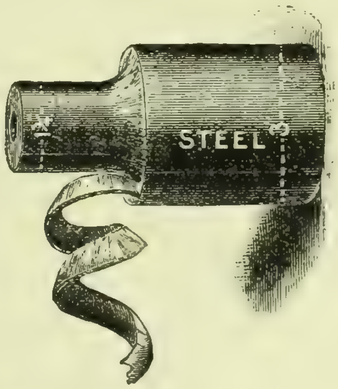


Fig. 1.

In these dogs there are two set screws, which are mere thumb screws. Their office is to adjust the size of the dog rather than to perform the gripping work of the usual screws. In the face of the bore of the dog, opposite the set screws, is a pivoted jaw with a serrated face, the face being practically a double eccentric with regard to the pivot of the jaw. By screwing down the set screws the work is clamped between the set screws and the jaw, but not with very much force. The merest trifle of rotation of

Fig. 2.



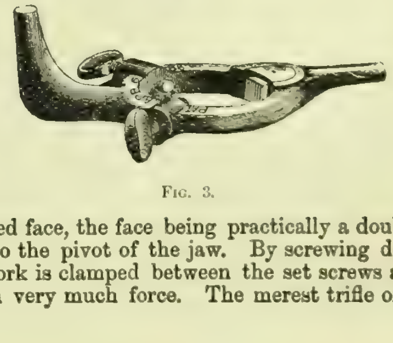


Fig. 3.

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* *American Machinist.*

the work causes a tipping of the jaw, and the work then becomes subjected to powerful compression. The grip is an unyielding one so long as rotative strains are applied, but the work never jams in the dog; the thumb screws are always easily unscrewed. These dogs are especially useful where they are to be used on tapering work, in which case a jaw with a tapering face is used, thus giving a fair clamping bearing on the taper. The jaws are very easily removed. There is no strain on the pivot of the jaw, the heel of the jaw fitting fairly in the bottom of its recess. The recess is closed at one face by a plate sliding in a dovetail. This plate can be pulled out, and the jaw can then be removed if a taper one is to be inserted. The body of the dog is a steel casting, and the other parts are of drop-forged steel. These dogs are now getting into quite common use, and are in the market in sizes from ½in. to 8in. They are manufactured by the Middletown Machine Works, of Middletown, Ohio.

POPP'S COMPRESSED AIR SYSTEM.

Prof. Alex. B. W. Kennedy, M.I.C.E., F.R.S., read an interesting paper before the Mechanical Section of the British Association, on Thursday, 12th September, of which the following is an abstract :—

The subject of transmission of power to a distance is one of immense importance in an industrial country like our own. In a case such as that which I have to describe to you, where the distance to which the power is to be transmitted is great enough to be measured in miles, the possible methods of transmission are not very numerous. Steam, water, air, and electricity seem to be the only four agents practically available. All four agents have been used to a greater or less extent, and with more or less complete success. In our own country the distribution and use of high-pressure water has been carried out with the greatest engineering skill, and with corresponding great success, by the Hydraulic Power Company in London, and also in Hull. Electric transmission (for traction at least) has been at work on a small scale for some time in various places, and is about to be tried on a much larger scale, under Mr. Greathead, on the Southwark Subway. The Birmingham Compressed Air Power Company has established works on a very large scale, but various causes have unfortunately combined to cause delay in the commencement of its operations, which, indeed, are hardly yet fairly started. In Paris, however, the transmission of power by compressed air has been in operation on a somewhat enlarged scale, and with very great mechanical success, for a few years past. I have recently had occasion to spend some weeks in making experiments in connection with the Paris compressed air plant, and having been given the fullest permission to publish the results of my experiments, I have pleasure in taking this opportunity of bringing them before the members of the British Association. To avoid any misunderstanding, I must premise that it is not my intention to institute any comparison between the different methods of power transmission which I have mentioned. On this matter I wish to say only one thing, in view of a recent discussion on the Hydraulic Power Company's work in London, in which some comparisons were made between power transmission by air and by water. So far as I see, the two systems at present practically occupy different fields and overlap but little. The work that each appears to do best is exactly that for which the other is least fitted. The work now carried on by the Paris Compressed Air Company has developed from very small beginnings, at first slowly, lately very fast. It originated in a pneumatic clock system which was started about 1870 with a small "central station" in the Rue St. Anne, in the centre of Paris. This business grew gradually until it became far too large to be carried on from such a position, and a few years since a central station, with much enlarged machinery, was established in the Rue St. Fargeau, which is in Belleville, about four and a half miles east of the Madeleine. There are now about 8,000 pneumatic clocks, public and private, in Paris, driven from St. Fargeau, and regulated by a standard clock in the Rue St. Anne, but as this part of the work, although it originally formed the basis of the whole system, is now a comparatively very small part of it, and is of an entirely special nature; I do not propose to say anything further about it here. Until about two years since, a pair of single-cylinder horizontal engines by Farcot, and a beam engine by Casse, sufficed for the whole work, but by that time the demand for compressed air for working motors had so increased that extension had become imperative, and the present working plant of six compound condensing engines, each working two air compresses, with the necessary complement of boilers, was put down. This plant, except the compressors, was supplied from England by Messrs. Davey, Paxman, and Co., of Colchester. The compressors for the English engines were made in Switzerland on the Blanchod system. The demand for power is at present so great that at certain hours of the day practically the whole plant, old and new, indicating considerably over 2,000 horse power, is fully at work, and in consequence a duplicate main is being laid throughout, and new engines and compressors, half of them constructed by Davey, Paxman, and Co., and half by John Cockerill and Co., of Seraing, are being pushed forward as rapidly as possible. After describing the general arrangements of the Paris company's work, the author of the paper proceeded: I come now to the experiments which I made to ascertain its efficiency. Starting from the main engines at the central station, the particular matter which I had to determine was the indicated horse power which would be shown by a small motor three or four miles from St. Fargeau for each indicated horse power expended by the main engines on the air which passed through that motor. The ratio thus obtained would be the total indicated efficiency of the whole system of transmission. This ratio is in reality the product of a number of separate efficiencies, and the separate determination of these formed a necessary check on the value of the total efficiency. These separate efficiencies may be summarised as follows: (1) Mechanical efficiency of main engines, or ratio of work done in compressors to indicated work in steam cylinders; (2) efficiency of compressors, or ratio of *maximum* work which could be done in a motor by each cubic foot of compressed air at 70 deg. Fah. to the work actually done in compressing that air; (3) efficiency of mains, or ratio in which the capacity of the compressed air for doing work is reduced by friction and leakage; (4) efficiency of reducing valves, or ratio in which the capacity of the compressed air for doing work is reduced by the lowering of its initial pressure at the motor; (5) indicated efficiency of motor, or ratio in which the actual indicated work done falls short of the *maximum* work which the quantity of air measured through the meter could do after passing the reducing valve. The product of these five efficiencies is the total efficiency of transmission without the use of a heater. When the heater is used the matter is somewhat more complicated. Summarising the whole matter as regards efficiency, it may be said that the result of my detailed investigations is to show that the compressed air transmission system in Paris is now being carried on on a large commercial scale in such a fashion that a small motor, four miles away from the central station, can indicate in round numbers 10 horse power for 20 indicated horse power at the station itself, allowing for the value of the coke used in heating the air, or for 25 indicated horse power if the air be not heated at all. Larger motors than the one I tested (and there are a number of such in Paris) may work somewhat more, and smaller motors somewhat less, economically. The small rotary motors would, of course, be much less economical. The figures which I have given are, however, such as can be reached by any motor of between 5 and 25 indicated horse power if worked at a fair power for its size. M. Victor Popp himself and the engineers of the company, by no means content with the results already obtained, are experimenting in various directions with a view to greater economy, and I have not the least doubt that they will attain their end. But although I made several experiments on new apparatus, I prefer to leave their results here undiscussed, confining myself as strictly as possible to the work which has been already carried out, and the economy of actual present working, rather than giving any credit for the result of improvements, which, however certain, are not yet actually carried out in practical work. A system of transmission which has actually been carried out on a large commercial scale, in such a way as to have an indicated efficiency of 50 per cent between prime mover and secondary motor four or five miles apart is one which needs no adventitious aids to commend it to notice, especially where its uses are so numerous and so varied, and its convenience so extremely great as are those of compressed air. Both M. Victor Popp, who has organised and carried through the work of the Paris company, and Mr. James Paxman, who has designed and made the greater part of the machinery used, are to be heartily congratulated on the results which have attended their work. While, however, I am unwilling to lay stress on possibilities which are not yet actualities, there can be no harm in saying that I have no doubt whatever that with mere improvement of existing methods and appliance, and without the adoption of any untried methods whatever, the new plant of the new Paris company now being constructed can be made to have an indicated efficiency of 67 per cent instead of 50 per cent, and to give about 0·54 effective horse power at the motor for each indicated horse power at the central station in the case of such a motor as that on which I experimented. Under these circumstances the air used per indicated horse power at the motor would be 520 cubic feet, or 650 cubic feet per brake horse power. I have the less hesitation in giving these hypothetical figures because the more important imperfections of M. Popp's transmission system arise from such a very obvious cause. Nothing, indeed, can be easier (as was evident on the recent visit of the Institution of Mechanical Engineers to St. Fargeau) than to point out various weak points in the arrangements adopted. And, in spite of all such somewhat cheap criticism, the fact remains that no one has carried out a compressed air transmission with anything approaching to the same success on anything like the same scale. The fact is that the success of the system has been essentially due rather to the practical good sense with which the work has been carried through than to any special novelty in the methods employed. The air compressing arrangements at St. Fargeau are in no respects novel or specially perfect; they had been used over and over again before; there is no special advantage in M. Popp's rotary motor, that may not probably be possessed by many other rotary motors; the larger motors are simply good ordinary steam engines, such as can be bought in any day in open market, used without the slightest alteration. Of the fan motor it can only be said that it works well enough to allow progress to be made while it is being improved, and even of the coke stove one would not like to say very much more. The plan of heating compressed air before using it in a motor was first proposed many years ago. The great success which has attended the work in Paris has been attained because its directors have wisely chosen rather to set to work with imperfect apparatus if only it were simple, fairly effective, and ready to hand, than to wait for the possible invention of novelties and improvements, or to risk the success of their start by the use of any unknown or untried apparatus, however promising its nature, They have had, moreover, the great advantage hitherto of being always asked for more air than they could supply, so that their works have grown and increased simply to meet a growing and increasing demand, and (fortunately, perhaps) the urgency of the demand has left them no alternative but to meet it by the very simplest possible means. I have already mentioned the great convenience and handiness which a compressed air motor possesses. From the engineer's point of view these qualities are most striking. The engine starts, for instance, without the least hesitation even with full-brake load on, directly the valve is opened if the crank is just past the centre. This, of course, is impossible with a gas engine, and hardly less impossible with any ordinary (single cylinder) steam engine. The absence of the heat and leakage and of the noise and smell, which so often in greater or less degree accompanying the smaller steam or gas motors, constitute a very much larger difference than could at first be thought possible, but from the consumer's point of view the advantages are even greater than from the engineer's. There is, first of all, the complete absence of danger and of nuisance of every kind. There is then the great saving of space even as compared with the gas engine, and much more as compared with the steam engine and boiler. There is reduction of insurance on account of the entire absence of fire risk. Not only this, but the air motor seems to me completely to supply that most important industrial want, a motor suitable for "small industries," that is—for work carried on in workmen's own houses, or in very small workshops, for here it is not only mechanically most suitable, but in the nature of things it can be made to cool or ventilate by its exhaust to any desired extent. The sanitary advantage of this in cases where work is carried on in confined spaces can hardly be exaggerated. Even in a large printing office in Paris, I found an almost unbearable atmosphere made quite pleasant as long as the motor was working, by allowing a portion of the exhaust to come into the room. By using air direct from the main in the motor, or by heating it only very slightly, the exhaust air can be, of course, so greatly reduced in temperature as to be available for freezing purposes.

(To be continued.)

THE NEW PATENT FIRE DETECTOR.

On Friday, September 13, we had the pleasure of witnessing a second test of this "Detector," at Dawson's Croft Mills, Greengate, Manchester, and the apparatus again proved successful. As before, the roof of the building was divided into a series of arches, yet, notwithstanding this drawback, the action of the apparatus was perfect.

A fire was kindled under one of the copper air chambers (see page 624, *Practical Engineer*), and in less than 32sec. the alarm apparatus came into action, and the position of the fire was correctly shown by the indicator.

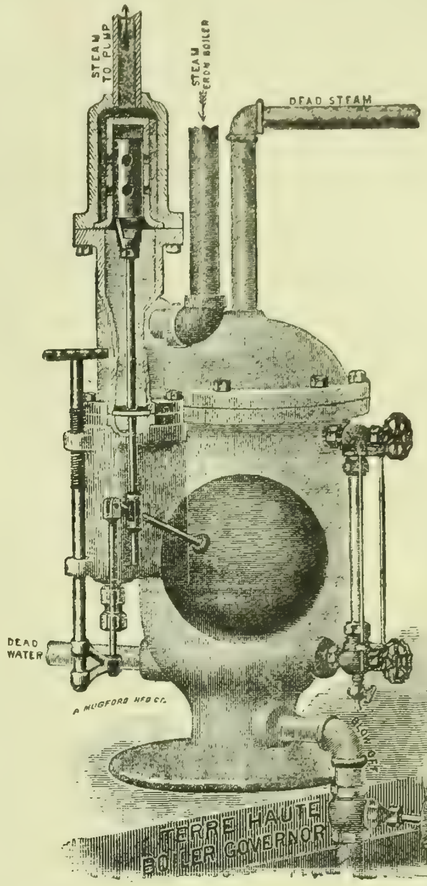
A second experiment was tried, and the fire placed at a distance of 15ft. on one side of another air chamber. In this instance, the alarm was 35sec. in acting, owing, of course, to the increased distance between the fire and the air chamber. In the third trial the fire was divided from the copper chamber by three arches of brickwork which composed the roofing, yet, notwithstanding these, the time occupied from the lighting of the fire to the ringing of the alarm bell was only 37sec.

These experiments may be considered very satisfactory, and as the apparatus is extremely simple in form, and also inexpensive, it is likely to become extensively used.

AN AMERICAN WATER REGULATOR FOR STEAM BOILERS.

We here illustrate a contrivance for regulating the action of the pump supplying steam boilers with water, as constructed by the Terre Haute Boiler Governor Company, in America. It consists of a vessel twenty-four inches in length and eighteen inches in diameter, placed between the feed pump and the boiler, and so connected that the level within it corresponds to that in the boiler. A strong copper float rides on the water, and actuates a lever connected to the steam valve of the boiler feed pump, and by opening and closing it keeps the level of the boiler constant. The steam valve is of the balanced type, so that the lever has little work to do in starting or stopping the pump.

A hand wheel and screw, shown in the illustration, regulates the relative position of valve and float lever, so that the height of water in the boiler may be adjusted within certain limits at will. Once set, the float keeps the water level without attention on the part of the attendant. It is stated that the apparatus is so sensitive that the boiler level does not vary perceptibly. We are indebted for our illustration to our esteemed contemporary the *American Machinist*.



We fear that the hollow copper float will prove a source of weakness, as it has done in many types of steam trap, and it does not seem to us a very desirable feature to do away with the necessity of watching the boiler level on the part of the attendant.

INSTITUTE OF MARINE ENGINEERS.

A meeting of the Institute of Marine Engineers was held at the Langthorne Rooms, Broadway, Stratford, E., on Monday evening, the 2nd September, presided over by Mr. Wymer, Senior Engineer Surveyor, Board of Trade, London District.

Mr. W. J. Craig read a paper specially for the junior section, entitled "Scientific Triunities."

Preliminary to the subject matter of his paper the author referred to the paper on "Pressure," read by Mr. McFarlaine Gray, at a previous meeting, from which he and those who were present had derived very great pleasure and profit; and the present paper and its title was an outcome of thought induced by Mr. Gray's paper and remarks on the evening in question.

The title of the paper called for some explanation, the literal meaning taken for triunity being unity under three aspects or divisions. In order to discover how far the theory of three divisions or aspects of unities extended, the Age of the Pyramids had been searched, and had repaid the seeker after three in one and one in three with several illustrations beyond the Age of the Pyramids to the days of the first known shipbuilder.

The science in which the members and visitors present were presumably most interested—mechanical science—is not without many examples of triunities; the mechanical forces—for instance, the lever, the wedge, and the wheel—each in turn being capable of sub-division into three kinds, as in the case of the lever of the first, second, and third kind. Mr. Craig referred to the subject of education, discovering even in this examples of what gave rise to the title he had chosen for the opening paper of the session. The three R's—once at least the school board rallying cry—the Rule of Three, and the peculiarities which may be traced to the figure three itself, were all remarked upon.

In concluding his long, carefully written, and suggestive paper, Mr. Craig impressed upon the younger members and graduates to be diligent students, not only of what lay directly in connection with their work as engineers, but of the allied sciences, in which they would find great pleasure and mental profit. The paper was illustrated by several well-executed diagrams.

Mr. Prior, while questioning the strict accuracy of some of his remarks on astronomical science, as considered in the light of the most recently accepted theories and observations, expressed himself as much pleased with the result of Mr. Craig's painstaking and study.

Mr. Rowe could not quite accept one or two of the deductions referring to the formation of the earth itself and the solar system, as he considered them rather at variance with the nebular theory of Laplace, now generally supported by scientific authorities. He, however, agreed that Mr. Craig had given his hearers a paper which was well worth listening to, and would no doubt be productive of much good.

Mr. Hawthorn made a few remarks, and expressed himself surprised that the author of the paper had been able to find so many triunities. The title was very suggestive, and many other triunities following on the lines laid down by Mr. Craig would no doubt suggest themselves to others as to himself, even keeping within the limits of the engine-room, starting from the process of filling the boilers, coaling the bars, and getting up steam.

The Chairman expressed himself well pleased to be in the position he occupied that night, in response to the invitation conveyed to him by the hon. secretary, and hoped that the institute would go on and flourish. He pointed out that Mr. Craig evidently wished to impress upon the juniors that there was an abundant field for them to study in, and he wished to endorse this, and express his own strong conviction that a very grave mistake was made in allowing young engineers, just out of their apprenticeship, to go to sea. They ought to be more proficient in the rudimentary principles and knowledge of the uses of the various details before being entrusted with the charge of valuable machinery, let alone the charge of a watch in the engine-room. He hoped the juniors would all have an opportunity of reading the paper carefully.

The Hon. Secretary, in rising to move a vote of thanks to Mr. Craig, expressed regret that those for whom the paper was specially prepared had been silent. Doubtless this was partly due to the presence of their seniors; he proposed that another evening might be devoted to the subject matter of the paper, and no doubt Mr. Craig would kindly spare them an evening. While overhauling some old papers, he had the previous evening met with an old university paper on "External Perception." In that the conclusion he had arrived at was somewhat different to a theory which Mr. Craig had advanced at the outset, his own conclusion in the paper being that things are not what they seem to be; *i.e.*, taking the eye as the organ of perception, our knowledge of things visible is unreliable. As a proof of the truth of this, he would only refer to an incident of the evening. Mr. Craig, as an illustration, showed the small model piston he now held in his hand. This, he stated, anyone who was acquainted with such things could tell at a glance was a Buckley piston. He would now remove the cover, and it would be observed that it was not a Buckley piston at all, but a common one. The removal of the junk ring, concealing in part the internal form of the piston, caused considerable amusement.

The vote of thanks was seconded by Mr. Storey, and heartily responded to.

Mr. Conbro moved a vote of thanks to the chairman for his kindness in coming among them, and for the interest he had manifested in the institute, which was now incorporated and registered.

The vote of thanks was most heartily responded to, and the proceedings terminated with an intimation from the chairman that the syllabus of papers before him was made up from September 2nd to the 23rd February, 1890; the next paper being by Mr. R. Bruce, on "Radial Valve Gear," on the 26th September, followed by one in October by Mr. Jos. Williams, on "Forced Draught."

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

MR. WORSDELL'S COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

SIR,—On reading the interesting account of a "Trip with the Flying Scotchman," in your last week's issue, reprinted from the *Railroad Gazette*, New York, I found it, with a few exceptions, pretty accurate. My object in writing you is to correct a few of the mistakes made, no doubt innocently, in describing the locomotive the writer was riding on, which was one of Mr. Worsdell's compound passenger engines, with single driving wheels, 7ft. 1¼in. diameter, and not 7ft. 6in. diameter, as written.

He states that automatic oilers are not in general use, but instead the well-known "tallow-cup" is mounted on each side of the cab. The fact is, all Mr. Worsdell's (the locomotive referred to included) compounds are fitted on the cylinders, steam chest, and motion bars with one of the latest automatic lubricators constructed.

The tallow cups which the writer saw are what we term "flushers" for the slide valves, and are only used when the steam is shut off, when running down a long incline, or just before stopping at a station. They could be dispensed with altogether. They are simply put on as a reserve in case of an emergency. Again, the cylinders of this locomotive are 18in. by 24in. and 26in. by 24in., and not, as he states, 20in. by 24in. and 28in. by 24in.

The writer is correct in saying that Mr. Worsdell is building several locomotives with 7ft. 7¼in. driving wheels, and cylinders 20in. by 24in. and 28in. by 24in., which I consider will be the most powerful and fastest locomotives in the world. One of this class was turned out of the shops at Gateshead a few weeks ago, and has been tried with 30 coaches between Newcastle and Berwick, and took them at express speed as easily as any non-compound with 18 coaches on.—Yours, &c.,

Gateshead. LOCO.

QUERIES AND REPLIES.

80. BOOK ON LOCOMOTIVES.—Can any of your readers inform me of the best book on railway locomotives—chiefly Midland Railway locomotives?—W. B.

Answer.—Evers' book on "Steam" contains a long chapter on the locomotive, which is prefaced with the remark that the author has availed himself of Colburn's "Locomotive Engineering," also published by Collins (40s.). Forney's "Catechism of the Locomotive" is published by Spon (10s. 6d.). All these works appear in the Science and Art Catalogue. Respecting the latter part of the query, it would be advisable to refer to the back volumes of the engineering journals for examples.—ORION.

82. OSCILLATING ENGINE.—If CP be the crank and PQ the piston rod of an oscillating engine, find the velocity ratio of P to Q, and set out result in diagram. Find also the angular velocity ratio of CP and PQ at any point of stroke.—C. P. W.

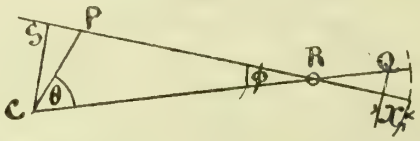
Answer.— Let $CP = a$. $PQ = b$.
$CRP = \phi$. $PCR = \theta$.
R = centre of oscillation.

Let V = velocity (linear) of P, and v = linear velocity of Q. Then the velocity of P resolved along PQ equals the velocity of piston. $\therefore V \sin(\theta + \phi) = v$. $\therefore \frac{v}{V} = \sin(\theta + \phi)$. From C draw CS perpendicular to PR. Then $\sin(\theta + \phi) = \frac{CS}{CP}$. $\therefore \frac{v}{V} = \frac{CS}{CP}$ which gives the required velocity ratio.

To set the result out in diagram, we have merely to trace the locus of S, supposing CP unity, and measuring the distances CS.

Again,

$$\frac{CP}{CR} = \frac{\sin\phi}{\sin(\theta + \phi)}.$$



Differentiating, we get

$$\sin(\theta + \phi)\cos\phi\frac{d\phi}{d\theta} - \sin\phi\left\{\cos(\theta + \phi) + \cos(\theta + \phi)\frac{d\phi}{d\theta}\right\} = o,$$

since CP and CR are constant.

$$\therefore \sin\phi.\cos(\theta + \phi) - \left\{\sin(\theta + \phi)\cos\phi - \cos(\theta + \phi)\sin\phi\right\}\frac{d\phi}{d\theta}$$

$$= \sin\theta\frac{d\phi}{d\theta}$$

$$\therefore \frac{d\phi}{d\theta} = \frac{\sin\phi}{\sin\theta}\cos(\theta + \phi). = \frac{CP}{PR}.\cos(\theta + \phi) \qquad (1)$$

and this expresses the angular velocity ratio of CP and PQ.

Let x equal distance travelled by piston measured from end of stroke, we now require the relation between CP, PR, θ, ϕ, and x.

$$PR = PQ - QR = b - a + x. \quad CP = a. \quad CR = b.$$

$$\frac{\sin\theta}{\sin\phi} = \frac{b - a + x}{a} \therefore \sin\theta = \frac{\sin\phi}{a}(b - a + x) \qquad (2)$$

At any point of the stroke the three lengths, CP, PR, and CR, are known, and thus we can determine

$$\sin\phi, \cos\phi, \text{ and } \therefore \sin\theta,$$

and substituting these values in (1) we get the velocity ratio of CP and PQ in terms of x, the distance travelled by piston.—H. G. C.

87. DIAMETER OF PISTON RINGS BEFORE CUTTING.—In the case of cast-iron piston rings of equal thickness—*i.e.*, where the inside and outside circumferences are concentric—could you give me the diameter of the ring before being split, in terms of the diameter of the cylinder? Also, where the ring is ½in. thicker in the middle than at the split ends, what would be the diameter of the ring before being split? A text-book I have says 1/16 larger diameter than the cylinder, but this seems to me excessive.—H. V.

Answer.—In the case where the piston rings are concentric, suppose the cylinder to be 17in. diameter, I find that most engineering firms make their rings half an inch bigger in diameter, or 17½in. diameter, and when they are fitted into cylinder about 1/16in. play is allowed. After the ring is split, it is again put into the lathe and the two ends drawn together and turned up to the diameter of the cylinder.—YOUNG LOCO.

90. HEATING FEED WATER.—If feed water is heated up to 190 deg. F. what is the percentage saving over feeding with water at ordinary temperature?—T.

Answer.—Taking the ordinary temperature of feed water at 52 deg., and the pressure of steam used at 60lb., the saving of fuel by heating up the feed water to 190 deg. by the exhaust steam from a high-pressure engine would be 12 per cent. Thus, the sum of the apparent and latent heats of steam at 60 deg. is approximately 1,200 deg.; that is, 1,200 deg. − 52 deg. (= temperature of feed water) must be added to the feed water to make steam of 60lb. pressure = 1,148 deg., but 138 deg. are added by the exhaust steam = 12 per cent.—H.

92. **Tannate of Soda.**—What is tannate of soda, and how is it prepared? Will it prevent a boiler feed-pipe from choking up if injected with feed water? Is there any composition which will do this?—Engine-driver.

Answer.—Tannate of soda is a chemical compound of tannic acid and common hard soda, made by taking the hard soda and crushing it to a powder, and then mixing the tannic acid. It is then put into the feed water.—Young Loco.

95. **Rail Connections.**—Why are rails connected by fish plates, instead of the ends being laid in chairs on sleepers? It would surely cause less jolting if they were laid in the latter manner. Information will greatly oblige.—Young Engineer.

Answer.—The reason why fish plates are used for connecting the ends of rails instead of placing the ends in chairs is, that fish plates, being made of the best steel, are very strong and can bear the greatest strain which can be brought to bear upon them. They are fastened together by means of four strong ¾in. bolts, made of Bessemer steel. Now, the cast chairs, being very brittle, would break off with the continual knocking to which the joint is subjected. The wood key knocked in to lock the rails to the chair would be apt to shake out and cause great danger, especially at a curve, where the tendency is to run off at a tangent. The fish plates are fitted on rough, and do not cost as much as a chair would.—Young Loco.

91. **Aluminium and Steel Castings.**—I see from an American contemporary that steel castings are now produced which can be worked like the best wrought iron, and yet tempered by the use of a flux containing aluminium. Can any reader inform me how steel castings can be produced, capable of being easily worked and tempered, or case-hardened, and possessing great breaking and elastic strength? Is there any work on this subject?—C. H. B.

94. **Portable Electric Lamp.**—Is there a portable electric reading lamp in the market, containing its own battery? Any information, with cost and where obtainable, will be appreciated.—Steam.

96. **Stroke of Hydraulic Engine.**—What is the advantage derived from making the stroke of a hydraulic engine variable? How is it done? A sketch will oblige.—J. S.

97. **Corrosion in Steam Cylinder.**—I have recently seen an old steam cylinder in which a deep groove is corroded into the metal of the cylinder at each end of the piston stroke. The groove is so deep and completely round the circumference, that the metal is almost eaten through. Can any reader explain this?—E. H.

98. **Working out Valve Gear.**—Would some of your readers be good enough to inform, me as early as possible, the best book I can get explaining clearly how to draw and work out the following valve gears—Joy's, Hackworth's, Morton's, &c.?—Valve Gear.

99. **Strut.**—I want to find what a round rod of wrought-iron, say 3ft. long and 2in. diameter, will carry with safety when acting as a strut. Again, given the length of a rod (round), and the load it has to carry, to find what the diameter should be.—Luton.

100. **Pulsometer.**—What is the reason for giving the upper portions of the condensing chambers their peculiar tapered form?—Shiny Boots.

101. **Differential Pulley-block.**—In what way are the parts of these blocks arranged so as to get excessive friction, which must equal half the load, except in some cases where special retaining mechanism is applied? I should be obliged by sketch and description of the last-named arrangement. Shiny Boots.

PATENTS AND INVENTORS' QUERIES.

4. **Rights under Provisional Protection.**—If I take out a provisional patent, and sell the article before completing the patent, and mark it provisional patent No. —, and also send out circulars setting forth the advantages and construction of my invention, and call it my patent No. —, do I run any risk of losing my rights?—R. S., Liverpool.

Answer.—You are in no danger of invalidating your patent by publishing and selling your invention during the provisional stage. In the case of articles which are easily made, however, it is advisable to file your final specification before putting the invention in the market, as you cannot proceed against any infringer until you have obtained the complete patent. In some cases, infringers have taken advantage of this, and sold largely during the provisional stage of a small article. With heavy machinery this is impracticable, on account of the time necessary to prepare patterns, &c., but with small articles it is quite possible to inflict great loss on the inventor.

5. **Utility Necessary in a Valid Patent.**—In a patent of mine, I describe two modifications of the invention, and in actual practice I only use one mode of construction—that which is the best, in fact. I am told that if the other modification is useless, then my patent is seriously weakened. Is this so?—B. L., Stockport.

Answer.—If any machine or process described in your specification is absolutely worthless, and cannot perform any of the work which you state it is intended to do, then that is, no doubt, a weakness in your patent. If, however, you can show that the arrangement acts as you describe, although the other is preferable, your patent is quite good. The law is satisfied with a moderate proof of utility in an invention, as those who object to your claims on the grounds you mention would probably find, if you took action against them for infringement.

6. **French Patent.**—Can I obtain a French patent after the publication of my English specification?—Engineer, Wolverhampton.

Answer.—You can obtain a valid French patent for your invention, notwithstanding publication of your English specification, provided that the application is made in France within seven months of the date of your English application.

TO CORRESPONDENTS.

Septimus Farrer, Padiham.—Any good construction of Richards' indicator will suit your purpose. The springs you will require are 30 or 40 to the inch, and 8 or 10 to the inch. We ourselves use the Thompson indicator, made by Messrs. Schäffer and Budenberg. It is an admirable instrument for either low or high speeds.

MISCELLANEA.

On Sept. 1 the telephones throughout France were taken possession of by the State, the company being, against its will, expropriated.

An Austrian railway official has invented a portable telephone for connecting a railway train at any point at which it may happen to stop with the nearest station. The experiments which have just been made with the instrument are said to have given satisfactory results.

Among the various uses of celluloid, it would appear to be a suitable sheathing for ships, in place of copper. A French company now undertakes to supply the substance for this at 9f. per surface metre and per millimetre of thickness. In experiments by M. Butaine, plates of celluloid applied to various vessels in January last were removed five or six months after, and found intact and free from marine vegetation, which was abundant on parts uncovered.

A little railroad recently opened in Vermont is remarkable for the steepness of its gradients and the sharpness of its curves. The line rises 875ft in a distance of four miles, the steepest grade being at the rate of 264ft. per mile, and the sharpest curve is 70 deg., which, however, only occurs on some of the sidings. The line has been built, in the first place, to carry granite from the quarries, but it is expected that it will have a fair amount of passenger traffic in the summer time.

It is proposed that the Bengal Chamber of Commerce should memorialise the Secretary of State by telegram requesting fuller consideration for the Bengal Railway scheme. Public feeling is greatly opposed to furthering any scheme calculated to increase the existing overgrown monopoly of the East Indian Railway. A competing line is essential to open out trade, which is already greatly hampered and obstructed.

It is stated that Professor Thomson, of electric-welding fame, has perfected an invention by which the rails of street or steam railways may be welded together by electricity after being placed in position. A dynamo propels over the track an electric welding machine, which welds the rails into one continuous line after it passes over them. It is proposed to have at every 100 feet a break, to allow for expansion, &c.

Submarine Telegraph.—Figures are just published showing that the total length of the submarine cables now in use is 113,031 nautical miles, which is as near as may be 130,291 statute miles. Submarine telegraphy is mostly in the hands of private companies; because of that total only 10,500 miles are described as national property. When the British Association was last in Newcastle the Great Eastern was busy with her first exploit of paying out 2,300 miles of cable between the old world and the new.

Glasgow University.—Professor Barr, who has just been appointed to the Chair of Engineering in the University of Glasgow, is the second professor from the Yorkshire College at Leeds who has been translated to Scotland. His predecessor, Professor Armstrong, was appointed to succeed Fleeming Jenkin at Edinburgh, and is as popular and as successful as he was in Leeds, though to follow a man of such genius and wide sympathies as Jenkin was a task of no small difficulty. Professor Barr has a high reputation in his profession as a man of ability and a remarkably clear and effective teacher, though he is not perhaps so well known as his Edinburgh colleague.

A New Petroleum Dock for Stettin.—Our Berlin correspondent says that a company has been formed, with a capital of 4,000,000 marks, for the purpose of constructing a petroleum dock in Stettin, which will be able to admit the largest tank steamers. Of late years the petroleum trade of Stettin has suffered considerably through the competition of Bremen and Hamburg, as these ports were able to receive the oil in tank steamers and deliver it at Stettin at a lower price than it would have cost in the latter town if imported direct from America in barrels. With a view to facilitating the enterprise, the Municipal Board of Stettin has consented to waive its claim to about a hectare of ground through which a canal has recently been cut.

The shareholders of the Teeside Iron and Engine Works Company have resolved that the company shall be reconstructed, and a pamphlet setting forth the state of affairs has been put into circulation. There were in December arrears to the amount of £35,697. Under existing conditions the whole of this, as well as £16,723 standing to the debit of profit and loss, will have to be paid out of future profits before the ordinary shareholders can participate in any dividend. The preference shareholders can receive no dividend until £16,723 is wiped out. The amount of preference capital to be dealt with is 23,798 shares with £2 each paid, equal to £47,596. The arrears of dividend for seven and a half years reached £35,697 12s., which give a total preference capital and arrears of dividend of £88,053. It is proposed to capitalise the arrears and preference dividend and to reduce the nominal value of the ordinary shares by the amount necessary to wipe out the sum standing to the debit of profit and loss account and the capitalised arrears for preference dividend.

A "Phonopore Telegraph" has been erected in the Paris Exhibition, two "stations" being connected by a single wire, on which three telegrams travel simultaneously. When a telegraph wire is in use for the transmission of ordinary telegrams by means of ordinary currents, such as the wire from a station A to station B, phonopore telegrams may be added to that same wire without affecting the ordinary telegram in any way whatever. The ordinary telegraph messages continue to travel in the wire as if the phonopores were not there, and phonopore telegraph messages also travel in the same wire as if the ordinary telegraph messages were not there.

AUTOMATIC VACUUM BRAKES.—Some of the southern railway companies which, in regard to the application of the continuous brake, have not shown such activity as their northern neighbours, are at present working almost night and day in order to fit the whole of their rolling stock with the automatic vacuum brake before the Regulation of Railways Act comes into operation in November. Very great strides have been made in this respect in recent years, but under the measure passed last session it is no longer open to any company to adopt an inefficient automatic brake or to trust to the old and less efficient machinery. It takes a week to fit a whole train with the new brake, and exchanges of stock are being made between one company and another, so that the process may be expedited as far as possible. By the end of the year there will not be in the United Kingdom a single passenger, goods, mineral, or cattle train without a continuous automatic brake.

THE METAL INDUSTRIES OF LOMBARDY.—Although the price of coal has fallen 15 to 20 per cent in Italy during the last six years, it is still, however, too high to enable the ironmasters to produce pig iron at a cheap rate, so that they are mostly compelled to work up old scrap iron. On the other hand, pig lead is produced in much larger quantities than formerly, and the exportation of this metal from the works in Lombardy is at least double what it was eight years ago. The engineering establishments in this province were actively employed last year, especially in the branch of railway plant. An important establishment has recently been started at Saronna, near Milan, for constructing and repairing locomotives and boilers. A large quantity of bridge work is turned out by the engineering firms in Milan, and projectiles are manufactured on a large scale in Brescia for the Italian Government. Steam engines and boilers of all sizes have for some years past been constructed in the best manner at Legnano, and a torpedo building yard now exists in Venice to which the Italian Government contributed above 7,500,000f. Nevertheless, Lombardy is still a good outlet for foreign iron goods. Rails are still imported from England, Belgium, and France; locomotives and tenders from Germany; boilers from England and Germany; and chains and anchors from England. The Italian Mediterranean Railway Company, which is domiciled in Milan, only possesses at present 1,090 locomotives, 3,039 passenger carriages, 743 luggage vans, and 19,406 goods trucks, although its railway system represents 4,555 kilometres of line; and as this rolling stock is manifestly insufficient, and the Italian works will not be able to execute all the orders which are pending, there is no doubt that some important contracts will fall to the share of foreign countries. It is stated that the company intends spending about 14,000,000f. on new rolling stock.

PROPOSED BOILER LEGISLATION.—The chief engineer of the Engine, Boiler, and Employers' Liability Insurance Company, in his annual report, just issued, discusses the question of boiler legislation, and condemns the proposal to make inspection compulsory. He suggests that a bill on the following lines might be drafted and submitted to Parliament by steam users themselves: 1. It should contain a very careful and explicit definition of the terms "boiler" and "explosion." 2. Every explosion should be reported to the Board of Trade, who should send a surveyor to report briefly thereupon (1) the cause of the explosion, and (2) whether there was *prima facie* evidence of culpable negligence. 3. Should the surveyor be unable to ascertain the cause of the explosion, or should he report that there was *prima facie* evidence of negligence, the board should order a formal investigation in open court by a lawyer and an engineer not permanently in the service of the Crown. 4. Should the formal investigation disclose negligence on the part of any person or company, the court should have power to order him or them to pay costs and expenses. The court should also report to the Board of Trade whether there were grounds for a prosecution. 5. The bill should apply to all "boilers" in the kingdom. "Such a bill," it is said, "would be a mere amendment of the Boiler Explosions Act of 1882, but its effect would be entirely different, for it would ensure a formal investigation and punishment of the guilty whenever the surveyor holding the preliminary inquiry imputed negligence to anyone. It would leave the careful boiler owner as free as he is at present. It would not even compel him to employ outside inspectors if he felt he had competent men in his employment. On the other hand, the ignorant or reckless boiler owner would soon find out that it paid him better to make sure of the safety of his boiler than to face the certainty of conviction, involving pecuniary loss and risk of imprisonment. It would afford that check upon the proceedings of the insurance companies which some people are anxious to impose, and at the same time leave the companies free to conduct their business without restrictions or red tape."

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

August 27th.

13459 Electric Accumulators, G. Downing, London. (J. F. Weyde and F. Clas, Austria, and J. Elsner, France.)
13464 Shafting, J. W. Newall, London.
13465 Pulleys, J. W. Newall, London.
13468 Brakes, J. Gresham, Manchester.
13474 Scaffolding, W. Ebeling, Glasgow.*
13479 Rotary Engines, F. D. Owen, Glasgow.*
13486 Explosives, C. O. Lundholme and J. Sayers, Glasgow.
13490 Propelling Ships. W. H. Wise, West Hartlepool.
13491 Cavity Cylinder, J. Bridge, Accrington.
13492 Starting Flywheels, D. Kidson, Halifax, Yorkshire.
13501 Regenerated Steam, J. L. Natu, France.
13505 Lubricators, H. Scharpegge, London.
13514 Knitting Machines, W. L. Cathcart and A. T. Cathcart, London.*
13515 Wheels, G. H. Everson, London.*
13516 Railroad Ties, A. C. Nickloy and W. W. Whitaker, London.*
13528 Lubricators, J. H. Siegrist, London.
13538 Brakes, J. J. D. Cleminson, London.

August 28th.

13560 Keyway Cutter, W. Gayton, London.
13562 Coupler, J. Adcock, Sheffield.
13567 Forged Screws, A. Lilley, Southampton.*
13568 Bearings, H. Monie and S. M. Rutnagur, Manchester.
13569 Saddles, J. A. Wilson, Dundee.
13570 Gas Motor Engines, G. McGhee and P. Burt, Glasgow.
13571 Rotary Motion, W. Hinchliffe, Wakefield, Yorkshire.
13572 Gas Engines, C. F. D. McAllen, Birmingham.
13573 Extinguishing Fires, De Fonblanque Pennefather.
13574 Flywheels, T. Greenwood and J. W. Whiteley, Halifax.
13578 Motor Cycles, L. D. Copeland, Birmingham.
13584 Pumps, J. R. Burgess and A. S. Williams, Manchester.
13591 Ejector, E. Harrison, London.
13592 Pulleys, J. Johns, London.
13598 Generating Steam, H. McPhail, E. Simpson, and C. H. Simpson, London.

August 29th.

13601 Curved Sections, C. B. Cooper, London.*
13605 Chain Cables, R. S. Marsh de Ricci, St. Albans, Hertfordshire.
13611 Annealing Ovens, J. B. Goes and T. Evans, Llansamlet.
13615 Rotary Engines, M. H. Wrigley, Manchester.
13629 Brake, D. Walker, Highbury.
13635 Furnaces, H. H. Jones, Swansea.
13639 Crushing Mills, J. M. Stuart, London.
13640 Electric Switches, W. Thompson, London.
13645 Screw-cutting Die Stocks, J. H. Sternbergh and R. Pemberton, London.*
13650 Hauling, C. A. Jensen, London. (Messrs. Schüchtermann and Kremer, Germany.)*
13653 Mineral Oils, W. P. Thompson, Liverpool. (P. Marix and N. Notkin, Russia.)
13659 Hardening Steel, W. L. Wise, London. (M. Kramer, Germany.)
13663 Bucket Elevators, W. J. Purday, J. P. Anderson, and R. H. D. S. Montague, London.

August 30th.

13671 Making Bricks, T. C. Fawcett, jun., Halifax.
13677 Steam Generators, S. Northrop, Birmingham. (L. D. Copeland, United States.)
13683 Propeller, W. P. Ingham and H. Bennett, Middlesbrough.
13711 Steam Boilers, J. F. A. Schnarrendorf, London.
13712 Oxygen Gas, R. D. Bowman, London.
13714 Speed Indicator, G. Downing. London. (A. Loiseau and Son and Elsner, Nauhardt, and Co., France.)
13715 Refrectory Ore, A. Gutensohn, London.
13719 Steam Boilers, J. Walsh, London.

August 31st.

13741 Steam Engine, H. R. Lumley, London.
13745 Piston Valves, W. Fairweather, Glasgow. (J. McKechnie, Spain.)
13767 Sawing Machinery, F. R. Lane, London.
13771 Weighing Apparatus, W. Shapton, London.
13779 Ratchet Mechanism, J. Phillips, London.
13780 Water Heater, F. Albon and T. A. Marshall, London.

September 2nd.

13783 Steam Generators, W. Ripper, Sheffield.
13786 Automatic Ventilation, M. Walker and E. H. Maddock, Liverpool.
13794 Steam Condensers, B. L. Rinehart, Birmingham.
13805 Car Axles, J. E. Blackmore and S. J. Wainwright, jun., London.*
13806 Car Brakes, R. A. Kiskadden, London.*
13814 Boiling Brine, W. Young, London.
13823 Indicators, J. Saxby, jun , London.
13827 Bearings, W. Joy, London.
13833 Centrifugal Pumps, A. Robins, Liverpool.
13835 Tidal Motor, F. W. Pyle, Kent.
13836 Wool-washing Machines, A. Deru, London.

September 3rd.

13839 Aluminium, H. J. Allison, London. (The Great Western Aluminium Smelting and Refining Company (Incorporated), United States.)*
13840 Cutting Logs, E. Bradley, London.*
13843 Steam Engines, P. Ferguson and W. Y. Fleming, Glasgow.
13852 Condensing Vapours, G. Wilkinson, London.
13859 Regulator, E. J. Houghton, Dulwich.
13863 Propellers, J. Bielby, Bridlington, Yorkshire.
13873 Steering Apparatus, G. D. Davis, London.
13875 Freezing Apparatus, A. Brunetti, London.
13878 Railway Rails, J. W. Cloud, London.*
13894 Coal Conveyors, E. Powell and S. Pitt, London. (W. N. Page, United States,)*

The Practical Engineer,

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THE

PRACTICAL ENGINEER,

SEPTEMBER 27TH, 1889.

HIDDEN FLAWS.

The possible existence of hidden flaws, not discoverable by the ordinary tests of the workshop, has always been a source of considerable anxiety to the engineer, and, we may say, especially to the marine engineer. The breakage of a main shaft in mid-ocean is a calamity fearful to contemplate. In positions of difficulty and danger, the failure of the engines may destroy all hope of escape, and it is the total reliance that must be placed upon them at such times that renders the soundness of all these parts a matter of paramount importance, and, although other parts may break down, it is in the main shaft that so much interest centres on account of the large size which it often presents, and the correspondingly enhanced difficulty of securing homogeneity of material throughout, which always leaves some shadow of a doubt as to the safety of the vessel, should extra efforts be demanded from her machinery.

Such tests as may commonly be applied to detect a blowhole in cast iron, or a defective weld in wrought iron—measuring extensions, for instance, and observing whether they are uniform in different parts of the length—are only applicable to comparatively small work; and the same remark applies to the fire test for bad welds, which serves well enough for chains and cables, but is not applicable to large masses of metal.

It is, however, no consolation to point out these difficulties, which are already acknowledged, if we have no suggestion to make as to a remedy—and it is to this we are now coming. The method of testing to which we are about to refer is no new thing, but it seems to have dropped out of notice almost as soon as it was introduced, although in point of simplicity and cheapness it could not be excelled. It was devised by Mr. S. M. Saxby, R.N., and depends upon the conditions under which a bar is capable of becoming perfectly magnetic. It had been known for a century and a half that a bar of soft iron, placed in the position of the magnetic dipping needle, becomes sensibly magnetic, the lower extremity becoming a north and the upper extremity a south pole in our hemisphere. The same action in a less degree takes place in a bar hanging in a vertical or any other position, the effect being weaker the more the position of the axis of the bar departs from that of the dipping needle. If the bar is perfectly homogeneous, it will form one uniform temporary magnet; but if this is not the case—if the mechanical continuity of the bar is not perfect, it will be, as it were, broken up into several magnets having different magnetisms. If a bar is placed in the magnetic equatorial plane—that is, east and west—and a delicate compass needle passed along in front of it, the position of the needle will remain normal—that is, pointing north and south if the induced magnetism of the bar is continuous; but should there be any solution of continuity, the needle will be deflected, and, as the break is caused by some mechanical flaw, its position will be indicated by the disturbance of the needle.

Some fourteen years since a series of experiments, undertaken to test the value of Mr. Saxby's method, and conducted at the Royal Dockyards at Chatham and Sheerness, gave results of a very satisfactory character, apparently thoroughly establishing the reliability of the test in a practical manner.

Several bars were given to Mr. Saxby, that he might by the magnetic test determine the weakest spots. This was done, and their position marked. The bars were then immediately broken in a testing machine, and in every case the fracture occurred at the place indicated by the needle. One device, out of several, to try the scope of this method, consisted in welding a piece of unmagnetised steel, about 5in. long, in a piece of square iron. The needle indicated a flaw at about the centre of the strip of steel.

Anyone accustomed to handling bars from the rolling mill will know that they are not absolutely uniform in structure throughout; and thus, although the bars alluded to above were good bars, breaking under tensile strains of from 24 to 28 tons per sectional square inch, there was sufficient difference in molecular constitution between the strongest and the weakest sections to be indicated by the needle. This at first seems to militate against the use of the method, as a flaw might be indicated when the deterioration of structure is not sufficient to be of any practical importance, but this indication is due to the delicacy of the needle, and by trials the necessary amount of delicacy to be given to a test needle might be determined so as to make this method of practical value. As in other applications of scientific facts to commercial purposes, it is not to be expected in this that first trials will be conclusively satisfactory in every respect. In these experiments the too great delicacy of the test would lead to the condemnation of material quite suitable to the purpose for which it may be required; in fact, absolute homogeneity is demanded, and for the class of work to which our present remarks apply it is the detection of serious flaws only that is needed. But it is to be expected that special forgings, such as are used for large screw-shafts, will generally be more uniform than merchant bars, as the material from which they are made will be carefully selected, and free, therefore, from a suspicion of cinder; in short, if there be a flaw at all, it will be a serious one, such as an internal crack, or considerable area of non-adhesion.

What is required to be done is to bring the method into some form in which it can be used by any intelligent mechanic with the same confidence as that with which he takes up his callipers and square; and in view of the great advantages to be gained by success in such a direction, it is certainly worth the serious attention of those interested, not only in marine work, but in all branches of constructive engineering. So long as it remains a laboratory test only, it is useless for practical purposes.

The mode of suspension of the needle will have to be of a more positive character than any of the ordinary systems; it must be carried on an axis definitely supported at its ends, and for examining large masses which cannot readily be moved into the magnetic equatorial position a special apparatus would be required, in which the normal position of the test needle would be determined by an artificial current supplied by a small galvanic cell. This, however, is not a matter that can be settled by theorising, though a few inexpensive experiments would probably be sufficient to determine whether the plan can be reduced to a form of such simplicity and certainty as would assure its general acceptance by superintending and manufacturing engineers.

THE NAVAL MANŒUVRES.

In summarising the results of the naval manœuvres, Rear-Admiral Mayne holds that we need higher speed in our large battleships and cruisers, and that the armour belt must disappear, as of no practical service, and its place be taken by a turtle-back steel deck, with vertical armour only on the turrets and barbettes. He is delighted that the Admiralty have given up the notion of equipping vessels with the 110-ton guns, and are contented with guns of 67 tons. Even these he regards as too large, for the slightest accident might derange the machinery used in working them, and then they would be useless. The aim should be to have guns which the crew could manage irrespective of the machinery. Practically, any armour yet put on a ship's side may be pierced by much smaller guns than the huge Elswick weapons. On the subject of speed and staying power during a chase, Rear-Admiral Mayne says that continual breakdowns are not a credit to us. Our vessels should have larger boilers and larger tubes, and the engines should be stronger, to cope with the changes required while manœuvring. He ridicules the notion that engines for the navy are made of better metal than mercantile companies obtain, as companies procure the very best metal, and we cannot improve upon the quality. "Forced draught" he terms an invention of the evil one, only of use to give an erroneous estimate of speed on trial trips, and when tried afterwards certain to bring about a disaster. Of course this latter opinion of the Admiral must be received with a certain amount of reservation, because in no case that we are familiar with has anything like a disaster been brought about by means of forced draught, but, on the contrary, well-known engineers and leading shipowners are moving in the direction of strongly advocating the system.

NEW YORK INTERNATIONAL EXHIBITION.

The International Exhibition at New York is taking definite shape. An influential committee has reported on the site and the cost of buildings, and the leading newspapers support the project. It has been found possible to obtain sufficient ground outside the limits of Central Park, but if need be a portion of this resort may be used for the purposes of the display. As might be expected, the cost of the buildings is very heavy. The main building is to cover twenty-five acres; the machinery hall twenty acres; an agricultural hall ten acres; a horticultural hall five acres; and art will find sufficient space in five acres. The cost of the buildings alone is estimated at nearly a million and a quarter sterling. Rivals of M. Eiffel are invited to plan a tower 1,320 feet in height, or nearly the height of St. Paul's higher than the structure in Paris. The various competitive designs sent in for this gigantic work ought to embody some new ideas. What if M. Eiffel himself carries off the prize! Let us hope the foundations will be made as strong as the French engineer succeeded in rendering them, it being the intention to maintain the tower as a permanent attraction of the Empire City. The railway companies are certain to net a fine harvest out of the Exhibition.

THE NICARAGUA CANAL.

The Nicaraguan Canal Company have issued advance sheets of a pamphlet describing the main features of the proposed new canal, of which the following are the main points:—

The canal traverses the lowest depression of land in the Corderilla, between the Arctic Ocean and Cape Horn. Lake Nicaragua, a large inland sea of fresh water, occupies the depression, and is 110ft. above the sea level; the western is within 12 miles of the Pacific coast, and it drains towards the Atlantic on the east by the San Juan River. From ocean to ocean, the canal will be 170 miles long, and some 16 miles of excavation on the east side will be required to connect with the river. Free navigation will be had in the San Juan River of 64½ miles, and in Lake Nicaragua itself of 56½ miles, total 121 miles. The excavation will be wide enough for two ships to travel in opposite directions, and the locks will be sufficient to take two ships of 2,000 tons each at one time, being 650ft. long by 70ft. wide. It is estimated that 32 ships could pass per day, or in one year 11,680, which should give an average tonnage of 20,000,000 tons. The time from ocean to ocean is estimated at 28 hours. The lake supply alone of water is about ten times that required for the locks.

There is a very interesting model of the country, lakes, and canal at the Paris Exhibition, in the Nicaragua Pavilion, which clearly shows these features, and is complete in every detail, even to real water and little model ships floating on it.

MR. BAKER ON THE FORTH BRIDGE.

On Saturday evening week Mr. Benjamin Baker, M.Inst.C.E., one of the designers of the Forth Bridge, delivered a most able and interesting lecture on that great structure in Newcastle, before the members of the British Association. As we have already published a similar lecture by Mr. Baker, delivered before the Society of Arts, we need not enter into the details of the undertaking, but merely touch upon the additional points of interest raised by the speaker. Remarking upon the Eiffel Tower, he said: "On the same diagram is shown the much-talked-of Eiffel Tower, laid horizontally for comparison. You will see it is very much the equivalent of one-half of one of the spans of the Forth Bridge placed vertically. I leave it for you to judge whether it would be easier to build vertically or horizontally, or whether our French friends are justified in saying that such a bold undertaking as the Eiffel Tower could never have been conceived of by Englishmen. It is a graceful and thoroughly creditable work, but not so difficult, especially as regards the workmen engaged, as the Forth Bridge."

This is undoubtedly the opinion of all of us who have examined both structures. There cannot be a doubt of the gigantic nature of the British undertaking as compared with the French.

In concluding, Mr. Baker stated that he had had an opportunity of seeing Messrs. Schneider's plans for a bridge to cross the English Channel. The total length was 24 miles, the number of piers 120, the width of the openings 329ft., and the clear span 1,640ft. It was quite practicable as an engineering feat, but the question of expense was so overwhelming that it would probably for ever remain an ideal. A million tons of steel would be required for the trifling job, that is without the piers. Both Forth Bridge and Eiffel Tower had already been eclipsed, at least on paper.

WORKMEN'S WAGES IN GERMANY.

WHATEVER assumed advantages the German workman may have over his British brother, a comparison of the wages paid in different parts of Germany would seem to point to a much more dependent and less comfortable life. The wages are, from our standpoint, exceedingly low. It appears from a Board of Trade note that only a few classes of workmen are well treated in Germany, including the engineers, glass cutters, and makers of fancy wares in Berlin. The engineers, however, rarely earn more than 3s. 3d. or 4s. per day, and the workmen on glassware or porcelain about 2s. 9d., and as these sums are paid for ten hours' work, it is evident that, working 60 hours per week, even the comparatively highly paid engineer only gets 24s. per week.

These figures seem to prove that the average German workman cannot equal the British, otherwise, with wages expenditure so low, German manufacturers should be able to compete with British manufacturers in foreign markets much more energetically than they now do.

NEW ITALIAN CRUISER.

THE Admiralty have no doubt taken careful note of the firing trials of the new Italian cruiser Piemonte, built and equipped at Elswick. This vessel has realised a speed on her trials of 22 knots per hour, but whether she will always do as well, or, like so many of our own cruisers, fall off five or six knots, remains to be seen. The most marvellous thing about her is the powerful equipment of rapid-firing guns she possesses. She has six 6in. quick-firing guns, six 4½in. guns, ten 6-pounder Hotchkiss guns, and four Maxim guns, besides three torpedo tubes. The 6in. guns are able to pierce 15in. of armour. In a given time this cruiser can discharge twice the weight of shot that the largest of our ironclads is capable of doing, and she is, therefore, one of the most formidable and efficient vessels afloat.

ELECTRIC LAUNCHES ON THE THAMES.

A SMALL party started in the Immisch electric launch Eta from Hampton on Saturday, the 7th inst., for Oxford. It consisted of Mr. A. Rawlinson, of Brighton, Mr. Saunders, of the Miller of Mansfield Hotel, Goring, and Mr. Volk, manager of the Platt's Eyot Works, Maidenhead. The first stopping place, a distance of 26 miles, not counting the locks, was reached in about 14 hours, and the Eta was recharged during the evening at the charging station stationed there. On Sunday a little excursion with a few additions to the party was made to Medmenham and back, but on Monday morning the experiments were renewed by running to Goring, 34 miles, where the Eta was recharged during the small hours of the night. Ten o'clock on Tuesday morning saw Goring left behind, and after two halts on the stream, Oxford was reached by four o'clock in the afternoon. During the two hours the Eta lay at Oxford she was an object of considerable attraction, being the first electric launch that has been above Goring, and a large portion of the boating public, whose curiosity has been excited by the account and illustrations of these craft, had an opportunity of examining the handsome and attractive Eta. Leaving Oxford at 6 p.m., a stop was made at Abingdon for the night. Goring being reached by noon on Wednesday, a small charge was put in during lunch, after which the journey was resumed to Reading, which was left on Thursday morning at eight o'clock, a short stay being made at Henley. Maidenhead, the end of the journey, was reached at 1 p.m. It is noteworthy that not only was no time lost in the recharging of the launch, which was effected during the night or at meal times, but also that 60 miles, from Goring to Oxford and back, was covered with but one charge of electricity. The Eta has therefore made two records, one for distance and another for work, and her owners have just cause to be proud of her performance.

POSITIVE PISTON PUMP.*

To raise a column of fluid, power applied with a pump yields directly effective work in overcoming gravity of the mass, and the friction which is indispensable from necessary contact in pipes and pump chamber. These resistances are obvious necessities with any method we may employ. In practice, however, other resistances are developed, arising from mechanical methods of construction, which absorb power, often to a great degree, where it yields no effective work, while causing much wear and tear.

The reciprocating system has maintained pre-eminence, because by the piston or "plunger" any desired pressure can be directly applied against the column of fluid to be moved. Were it possible to make this action continuous, without reversals of reciprocation, no resistances would be met in addition to those noted as inseparable from efficient work, and momentum would become an aiding and equalising force, as it does with the flywheel of a steam engine. But reciprocation converts this force into an active resistant.

Water not being compressible to any appreciable extent, and possessing much weight, through its momentum causes serious difficulties in operating reciprocating pumps, which were expressed by the late Mr. H. R. Worthington, to whom we are so much indebted for improvement in pumping machinery, in these words: "A moment's reflection will show that when the motion of a pump changes, the valves are in the wrong relation thereto, and must be immediately changed. For an instant of time, therefore, the resistance is suspended, much as in the case of a gear suddenly reversed and producing 'backlash.'" Again he wrote, when referring to the valves of a pumping engine: "Before one set can be seated and the other lifted, the engine, by a sudden jump, strikes the water heavily, and pounds the valves to their seats. Hence the noise which always has, and always will, to a greater or less degree, mark the self-destructive action of an ordinary reciprocating pump." Mr. Worthington's remedy was to allow the valves to seat themselves by gravity before beginning the return stroke. This necessitated a very low rate of speed, and reduced resistance to the extent that would be realised from a body at rest, instead of moving to meet a momentum. He also appears to have used another means for relieving impact, by making the valve openings of such area that water would not flow fast enough to fill the chamber until after the plunger had come to rest; for he writes: "It reaches the end of its stroke and stops—what follows? The water continues to press by its momentum into the chamber, filling every inch of space."

A modification of this practice is a well-known necessity with builders and operators of all reciprocating pumps which move large masses of water. Taking ten of the best known pumping engines in this country, we find a speed of only eight to nineteen revolutions per minute. Indicator cards taken from water cylinders of such pumping engines show that those which run at the highest rate of this very moderate speed exhibit clearly the "water hammer" in its sudden resistance against the plunger. Therefore, to lessen this resistance, a low rate of speed must be maintained. Large air chambers are provided for the same purpose; also the passages and valves must be carefully proportioned to a definite rate of speed.

Small reciprocating pumps often run at higher speeds; in such cases there is much vibration and resistance from impact, with great wear and tear; but, as the containing parts are porportionately strong, these difficulties have assumed position as necessary evils, although the concussions and vibrations may often be heard and felt throughout large buildings. That we may reach some idea of the real value of this destructive work, let us examine:

1. The physical laws which govern reaction, when motion of a body is arrested.
2. The results of expert tests, exhibiting value of the reaction in pumps.
3. Mechanical construction of reciprocating pumps, which causes the reactionary resistance.

For the physical laws it will be sufficient to select three well-known authorities. From Professor Rankine: "Momentum is the product of the mass of a body into its velocity, in units of distance per second. The reaction of a retarded body is as the force required to produce the change of velocity."

From Professor Thurston: "Acceleration and retardation of masses in motion can only be produced by doing work upon them, or by causing them to do work. Every mass undergoing retardation must perform work, and thus must restore energy previously communicated to it."

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* Paper read by Mr. Josiah Dow, Journal of the Franklin Institute, Philadelphia.

From Weisbach: "There can be no action of a force without an equal and contrary reaction."

Work performed by a moving mass of water, confined in a pipe, on coming to rest, is represented by the familiar expression—

$$\tfrac{1}{2}\ M\ V^2, \text{ or } \frac{W\ V^2}{2\ g}.$$

Where W represents weight of water in the pipe, in pounds; V its final velocity in feet per second, and g (gravity) 32·2. The quotient is in units of one second, because V and g are in units of one second; therefore, if the mass is brought to rest in a definite time, the rate of doing work through its momentum will be

$$\frac{W\ V^2}{2\ g\ T},$$

the unit of T being one second.

E.g., a 16in. suction pipe, 40ft. long, contains 3,500lb. of water; take its motion at the moderate speed of 3ft. per second, which is arrested within the time of change in direction of a pump plunger, running at 15 revolutions per minute. This would give 15 × 2 = 30 movements of the plunger per minute. Allowing for change in direction one-twentieth of each stroke, or one-tenth of a second (time in which water is brought to rest, as shown by many indicator cards, is often less than this), then is—

$$\frac{3500\ \times\ 3^2}{64{\cdot}4\ \times\ 0{\cdot}1} = 4891{\cdot}3 \text{ foot pounds},$$

the power by which such a column of water resists being brought to rest in one-tenth of a second. To restore the same degree of motion, in a time equal to that which brought it to rest, requires an equal measure of power.

A familiar illustration of these laws is found in the hydraulic ram, which is analogous, in its useful work, to the destructive work of the "water hammer" in a pump, including application of an air chamber to avoid rupture.

The sudden closing of a cock, after drawing water, under pressure, through it, is also a familiar illustration: To avoid risk from heavy impact, the pipe is usually continued above and beyond the cock, that it may contain an air cushion.

It was shown by experiments made in 1884, and published in Transactions of American Society of Civil Engineers for 1885, that arresting a velocity of 5·36ft. per second, with water in pipes aggregating a length of 272ft., yielded a force of impact, upon being brought to rest, equal to 129·31b. per square inch. More than half of the pipe was very small, which would cause retardation through friction and prevent a free action at the outlet from momentum of the whole mass. The terminal length was but 1in. in diameter.

The report made by a board of experts for testing a large pumping engine at Cincinnati, in 1879, shows that "pressure per superficial inch of pump piston, required to open the suction and delivery valves, in addition to frictional resistance of water passages into and out of the pump, was 13·44lb. (8·816 inlet, 4·624 outlet). Here, the resistances upon the inlet side of a reciprocating pump are shown to be about double the value of those upon the outlet side. In the record of a series of tests, made in 1885, by engineers of the Philadelphia Water Department, upon a direct-action reciprocating pump, with 8in. pipes, working against a head of 129ft., and without suctional lift, there is shown a loss of effective indicated horse power of 13 per cent. This was apparently sustained at the outlet side.

By comparing expert tests upon eight of the best known waterworks pumps, it is shown that loss of force expended within the water cylinders—ascertained by testing the effective work delivered into water mains by the pump—varied from 14 to 25 per cent, and in one case 27 per cent of the indicated horse power at the engines. Smaller pumps show much greater percentages of loss. The tests were all made with pumping engines built for the best economy of work, and running at low speed for the purpose of avoiding as much as possible the resistances under discussion. None of them were pumps working in connection with direct distribution, which often necessitates very high pressure and greater speed. Acceleration of speed will rapidly increase losses from arrested momentum, notwithstanding the use of air chambers, because they cannot effect avoidance of the reaction; they receive it as would a spring, to immediately restore it again, and only lend a partial elasticity, near the point of impact, but not in direct line with it. Indicator cards from the water cylinders show this reaction sometimes, in decreasing vibrations throughout the whole stroke. Occasionally, at high speed of flow, for a moment, resistance to closing the inlet valves is so great that the current passes directly through both sets of valves, and almost completely blocks the mass of water within the cylinder which the plunger is struggling to remove.

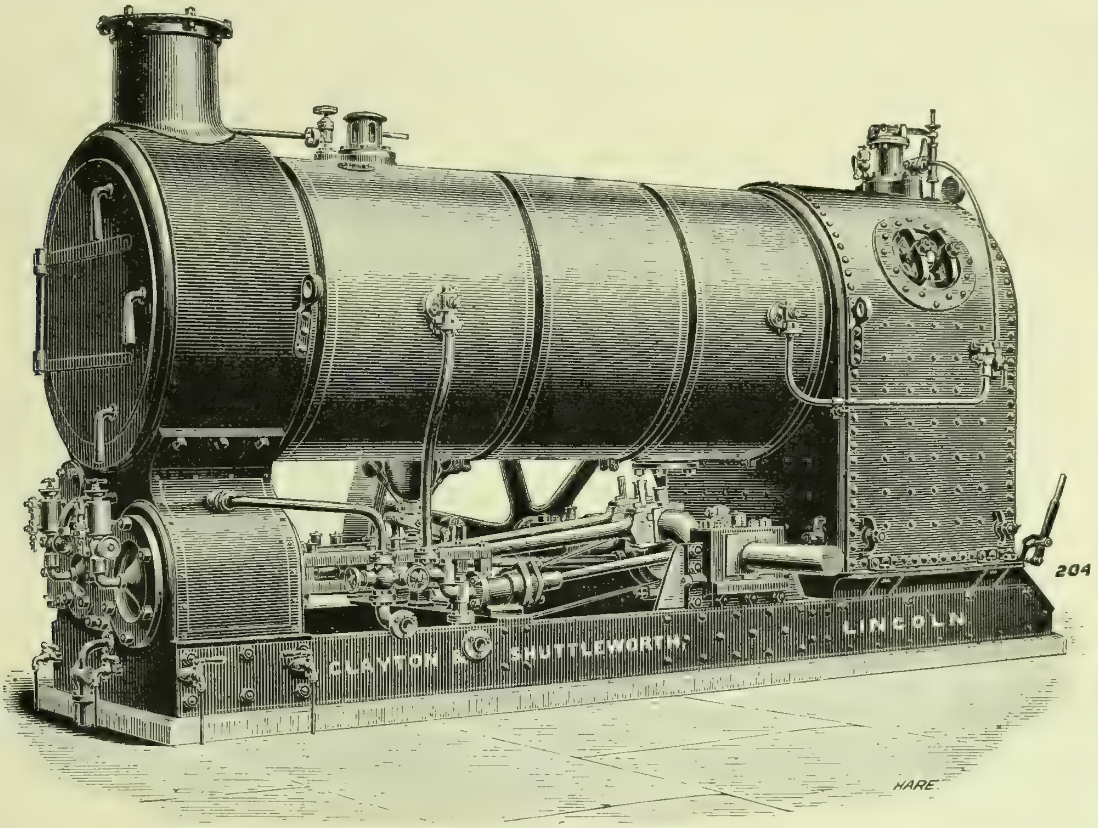
(To be continued.)

THE ELECTRICAL AND INDUSTRIAL EXHIBITION, BIRMINGHAM.

THE Exhibition at Bingley Hall, which has now been open about half the allotted time, may now be seen at its best. All the stands are fitted up, the machinery is in working order, and, apart from the exhibition itself, an enjoyable entertainment is given each evening. The committee regard the exhibition as an exceedingly important one for Birmingham, inasmuch as this is the first time that electricity on an extensive scale has been applied to the working of machinery. Sceptics who doubt the applicability of electricity, both as a motor and for lighting purposes, should pay a visit to Bingley Hall, where electricity is being put to all kinds of uses—from working a sewing machine to driving a 2½-ton crane, and from producing a three-candle-power light to a brilliant blaze equal to 2,000 candles. The committee anticipate very great things from the exhibition. They hope to have done not a little towards educating the public to the many advantages of electricity over any other power—of its safety from risk of fire, its cleanliness, its reliableness, its cheapness, and a variety of other "nesses." Many of the exhibitors have already received orders for laying down plant at manufactories where hitherto steam power only has been used, and further results are expected. It is also pointed out that with no other power could so many different machines as there are at the exhibition be worked at one and the same time. In proof of the triumph of electricity over steam, the visitor is pointed to a crane which will pick up a load of about a ton weight, travel forwards or backwards with it, and slue, all at the same time. No single motor of any other kind would be able to perform any two of these feats at once. But this is only one of the many uses to which electricity is applied. In one corner of the exhibition electricity is working a fan which creates draught enough to ventilate a coal mine, and which can only be worked occasionally on account of the complaints of visitors who wish to inspect any of the stands near; and in another place it propels a smaller fan suitable for ventilating a drawing-room. On one stand it lifts a heavy stamping press, and on another works a machine for pointing pens; while elsewhere it is employed for wood-turning, glass-cutting, weaving, and a number of other things. The machinery for generating the electricity is in a specially constructed room in the basement at the top right-hand corner of the hall, and is valued at £10,000. In the one room are two large Galloway boilers for supplying the steam to the various engines in the adjoining room. The capacity of the boilers is 300 horse power. The largest engine is one by Greenwood and Batley—a high-speed engine—which drives two dynamos, working in tandem, and which supply the principal lighting of the hall. Each machine is capable of supplying 35 arc lamps of 2,000 candle power each. Another large engine is by Ruston and Proctor, and drives the appliances for supplying power all over the exhibition. There is also a small compound engine, by Lawrence, Paris, and Scott, working a dynamo which supplies the various incandescent lights; a small-speed Robey, driving the Goldston installation of light; and a 9 horse power Crossley gas engine, driving a dynamo for lighting in various parts of the building. From this room a number of "leads" or wires run off to the different stands where machinery is at work, and on each stand there is a motor—to the visitor it looks like a small wooden box with a small pulley wheel by its side—from which the power is obtained. The standholder has only to move a switch to connect the circuit, and the little pulley is set revolving and his machinery put in operation. An indicator in the engine-house measures the power of the current, and users are charged accordingly. As a further illustration of the use to which electricity may be put, a Telpher, or aërial railway, in working order, is shown in the gallery of the winter gardens. It consists of four cars, which run, suspended upon a wire, round the building. It is a novelty so far as Birmingham is concerned, and attracts a good deal of attention. The wire is supported by brackets, placed at easy distances, so as to keep it tight; and the car is suspended upon two wheels, which run along the wire. The wire conveys the electricity, and operates a motor attached to the front of the cars. It is not necessary for anyone to travel with it, for the switch arrangement enables an attendant to stop the car after it has gone the required distance simply by disconnecting the circuit. Each of the four cars carries two persons, and they are taken round the room at a speed of from four to six miles an hour. This mode of locomotion is especially adapted for conveying coal and minerals from the pit's mouth over long distances to railway stations, and the cost of conveyance is about a quarter that of ordinary haulage. The exhibition is very well attended each evening.

COMPOUND FIXED UNDERTYPE ENGINE AND BOILER.

Messrs. Clayton and Shuttleworth have been long and favourably known for excellence in design and workmanship of the engines and machines constructed by them. Long experience has weeded out weak points, and simplified and improved their engine detail to a high standard of perfection. This is noticeable in their compound fixed undertype engine, with locomotive boiler, as now constructed by them, and illustrated below. The engine is erected on a strong wrought-iron frame, and has steam-jacketed cylinders, variable automatic link expansion gear, controlled by a powerful governor of the Porter type. The Porter governor is modified under Tyrrell and Deed's patent. The pistons and cylinders are supplied with oil from automatic sight-feed lubricators, seen in the illustration, attached to the covers. The boiler is constructed of steel, and mounted above the engine on the wrought-iron bed plate of the engine. It will also be observed that the bed plate is extended from the engine under the locomotive boiler firebox. Bent cranks are used, and the main bearings can be adjusted by set screws. The feed water supplying the feed pump is heated by a feed-water heater which utilises the escaping hot gases. The whole arrangement is very neat, simple, and compact. The engine we illustrate is of the 12 H.P. nominal size.



ENGINE PATTERNS.—VII.

Figs. 53 to 55 show a jacketed cylinder used for a small horizontal engine employed for driving pumps. In these figures A is the bore, B the steam iacket, C the metal surrounding it, D the flanges, E the steam chest, F the foot by which the cylinder is bolted to its bed plate, G the valve-rod stuffing boxes, H the steam inlet, I the exhaust, J the lubricator boss, and K the pet cock bosses.

It is evident that if we joint the pattern of this in the manner of ordinary unjacketed cylinders, we shall not be able to insert the jacket core in place, unless indeed we were to divide it longitudinally and support it upon chaplets, which would be a poor method. The pattern, therefore, is made to mould on end, which necessitates the leaving one end flange loose. The pattern made thus is shown in figs. 56 and 57. Going through the details of its construction, B are the ends upon which lagging strips C are built to form the body; D corresponds with the steam-chest face, and E is the print by which the chest is cored out; F is the foot, with those brackets G skewered on which go in the bottom of the mould; H is the print for coring out the recess L in fig. 55; I I the facings of the valve-rod stuffing boxes; J is the print for the steam inlet, K that for the exhaust.

Looking at fig. 57, one half the circular flange is seen at L, the other half being removed to show the lagging; M is the recess which retains the flange in place during ramming up, while permitting it to remain behind in the mould on the withdrawal of the cylinder body. This flange L and print N are seen in elevation in fig. 56. In both these figures there are bosses O with small prints, shown on the flange which goes in the bottom of the mould, which bosses and prints have no counterpart in the casting. These are used for setting the jacket core, as will be explained presently. At P, fig. 56, is seen a disc, which is of the same diameter as the flange, and forms the flange at that end in the top of the mould, with head metal of the same diameter.

In this pattern, therefore, the end A is in the bottom of the mould, and all parts are tapered in that direction. The loose parts are the flange L with its attachments, the brackets G, and the prints J and K, with their facings Q.

The core box for forming the jacket is shown in figs. 58—60, and requires a little attentive examination. In this the body D is of the same diameter as the portion M in figs. 54 and 55, and the distance E is equal to the distance N in fig. 54, and the distance F equal to O in fig. 54; also the radius G, in figs. 58—60, corresponds with the radius P in figs. 54 and 55. The distance Q in fig. 55 also corresponds with the distance H in fig. 58, and the distance R in fig. 55 with I in fig. 58, and the distance J in fig. 58 with S in fig. 55. It is therefore clear that in the box shown in figs. 58—6C we can make a core that shall give the shape of the jacket B in figs. 54 and 55, the inner part of the core being rammed against the body of the box, and the outer portion being strickled off by the edges of the box ends K. These ends are made of iron plate cut to outline, and they retain the other parts of the box in place during ramming. In order that the box shall be withdrawn from the core, it is necessary that the main body be made in three portions L, D, D (see fig. 58). D and D are screwed to L, and all three screwed through the plates K. The strips of wood M, M are also screwed to the edges, D D, and prevent the sand from becoming rammed out sideways. After the core is made the whole of the screws holding these several parts together are withdrawn, and the pieces taken away in detail. The main piece L has to be drawn before D, D, and the faces of L are tapered to facilitate withdrawal. This tapering is seen in fig. 58.

There are some other points about this core box that must be noticed. The core is very thin and requires ample stiffening. Grids are rammed up in it, of the form shown in fig. 61, which figure represents the pattern grid upon its board. The pattern grid is thus stamped into the sand, and is prevented by the board from being rammed out of truth. There will be about four or five of these grids in the core, and they are connected by means of three or more ¼in. or ⅜in. rods, which pass through some of the holes cast in the grids, the prints for these and other holes being seen in fig. 61. There are several holes cast, but they are used for vent rods, the rods passing through them from end to end, and being rammed in the core, from which they are afterwards withdrawn, leaving the vents open.

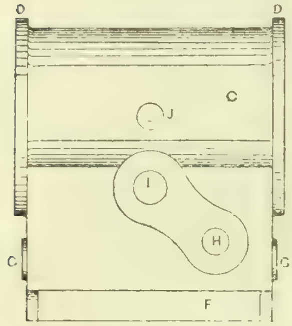


Fig. 53.—Plan.

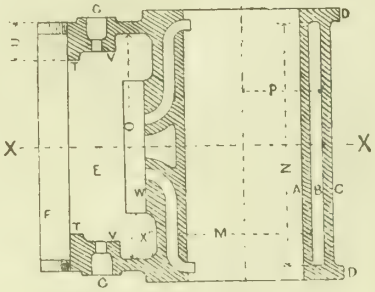


Fig 54. Longitudinal Section.

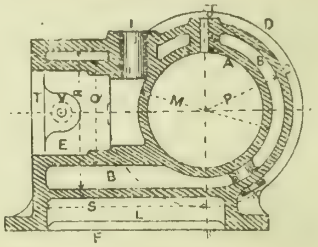


Fig. 55.—Section XX.

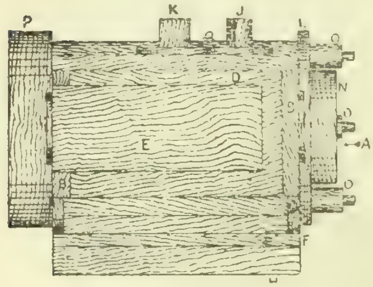


Fig. 56.—Elevation.

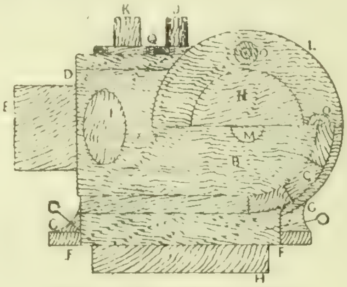


Fig. 57.—End View at A, fig. 56.

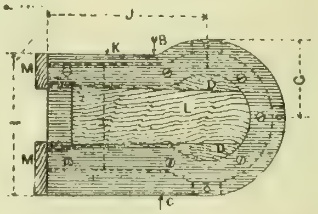


Fig. 58.—End View at A, fig. 59.

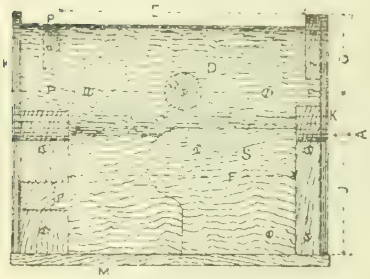


Fig. 59.—Plan at B, fig. 58.

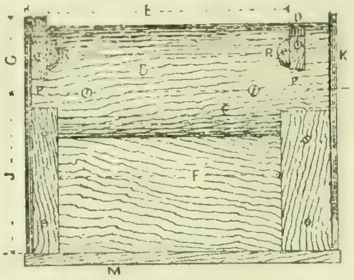


Fig. 60.—Plan at C, fig. 58.

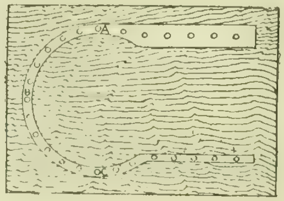


Fig. 61.

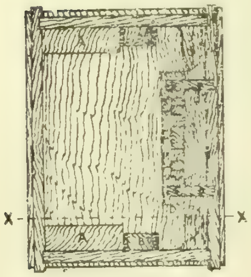


Fig. 62.—Plan.

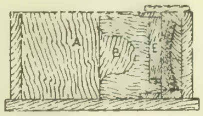


Fig. 62.—Section XX.

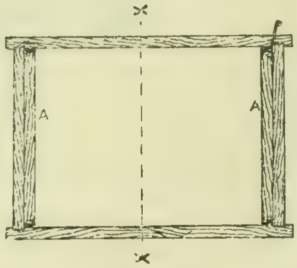


Fig. 65.

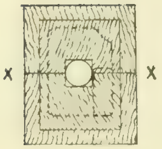


Fig. 63.—Plan.

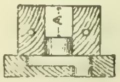


Fig. 63.—Section XX.

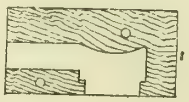


Fig. 64.

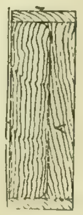


Fig. 65.—Section XX.

The use of the three bosses and prints O in figs. 56 and 57 is now apparent. The centres of these bosses and prints coincide with the three holes A, B, C, in the grid in fig. 61. The three rods that pass through those three holes project through the bottom end of the core and into the prints on the bosses O. The steam jacket core made in box, figs. 58 and 60, is then adjusted carefully in the mould to give equal thickness of metal, and when accurately set the sand is rammed tightly around the rods in the bosses O, and in this way the jacket core is held finally and firmly in place, with little or no aid from chaplets.

The open spaces P in figs. 59 and 60 are to permit of the free escape of the air from the core vents upwards and downwards. This is the only way in which the air can be carried off. As the distance E, in figs. 59 and 60, represents the distance N in fig. 54, it is clear that the spaces P P must cut right through the metal to the flange faces. These spaces are therefore filled up in the casting with blocks of iron before the flanges are faced, or the covers put on.

In figs. 59 and 60, Q is the metal of the lubricator boss; J, seen in fig. 55, and R, R that of the pet cock bosses K in the same figure; S is the metal around the steam and exhaust pipes H and I in figs. 53 and 55.

The core box for the steam chest is shown in fig. 62. It is framed together with grooved ends and bottom board. The blocks A A form the portion T in fig. 54, and the corresponding ends of the print E in fig. 56. As that print comes to the top of the pattern, the core is therefore stopped over to a distance equal to the distance U in fig. 54. In fig. 62 B B form the internal bosses V V in figs. 54 and 55; D forms the facings W, and E, E, E are prints for the steam and exhaust passages.

Fig. 63 is the steam inlet box, whose opening is shown at H, fig. 53, and the situation of whose entry into the top of the steam chest is indicated by the dotted lines at X in fig. 54. It will be seen on reference to figs. 56 and 57 that the print K for the round hole is made of square shape. The reason for this is that without some such precaution there would be nothing to prevent the core from becoming turned into a wrong position, so bringing the entry into the steam chest into a wrong position. In the core box, therefore, the depth A of the square part of the box corresponds exactly with the length of the print K in figs. 56 and 57, and thus, although the print is square, the cored hole is round.

One half the exhaust core box is shown in fig. 64; one end of the core entering into the print J in figs. 56 and 57, and the other end into the central print E in fig. 62. It is not necessary to show the steam passage core box, because it is precisely similar to others already illustrated.

The box in fig. 65 cores out the recess L in fig. 55, fitting into the print H in figs. 56 and 57. In this box the pieces A A form the ribs L seen in fig. 55, being included in the box, the print H extending over the ribs, fig. 56.

AN ARCTIC RAILWAY.

The Swedish *Post och Inrikes Tidningar* for the 20th July states that the surveying of the line of railway from Lulea to Ofoten is now complete. This will be by far the most northerly railway in the world. Lulea is a small town on the coast near the head of the Gulf of Bothnia, in Sweden, from which the line will start almost due north, soon crossing the Arctic Circle, and will proceed through the mining district of Gellivara; it will cross the river Kaitum, at Killingi, where the railway bridge is nearly completed, and then, turning to the north-east, will cross the mountain frontier into Norway, and reach the Atlantic Ocean at Elvegaard on the Ofoten Fjord. The line has been in rapid course of construction since last October, when 1,800 men were engaged to work on it. The extreme severity of the climate and the violent changes of temperature have been found very greatly to add to the labour of the work, and it is no longer expected that the line will be opened this year.

A large number of sanitary engineers and others went to the Wimbleton Sewage Farm on Wednesday, the 18th inst., to see the "Amines" process of disposing of sewage in operation. Under this method precipitation is obtained by the use of herring brine and lime, which, in combination, possess the two-fold advantage that they deodorise the sewage and precipitate the solids, and so rapidly is the effluent clarified that the settling tanks can be emptied every half hour. When deposited upon open ground the sludge is perfectly harmless, and exhibits no tendency to putrefy. A further important merit claimed for the process is its extreme cheapness, the cost of materials being between a halfpenny and three farthings per 1,000 gallons, and at this rate it is calculated that the disposal of the sewage of London could be successfully undertaken at no greater expense to the ratepayers than £2 10s. or £3 per million gallons.

PRESSURE AND VACUUM GAUGES.—II.

Bourdon vacuum gauges are constructed on the same principles as pressure gauges, but are necessarily of a more delicate and sensitive character, because of the low pressures to be registered, and the small changes which must be indicated. The tubes are therefore of lighter construction, and are much flatter in section than those illustrated in our last article. Greater care has also to be taken to reduce friction to the lowest possible amount, as the reduction of the moving power available for acting on the indicating pointer is considerable, and any undue friction would cause inaccurate reading. In such gauges, accordingly, it is desirable, when possible, to dispense with multiplying gear, and attach the link from the end of the tube direct to the lever on the pointer spindle, as is done in fig 3 (p. 614). In all gauges it is desirable to so proportion the Bourdon tube that small changes of pressure produce ample power to move the indicating gear and pointer; if this is not done, the pointer is liable to oscillate a great deal with a little vibration, such as occurs in many machines to which gauges are attached. Not only is this annoying, but another and more serious trouble arises. If some gauges be placed upon the testing apparatus shown in fig 5 (p. 614), and compared with a good standard instrument, they will be found to lay behind the pressure indicated by the standard as pressure is applied by the screw wheel, especially if the increase is slowly applied. Such gauges will often rise to the true pressure if tapped by the finger in the manner we are all familiar with in reading an ordinary mercurial barometer. On reckoning the pressure the same thing again occurs: the weak gauge follows the standard at a respectful distance, and its pointer indicates too low a pressure when the pressure is rising, and too high a pressure when pressure is falling.

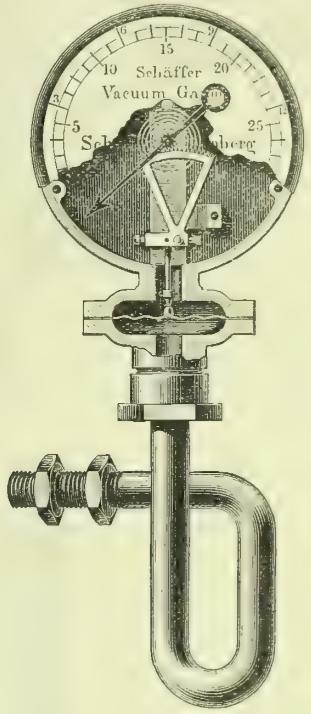


Fig. 6.

This effect may also be due to backlash in the multiplying gear. If the glass be taken off which covers the dial and pointer, it will be found that if the pointer be slowly moved from zero to, say 40lb., and then allowed to come slowly back again, the pointer will not return to the zero point. If pressure be put upon such a gauge, and the pointer moved by the finger either to one side or the other of the pressure indicated, it will be found that it will remain at various positions on either side of the true pressure. We have tested many gauges in this way, and often found a variation of from 10lb. to 20lb. per square inch. Such gauges, we need hardly point out, are utterly unreliable and misleading, and liable to occasion dangerous accidents. They are constructed only by careless makers, and can be readily detected by a little care. The pointer, if a properly made and proportioned instrument, should always come back to zero when it is deflected from it, however slowly it is moved; and, if pressure is upon the gauge, it should invariably settle at the true pressure when

PRESSURE AND VACUUM GAUGES—II.

(For description see page 663.)

Fig. 9.

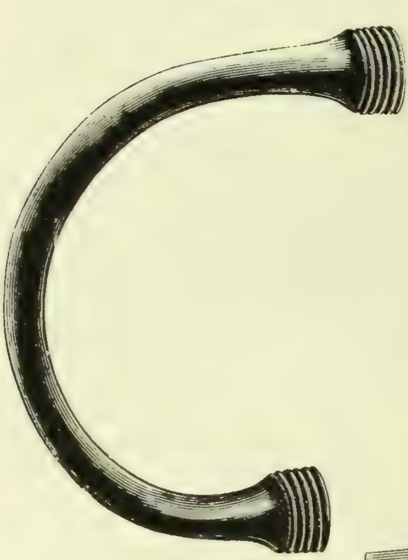
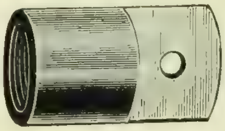


Fig. 10.



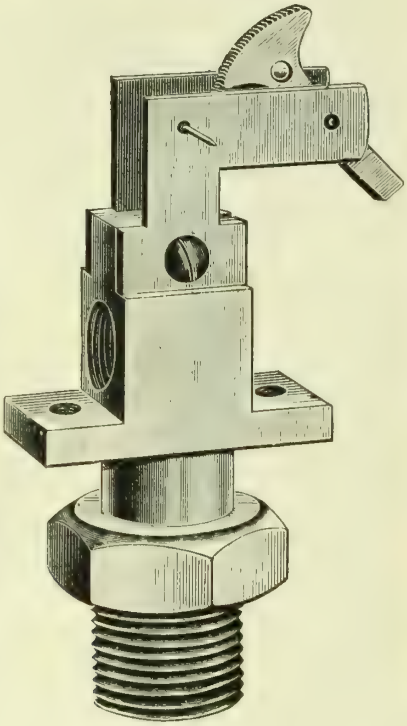


Fig. 11.

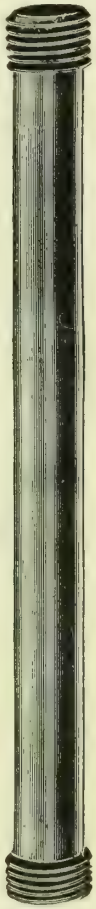


Fig. 8.

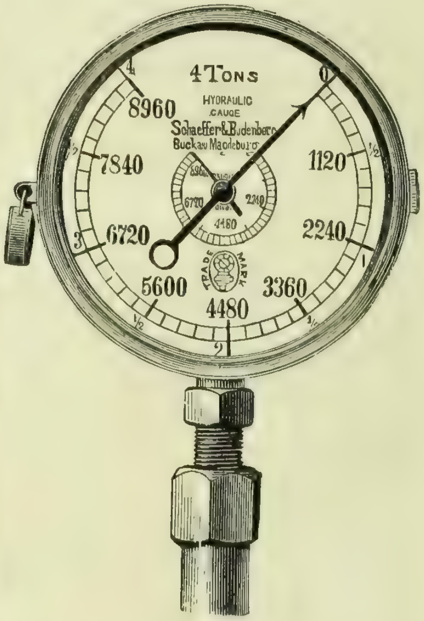


Fig. 13.

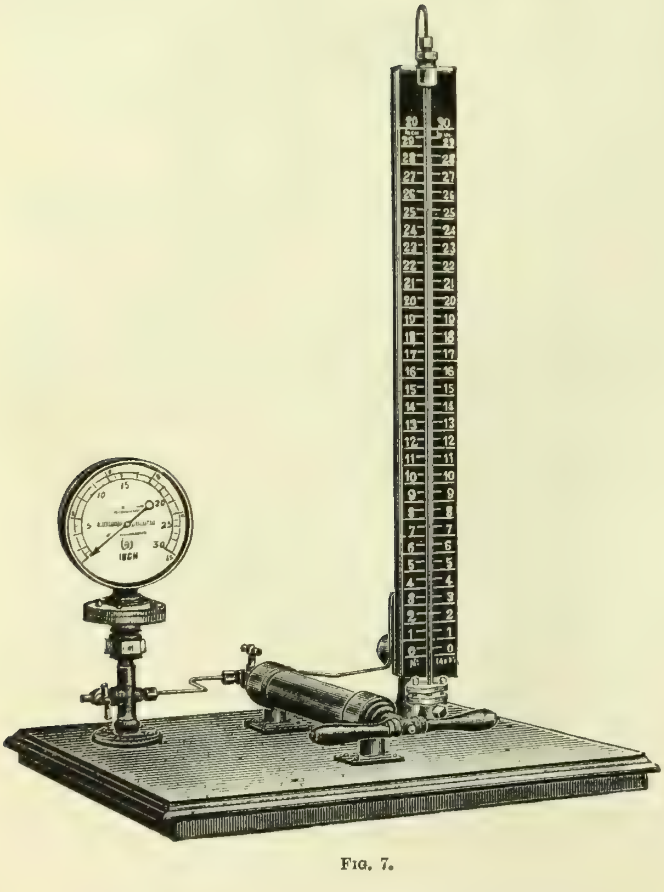


Fig. 7.

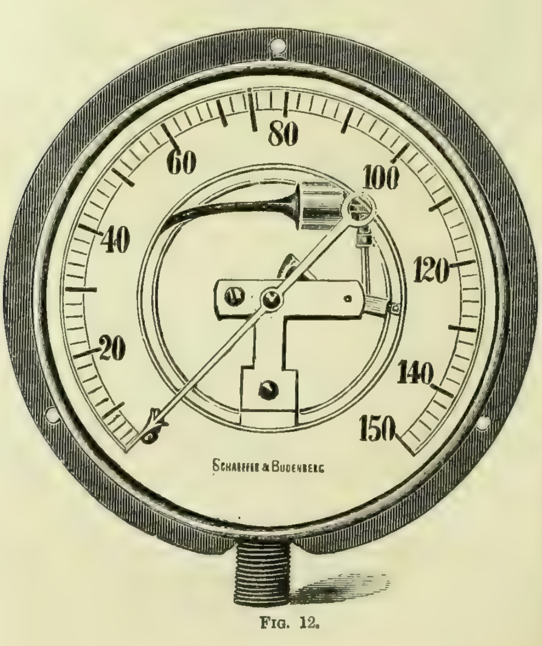


Fig. 12.

RADIAL DRILLING AND BORING MACHINE.

CONSTRUCTED BY MESSRS. GEORGE RICHARDS AND CO., LIMITED, ENGINEERS, BROADHEATH.

(For description see page 666.)

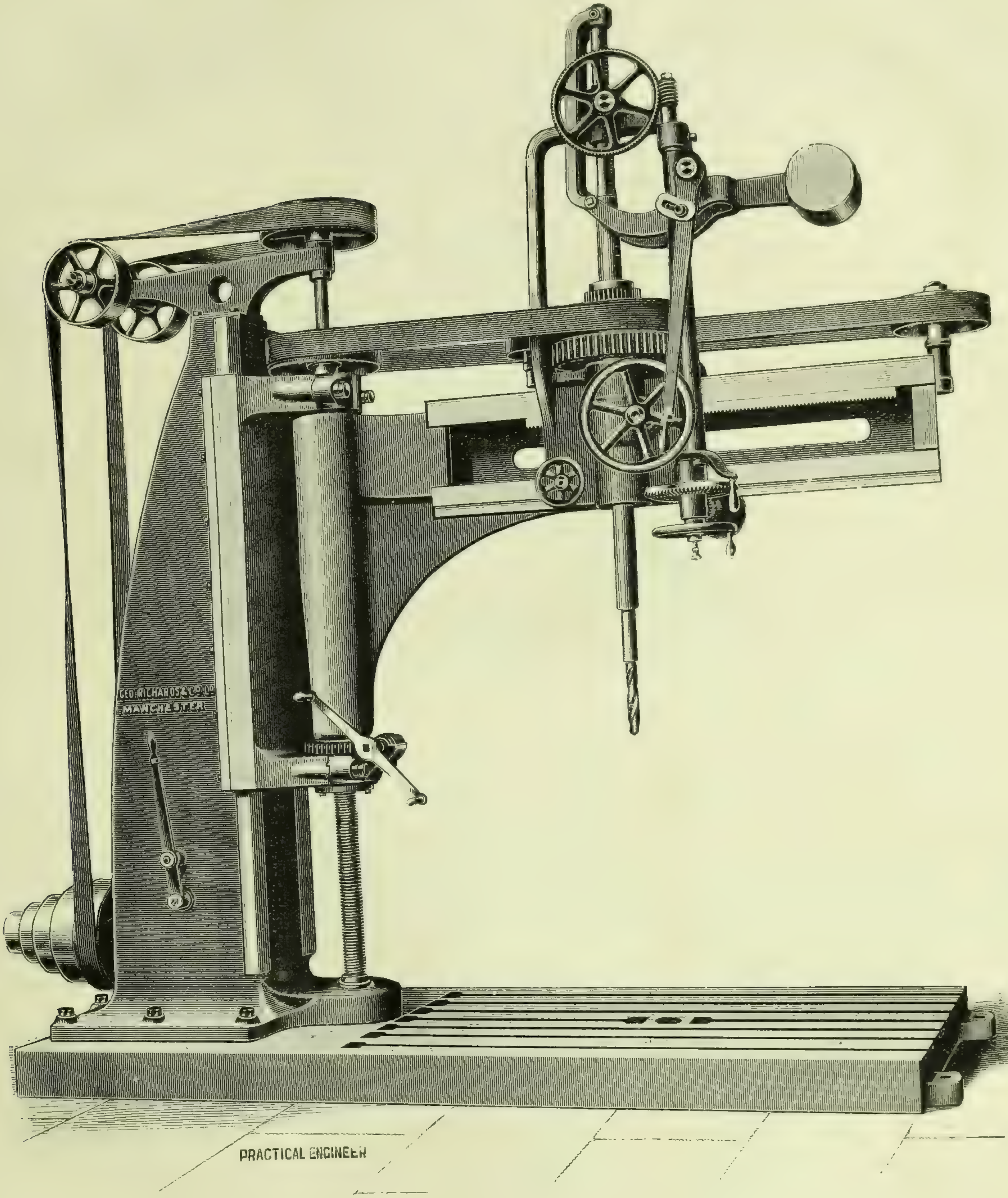


Fig. 1.

deflected and allowed to return slowly or quickly. A bad gauge will often settle at the true pressure if the pointer is suddenly relieved, as the oscillation causes the pointer to overcome the resistance of friction, and allows it to settle after a little vibration. The most trying test is the slow deflection of the pointer or index, and the slow return again. This imitates fairly the rise and fall of steam pressure in a boiler, and shows at once the errors likely to be made by the use of the indicator so tested.

In vacuum gauges, a double Bourdon tube is used, each tube acting on a pointer, both pointers indicating on the same dial. This arrangement is convenient, as in vacuum gauges there is greater difficulty in obtaining accurate indications, and the two serve as checks. This construction of vacuum gauge is also used by the Automatic Vacuum Brake Company, in order to indicate the pressures in the train pipe, and in the cylinders above the pistons. When the brake is not in action both pointers indicate the same vacuum; but when air is admitted into the train pipe to apply the brakes, as described by us in a recent issue, the vacuum then is destroyed to a greater or less extent, and the difference between the gauges indicates the pressure upon the pistons available for applying the brakes. The driver of the locomotive can see by the gauge the pressure upon his brake cylinder.

In addition to the Bourdon vacuum gauge described, Messrs. Schäffer and Budenberg manufacture a diaphragm vacuum gauge, known as the Schäffer gauge. We illustrate one example at fig. 6. It is also constructed as a pressure gauge up to 300lb. per square inch. The essential feature of its construction is the corrugated steel diaphragm, clearly seen in the illustration, which serves to receive the pressure of steam or other fluid. In pressure gauges this steel diaphragm is backed up by a spring thrusting against the steam pressure, and the movement of the diaphragm is communicated to the inclose or pointer by the lever toothed quadrant shown acting on a pinion attached to the pointer spindle. The helical spring surrounding the spindle, seen in the illustration, is intended to take up all backlash, by keeping the pinion teeth always bearing upon one side against the quadrant teeth.

This is a very necessary precaution when extreme accuracy is required. The steel diaphragm is protected from the corrosive action of the steam by a thin pliable sheet of platinum foil, shaped to fit the corrugations. This sheet is so thin that it in no way interferes with the free movement of the diaphragm, while it effectively protects it against corrosion. Such gauges are much used in portable and traction engines and locomotives—any position, in fact, where shocks or vibrations exist, and where, therefore, the Bourdon tube is not so conveniently applicable.

Vacuum gauges are tested by the arrangement shown in fig. 7, which consists of a stand carrying an air pump, which connects to a coupling for carrying the gauge, and also to the top of a tube immersed in mercury. When the air pump is set in action, it extracts the air from the gauge and above the mercury, and the scale gives the number of inches above the mercury level, and therefore the vacuum.

When high pressures require to be indicated, as for hydraulic presses, a steel Bourdon tube is now almost invariably used. Messrs. Schäffer and Budenberg were, we believe, the first to use this material for Bourdon tubes, and although the substitution of steel for brass does not seem a great departure, yet there were many difficulties to be overcome before success was attained. We illustrate, at figs. 8, 9, 10, and 11, the details of the steel tube gauge. In manufacturing these tubes, steel rods of the very best quality are first cut to the proper length required, then bored out and turned outside and the two ends screwed, as shown at fig. 8. They are then heated, and while hot are flattened, and then heated again and bent, as in fig. 9. After this they are carefully tempered. One end is screwed with the stem or principal part of the gauge (fig. 11), and upon the other end is screwed the cap. (fig. 10), to which is fixed the link for transmitting the movements of the steel tube to the pointer and dial of the gauge. The solid steel tube is exceedingly durable, and retains its elasticity perfectly, while it has the great advantage of avoiding all soldering which is necessary in the brass Bourdon tubes we have already described. When the semicircular tube (fig. 9) is adopted, it is most suitable for hydraulic pressures, and such gauges are made in different sizes to read up to 10 tons per square inch. The steel tube gauge, suitable for steam pressures, is shown at fig. 12, from which it will be observed that the tube is flatter in proportion to the circular cap, and is therefore more flexible than the hydraulic tube. In selecting the steel, and in boring and turning these tubes, the greatest accuracy has to be exercised. The process of flattening and bending when hot is also difficult, as an inexpert workman readily dints or heckles the tube in the process.

The interior and exterior are plated with tin in order to resist corrosion. Fig. 13 shows the exterior appearance of a hydraulic steel tube gauge. The hydraulic gauges cannot be tested by comparison with a mercury column, as the height required would be excessive; they are accordingly tested by pumping up the pressure on the gauge, and against a loaded ram, having a definite known area and known load. Special arrangements are made to reduce the friction to a minimum.

There is one type of gauge which we have not yet mentioned, on which a rubber diaphragm is thrust against the steam pressure by a spiral spring. It is somewhat largely used upon locomotives, but is, in our opinion, exceedingly unreliable on account of the great friction of the rubber and spring. We have tested gauges of this class, and found that the pressure is indicated in the roughest possible way, and seldom twice the same. In a gauge all the parts should have definite and unalterable relationships with each other, a condition which is quite impracticable with a material so variable and liable to change under pressure and heat as rubber. The mercury column cannot, of course, be conveniently used for testing gauges in position upon steam boilers, but this is easily done by using an engine indicator, and marking a couple of lines upon an indicator card, the atmospheric line and the line drawn when the pressure acts on the indicator piston, as it is not difficult to test the indicator spring. This method is quite sufficiently accurate for ordinary purposes.

In conclusion, we would thank Messrs. Schäffer and Budenberg for their courtesy in permitting us to examine their mode of working; and also Messrs. W. H. Bailey and Co., for section of a gauge as made by them.

RADIAL DRILLING AND BORING MACHINE.

Messrs. Geo. Richards and Co. Limited, of Broadheath, have devoted a great deal of attention to the design and construction of radial drilling and boring machines, as well as to their economical production in quantities, and they claim that their machines are of a very advanced type as compared with those of ordinary construction. We illustrate here (fig. 1) the 6ft. size. We have already briefly referred to the construction of the machine, but its features seem worthy of some further consideration. Its principal feature consists in the use of belts only to drive the spindle, in place of the usual bevel and other gearing. This peculiarity gives an exceedingly smooth and noiseless action, even when running at high speeds, as is necessary for drilling small holes. The arrangement of belting and pulleys, to allow the spindle bracket to be moved freely along the radial arm without interfering with the driving, is ingenious. A vertical shaft, forming the centre of the radial arm fulcrum, is driven from a cone pulley by belt, and the two quick pulleys at the top of the pillar, as shown in our illustration. A belt from another pulley on this shaft passes round a loose pillar, mounted at the end of the radial arm, and is led a half turn or more round the boring spindle pulley by a quick tension pulley. In this way the drill spindle bracket may be moved from one end of the radial arm to the other quite freely, and yet the spindle pulley is firmly driven by the belt. We show at fig. 2 the arrangement of the belt in a diagrammatic way: A is the driving pulley, B the loose pulley at the end of the radial arm, and C the drill spindle pulley, while D is the guide pulley fastened to the spindle bracket and moving with it. It will be readily seen that so long as the belt is stationary the only effect of moving the bracket is to cause the drill to revolve. This is a good feature, and gives a most efficient and easily made drive, free from all complications of toothed wheels and feathers travelling in slots, or equivalent contrivances often used in such machines.

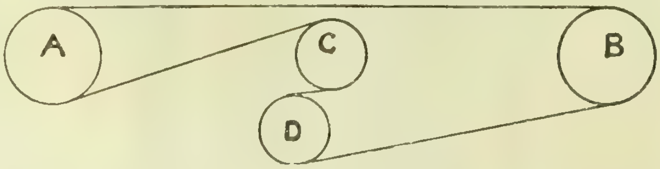


Fig. 2

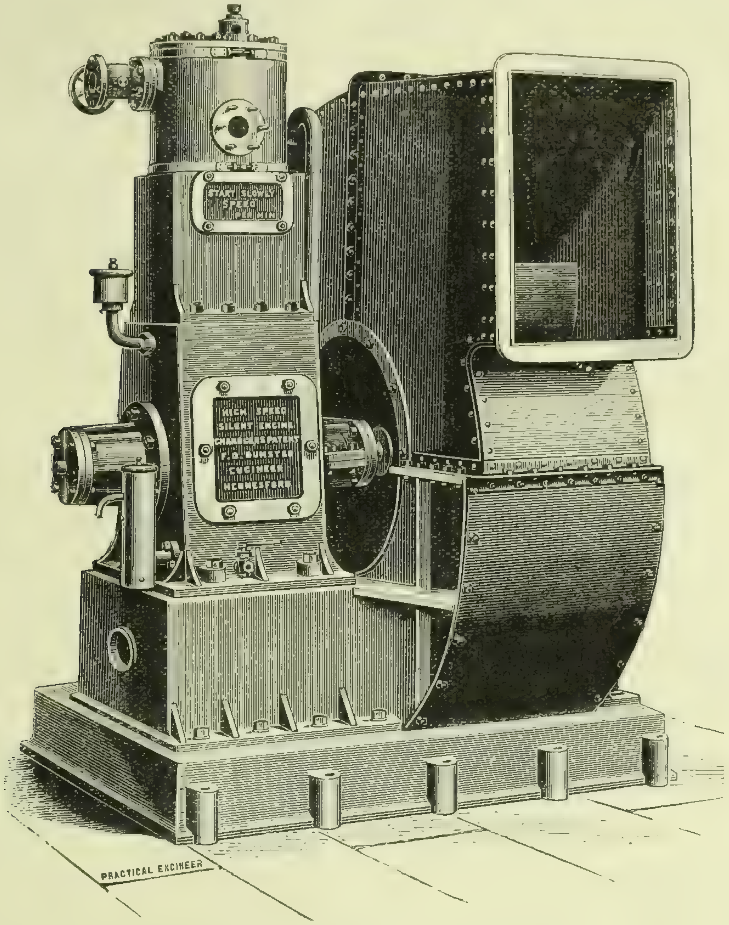
The back gear is direct on to the spindle, and the gears are cut. The spindle is counter-balanced, and has a rapid hand movement by lever, while the spindle bracket is moved rapidly by rack and pinion, and the rising and falling table is fixed at right angles to the base plate.

The leading dimensions are as follow: Spindle, 3in. diameter, with vertical feed of 18in.; base plate, 10ft. by 4ft.; distance from spindle to base plate spindle, in upper position, 6ft. Large sizes are also made with these novelties, but provision is made to raise and lower the radial arm by power.

Another High Tower.—A New York correspondent says that it is proposed to build upon the Eagle Rock at West Orange, New Jersey, which is 640ft. above the tidewater, an iron tower 400ft. high, with elevators to take passengers to the top, and to conduct to the rock, from Washington Street, Orange, a cable railway for passengers. In addition to this, the plateau will be improved and a hotel and wagon sheds will be erected. The view from Eagle Rock embraces the ocean, New York Bay, and Coney Island, besides the broad and beautiful valley in which the city of Newark, and the countries of Essex and Union lie, and an extended view of the Hackensack Valley.

CHANDLER'S PATENT HIGH-SPEED ENGINE AND FAN.

MANUFACTURED BY MR. BUMSTED, OF HEDNESFORD.



We illustrate above Chandler's combination of high-speed engine and fan driver direct, manufactured by Mr. Bumsted, of Hednesford.

The casing is built up of steel plates, and is exceedingly strong and rigid, the experience of the maker having led him to adopt extra precautions to remedy the defects of many high-speed engines, which are so troublesome to the marine engineer when under the strain and shock due to the rolling of the vessel. The blades are secured on to a turned steel disc, held between two substantial cast-iron flanges, keyed on to the engine crank shaft and to a steel spindle. The engine bearing and the outer bearing from the fan casing projects into the fan, so that a very rigid support is obtained for the weight of the fan. The blades are arranged in somewhat of an S shape, the inner portion of the blades having their edges presented in the direction of rotation to avoid offering any flat resisting surface to the entering air. Sliding doors are fitted to the air casings, and in the stokehole portable gauges are arranged to test the water pressure in the ashpits and in the air casings. The diameter of the fan is 60in.; speed, 450 revolutions per minute; volume of air passed by actual tests = 19,000 cubic feet per minute at 3in. water pressure, maintained in a large receiver with an outlet at one end = 2·8 square feet area; this pressure in the receiver being found sufficient to give an ample air pressure in the ashpits of a ship's boiler when the closed ashpit system of forced draught is adopted, while the closed stokehole takes a pressure not greater than 2in. The engine has one single-acting cylinder 8in. diameter by 6½in. stroke. A piston valve admits the steam, which is exhausted to under side of the piston. A steam cushion above the piston is necessary to ensure silent working. These combined engines and fans are now fitted to over one hundred modern vessels, including the Teutonic and the Majestic.

POPP'S COMPRESSED AIR SYSTEM.

(Concluded from page 653.)

In one Paris restaurant, for instance, which I visited, I found that the exhaust was carried through a brick flue into the beer cellar. In this flue the carafes were set to freeze, and large moulds of block ice were also being made for table use, while the air was still cold enough in passing away through the beer cellar to render the use of ice for cooling quite unnecessary even in the hottest weather. The nominal function of the engine in this case was the charging of batteries used in the electric lighting of the restaurant. The conjoint use of power and cold is common in Paris, the power being in this case generally applied in electric lighting. While in any large city such as Paris it is no doubt a great point that by a compressed air system the handiest possible cooling appliances can be brought everywhere within reach, in tropical climates this is something rather of necessity than of luxury. In such cases we might have the apparent paradox of a motor worked essentially for its exhaust; the work done would be a by-product, the cold air would be the principal thing. In such a case, if there were no useful work to be done, the motor could even be made (as has been suggested to me) to pump air back into the main, and thus virtually to about halve its air consumption. This possibility of "laying on" cold air in hot climates is, of course, a most important matter in connection with the future of compressed air. Most of the compressed air in Paris is used for driving motors, but the work done by these is of the most varied kind. A list which I have gives the locality, use, and power of 225 installations, nearly all motors working at from ½-horse power to 50-horse power, all driven from St. Fargeau, and the great majority of them more than two miles away from it. In a number of cases (as at the Eden Theatre, Théâtre des Variétés, office of the *Petit Journal*, &c.), the motor drives dynamo machines for electric lighting. In the offices of the *Figaro* and the *Petit Journal* large motors are also used for printing, and there are many small printing establishments also worked by compressed air.

Among the smaller industrial purposes for which the air motors are used in Paris, I find the driving of lathes for metal and wood, of circular saws, shearing machines, drills, polishing machines, and many others. They are used also in the workshops of carpenters, joiners, and cabinet makers, of smiths, of umbrella makers, of collar makers, of bookbinders, and naturally in a great many places where sewing machines are used, both by dressmakers, tailors, and shoemakers, and from the smallest to the largest scale. They find application also in all sorts of industrial work, with confectioners, coffee roasters, colour grinders, billiard ball makers, in many departments of textile industry, and other matters too numerous to mention. One particular instance of variety of application which interested me much I may mention. At the "Montagnes Russes" I found a large horizontal engine, placed in a recess, driving a dynamo and cells for the electric lighting of the whole building; a small vertical engine in another place worked the rotary pump which actuated the "cascade;" two or three large air-driven fans in wooden shafts served for ventilation; and, lastly, a simple connection on a flexible pipe threw the air pressure into the beer barrels as they were brought in, and transferred their contents to a height from which they could afterwards descend by gravity to a place where they were required. As to the rate at which the compressed air is sold, I believe that in most of the larger installations the work is done by contract (at so much per lamp-hour in the case of the electric lighting), but in the smaller one the air is charged for by meter. The rate of charge is 1·5c. per cubic meter for air used in motors, and 2c. per cubic meter for air used directly. Air used for raising fluids is charged according to quantity raised. The former rate is equivalent to 4·25d. per 1,000 cubic feet (the volume in all cases being measured at atmospheric pressure). In addition to this a fixed charge of from 100f. to 250f. is made for pipes and connexions, and a small rent for the motor if it be not bought outright or by 24 monthly instalments. In conclusion, I have to express my thanks to M. Victor Popp and to the directors and officials of the Paris Compressed Air Company for not only giving me permission to make the experiment of which I have laid some results before your, but also for taking much trouble to afford me every facility for making a thorough investigation of the matter upon the lines which I had myself laid down as those along which I proposed to work. I think it is not too much to say that, as the result of this, I have had the good fortune to be able to make a more detailed and complete evaluation of all the efficiencies which together make (or mar) the efficiency of a complete transmission system than has ever been made before. I shall be very glad if my experiments prove in any way useful to those who in future may have to do with the carrying out of power transmission by compressed air in this country or elsewhere.

BRITISH ASSOCIATION: PRESIDENTIAL ADDRESS.

(Concluded from page 651.)

Effects of External Forces.

Everyone will admit that an external force cannot be applied to a system in motion without affecting that motion; consequently matter, in whatever state, cannot be touched without changes taking place which will be more or less permanent. The application of heat will cause a change of volume, and, at last, a change of condition; the application of external stresses will also produce a change of volume; and it is natural to infer that there must be some relation between the two, and accordingly Professor Carnelley has drawn attention to the fact that the most tenacious metals have high melting points, though here again there is a great want of exactness, partly on account of the difficulty of measuring high temperatures, and partly by reason of the scarcity of pure materials. Again, long-continued stresses, or stresses frequently applied, may be expected to produce permanent changes of form, and so we arrive at what is termed the fatigue of substances. Stretched beyond their elastic limits, which limits I do not suppose to exist except when stresses are applied quickly, substances are permanently deformed, and the same effects follow the long application of heat. The constant recurrence of stresses, even those within the elastic limit, causes changes in the arrangement of the particles of substances, which slowly alter the properties of the latter, and in this way pieces of machinery, which theoretically were abundantly strong for the work they had to perform, have failed after a more or less extended period of use. The effect is intensified if the stresses are applied suddenly, if they reach nearly to the elastic limit, and if they are imposed in two or more directions at once, for then the molecular disturbance becomes very intense, the internal equilibrium is upset, and a tendency to rupture follows. Such cases occur in artillery, in armour plates, in the parts of machinery subject to impact; and, as might be expected, the destructive effects do not always appear at once, but often after long periods of time. When considerable masses of metal have to be manipulated by forging, or by pressure in a heated condition, the subsequent cooling of the mass imposes restrictions on the free movement of some, if not all, of the particles; internal stresses are developed which slowly assert themselves, and often cause unexpected failures. In the manufacture of dies for coining purposes, of chilled rollers, or shot and shell hardened in an unequal manner, spontaneous fractures take place without any apparent cause, and often after long delay, the reason being that the constrained molecular motion of the inner particles gradually extends the motion of the outer ones until a solution of continuity is caused. Similar stresses occur in such masses as crank shafts, screw shafts, gun hoops, &c. The late General Kalakoutsky some seventeen years ago commenced a systematic investigation into the internal stresses in the tubes and hoops of guns and in armour-piercing shells. The method he pursued was to cut discs or rings about half an inch thick off the hoops and shells, to divide the metal of each disc into from four to six rings, to fix by means of silver plugs, on which very finely marked cross-lines were drawn, from four to eight points on the surface of each ring, and then to measure, with extreme exactness, the changes in diameter produced in every ring by the cutting of the rings. Knowing by direct tests the mechanical properties of his material, he was able, from the changes in the diameters, to calculate what the tangential stresses in every part of each disc were, and to draw inferences as to their fitness for the work they were intended to perform. The same method of investigation has been pursued by Captain Noble, of the Elswick Works, and by Lieutenant Crozier, of the United States Artillery, with the practical result that probably much more attention will be paid in future to the principles on which the annealing and hardening of steel is carried on. A gun hoop or tube, to be in the best condition to resist a bursting stress, should have its inner circle in a state of compression and its outer in a state of tension, and the hoops should be shrunk on to the tubes or on to each other with but very little pressure. General Kalakoutsky proposed, in order to set up beneficial internal stresses, that tubes which were being annealed should be cooled from the inside by a jet of steam, of air, or water, or of oil; and he advocated the practice of testing the effects of each new method of manufacture or of treatment by the careful measurements of slices of the finished, material instead of working at random, as is still very much the practice. It is evident, also, that a sample of steel cut out of a gun hoop or crank shaft, and tested, can afford no indication of the available tenacity of the same sample *in situ*. When released from the constraint of its surroundings, the particles must, of necessity, change their condition, for the distributing forces have been removed; and the probability is that if the steel be good, the test will prove satisfactory, especially if some time be allowed to elapse between cutting out the sample and testing it, and a false security will be engendered such as has often led to disastrous results.

Influence of Time on Steel.

The influence of time on steel seems to be well established; the highest qualities of tool steel are kept in stock for a considerable period; and it seems certain that bayonets, swords, and guns are liable to changes which may account for some of the unsatisfactory results which have manifested themselves at tests repeated after a considerable interval of time. As all these things have been hardened and tempered, there must necessarily have been considerable restraint put upon the freedom of motion of the particles. This constraint has gradually been overcome, but at the expense of the particular quality of the steel which it was originally intended to secure.

Petroleum.

One of the most remarkable features of the last thirty years is the introduction of petroleum, and the wonderful development to which the trade in it has attained. Under the generic name of petroleum are embraced a variety of combinations of carbon and hydrogen, each of which is distinguished by some special property. At ordinary temperatures and pressures some are gaseous, some are liquid, and some solid, and most are capable of being modified by suitable treatment under various temperatures and pressures. The employment of petroleum in the arts is still extending rapidly. Used originally for illuminating purposes, it is now employed as fuel for heating furnaces and steam boilers; as a working agent in heat engines, valuable medicinal properties have been discovered; and as a lubricant it stands unrivalled. As an illuminant, even in this country, it is, to a large extent, superseding every other in private houses, and even in public lamps, because it gives a cheaper and more brilliant light than ordinary gas, and leaves the consumer free from the tyranny of great and privileged companies. As fuel it is especially convenient, cleanly, and economical. Stored in tanks of suitable construction, it is sprayed into the furnace without labour and without creating dust and dirt; and it is especially convenient in locomotive and marine work on account of the rapidity, ease, and cleanliness with which it can be run into the tender or into the oil bunkers of a ship As a working agent in heat engines it is employed in two ways. First as a vapour, generated from the liquid petroleum contained in a boiler, very much in the same way as vapour of water is used in an engine with surface condenser, the fuel for producing the vapour being also petroleum. Very signal success has been obtained by Mr. Yarrow and others in this mode of using mineral oil, especially for marine purposes and for engines of small power; there seems to be no doubt that by using a highly volatile spirit in the boiler a given amount of fuel will produce double the power obtainable by other means, and at the same time the machinery will be lighter and will occupy less space than if steam were the agent used. The other method is to inject a very fine spray of hot oil, associated with the proper quantity of air, into the cylinder of an ordinary gas engine, and ignite it there by means of an electric spark or other suitable means. Attempts to use oil in this way date back many years, but it was not till 1888 that Messrs. Priestman Brothers exhibited at the Nottingham show of the Royal Agricultural Society an engine which worked successfully with oil, the flashing point of which was higher than 75 deg. Fah., and was therefore within the category of safe oils. The engine exhibited was very like an ordinary Otto gas engine, and worked in exactly the same cycle. A pump at the side of the engine forced air into a small receiver at a few pounds pressure to the square inch. The compressed air, acting by means of a small injector, carried with it the oil in the form of fine spray, which issued into a jacketed chamber heated by the exhaust in which the oil was vaporised. The mingled air and oil was thus raised to a temperature of about 300 deg., and was then drawn, with more air, into the cylinder, where, after being compressed by the return stroke of the piston, it was exploded by an electric spark, and at the end of the cycle the products of combustion were discharged into the air after encircling the spray chamber and parting with most of their heat to the injected oil. The results of careful experiments made by Sir William Thomson and myself on different occasions were, that 1·73lb. of petroleum were consumed per brake horse power per hour: but the combustion was by no means perfect, for a sheet of paper held over the exhaust pipe was soon thickly spattered with spots of oil. It is hardly necessary to state that the use of petroleum for furnace purposes of all kinds is increasing very rapidly, and the demand has naturally re-acted on the supply in promoting improved means of transport; and Newcastle again has led the van in this matter, for Sir William Armstrong, Mitchell, and Co. have sent out a fleet of steamers constructed to carry the oil in bulk with perfect safety, both as regards the stowage of a cargo so eminently shifting, and with respect to risk from fire and from explosion.

Origin and Prospects of the Supply.

The enormous consumption of petroleum and of natural gases frequently raises the question as to the probability of the proximate exhaustion of the supply; and, without doubt, many fear to adopt the use of oil, from a feeling that if such use once becomes general the demand will exceed the production, the price will rise indefinitely, and old methods of illumination and old forms of fuel will have to be reverted to. From this point of view it is most interesting to inquire what are the probabilities of a continuous supply; and such an investigation leads at once to the question, "What is the origin of petroleum?" In the year 1877 Professor Mendeleeff undertook to answer this question; and as his theory appears to be very little known, and has never been fully set forth in the English language, I trust you will forgive me for laying a matter so interesting before you. Dr. Mendeleeff commences his essay by the statement that some persons assume, without any special reason — excepting, perhaps, its chemical composition—that naphtha, like coal, has a vegetable origin. He combats this hypothesis, and points out, in the first place, that naphtha must have been formed in the depths of the earth. It could not have been produced on the surface, because it would have evaporated; nor over a sea bottom, because it would have floated up and been dissipated by the same means. In the next place, he shows that naphtha must have been formed beneath the very site on which it is found—that it cannot have come from a distance, like so many other geological deposits, and for the reasons given above, namely, that it could not be water-borne, and could not have flowed along the surface, while in the superficial sands in which it is generally found no one has ever discovered the presence of organised matter in sufficiently large masses to have served as a source for the enormous quantity of oil and gas yielded in some districts; and hence it is most probable that it has risen from much greater depths under the influence of its own gaseous pressure, or floated up upon the surface of water, with which it is so frequently associated. One of the first indices to the solution of the question lies in the situation of the oil-bearing regions. They always occur in the neighbourhood of, and run parallel to mountain ranges—as, for example, in Pennsylvania, along the Alleghanies; in Russia, along the Caucasus. The crests of the ranges, formed originally of horizontal strata which had been forced up by internal pressure, must have been cracked and dislocated, the fissures widening outwards, while similar cracks must have been formed at the bases of the ranges; but the fissures would widen downwards, and would form channels and cavities into which naphtha, formed in the depths to which the fissures descended, would rise and manifest itself, especially in localities where the surface has been sufficiently lowered by denudation or otherwise. It is in the lowest depths of these fissures that we must seek the laboratories in which the soil is formed; and once produced, it must inevitably rise to the surface, whether forced up by its own pent-up gases or vapours, or floated up by associated water. In some instances the soil, penetrating or soaking through the surface layers, loses its more volatile constituents by evaporation, and, in consequence, deposits of pitch, of carboniferous shales, and asphalte take place; in other cases, the oil, impregnating sands at a lower level, is often found under great pressure, and associated with forms of itself in a permanently gaseous state. It is needless to remark that Dr. Mendeleeff's views are not shared by every competent authority; nevertheless, the remarkable permanence of oil wells, the apparently inexhaustible evolution of hydro-carbon gases in certain regions, almost forces one to believe that the hydro-carbon products must be forming as fast as they are consumed, that there is little danger of the demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greater depths to be reached; and it should be remembered that, apart from the cost of sinking a deep well, there is no extra expense in working at great depths, because the oil generally rises to the surface or near it. The extraordinary pressures, amounting to 300lb. per square inch, which have been measured in some wells, seem to me to yield conclusive evidence of the impermeability of the strata from under which the oil has been forced up, and tends to confirm the view that it must have been formed in regions far below any which could have contained organic remains.

Engineering Researches.

After alluding to the want of a standard horse power, the President said: I have expressed an opinion that the numerous engineering societies which exist at this day have it in their power to promote the advancement of mechanical science in a notable manner by appointing research committees, or by aiding individual investigations from their abundant means. The North-East Coast Institution of Engineers and Shipbuilders have done good service in their endeavours to establish a practical measure of the power of marine engines, while the Institution of Mechanical Engineers has, for the last ten years, been steadily promoting researches of an eminently practical nature Their expenditure has reached the handsome sum of £1,700, and their proceedings have been enriched with reports on the "Hardening, tempering, and annealing of steel," on the "Form of riveted joints," on "Friction at high velocities," on "Marine engine trials," and on the "Value of the steam jacket." The names of those who are acting on these committees are a guarantee that the investigations conducted by them will rank among the classical works of the profession, and will abundantly justify the liberal expenditure which has been incurred.

The Forth Bridge.

It is impossible to conclude the address which I have had the honour of delivering without an allusion to the most important structure which engineering skill and enterprise has ever attempted. The Forth Bridge is rapidly approaching completion, and on Saturday, September 14, Mr. Baker is to deliver a lecture, in which he will, no doubt, tell us when the great work is likely to be completed. I think that the members of this section belong sufficiently to the working classes to have a claim to admission to the lecture, and to hear from the lips of the creator of the bridge the story of its inception, of its progress, and his hopes as to its completion.

Sir William Thomson moved a vote of thanks to the president for his address, to which he said he had listened with thrilling interest. The necessities of the modern engineer led him to the very deepest questions of physics, and to those whose time and attention had been more devoted to the physical side of studies than to the practical it must be very pleasant indeed to find that the engineers were brought so thoroughly into harmony with the work of the physical engineer. The president had dwelt upon one of the most important subjects in physical and engineering practice; that was the molecular construction of matter. The researches into force in modern artillery would contribute very largely indeed to the advancement of science. Might they not hope that the time would come when explosives in guns would be turned away from their present purpose, and that great guns would be used to demonstrate the effect of enormous pressures on the properties of matter in a purely scientific way? Concerning the durability of the petroleum supply, he had heard it said that the petroleum was understood to be produced low down in the earth, and not taken from organic matter. But he could not hold that view with any certainty after he had heard Mendeleeff's theory so beautifully put before them by Mr. Anderson. They were very much indebted to their president for his address, especially upon a subject of such tremendous importance as the origin and possible durability of the petroleum supply.

Sir George B. Bruce (London) seconded the motion, which was agreed to.

The President, in replying, said it had been stated in the newspapers that the petroleum supply of the Caucasus was becoming exhausted. If this were true, it would go far to upset his theory. But, by a strange coincidence, he had that morning received a letter from Professor Mendeleeff, in which he desired him to say that it was absolutely untrue. There was not the slightest falling off in the petroleum supply, and the rumour which had got into the papers was a mere Stock Exchange scheme to make certain financial operations.

The scheme to construct a railway from Saxby, in Leicestershire, to Skegness, in Lincolnshire, connecting the Midland counties with the East Coast, which was abandoned last year owing to a difficulty in crossing Boston Docks, is again receiving considerable attention in the district through which the line is intended to pass. The promotors are forming a syndicate to provide the necessary funds to carry the proposed bill to the next session of Parliament. The project is influentially supported.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

PULLEY BLOCK LOADS.

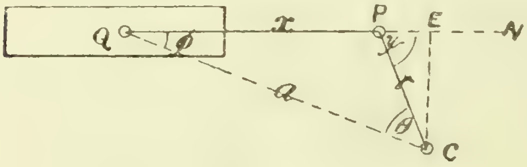
To the Editor of "The Practical Engineer."

SIR,—I shall be glad to have the opinion of your readers as to whether they think the test load of a pulley block should be greater than that which the makers consider safe for an actual weight to be lifted. This is a very serious question, for, having some pulley blocks marked "Tested to five tons," I am told by some other engineers that the makers say I must not lift a load equal to that indicated upon the block. Surely, "tested to five tons" should mean that I must not put more than that load upon the block.—Yours, &c., ENGINEER.

QUERIES AND REPLIES.

82. OSCILLATING ENGINE.—If CP be the crank and PQ the piston rod of an oscillating engine, find the velocity ratio of P to Q, and set out result in diagram. Find also the angular velocity ratio of CP and PQ at any point of stroke.—C. P. W.

Answer.—Let C represent centre of crank shaft, and Q centre of cylinder trunnion, while P represents centre of crank pin. The motion of the crank shaft being supposed uniform.



Let r = radius of crank pin orbit.
a = distance between trunnion centre Q, and crank shaft centre C.
x = distance between trunnion centre Q, and crank pin centre P.
θ = angle between crank and centre line of engine QC.
ϕ = angle between piston rod and centre line of engine QC.

Then by trigonometry—

$$x^2 = a^2 + r^2 - 2\,ar\cos\theta.$$

Differentiating which we have

$$2\,xdx = 2\,ar\sin\theta\,d\,\theta.$$

Therefore

$$dx = \frac{ar\sin\theta\,d\,\theta}{x}.$$

Whence

$$\frac{dx}{rd\,\theta} = \frac{a\sin\theta}{x} = \frac{\text{velocity of piston}}{\text{velocity of crank pin}}.$$

Or substituting for x its value—

$$\sqrt{a^2 + r^2 - 2\,ar\cos\theta}$$

we have

$$\frac{dx}{rd\,\theta} = \frac{a\sin\theta}{\sqrt{a^2 + r^2 - 2\,ar\cos\theta}} = \frac{\text{velocity of piston}}{\text{velocity of crank pin}}.$$

To find the angular velocity ratio of CP and PQ at any point of stroke. Let the angle NPC be represented by ψ; then

$$\psi = \theta + \theta\,;$$

and

$$a : \sin\psi = r : \sin\phi\,;$$

whence

$$a\sin\phi = r\sin\psi\,;$$

and differentiating

$$a\cos\phi\cdot d\phi = r\cos\psi\,d\,\psi\,;$$

whence

$$\frac{r\cos\psi}{a\cos\phi} = \frac{d\,\phi}{d\,\psi}\,;$$

and because

$$d\,\psi = d\,\theta + d\,\phi,$$

therefore

$$\frac{r\cos(\theta + \phi)}{a\cos\phi} = \frac{d\,\phi}{d\,\theta + d\,\phi}$$

$$r\cos(\theta + \phi)\,d\,\theta + r\cos(\theta + \phi)\,d\,\phi = a\cos\phi\,d\,\phi,$$

$$r\cos(\theta + \phi)\,d\,\theta = a\cos\phi\,d\,\phi - r\cos(\theta + \phi)\,d\,\phi\,;$$

and

$$\frac{r\cos(\theta + \phi)}{a\cos\phi - r\cos(\theta + \phi)} = \frac{d\,\phi}{d\,\theta} = \frac{\text{angular velocity of PQ}}{\text{angular velocity of CP}}.$$

If a perpendicular from C be let fall on QN, as at E, then

$$\frac{\text{PE}}{x} = \frac{\text{angular velocity of PQ}}{\text{angular velocity of CP}}.$$

W. A.

91. ALUMINIUM AND STEEL CASTINGS.—I see from an American contemporary that steel castings are now produced which can be worked like the best wrought iron, and yet tempered by the use of a flux containing aluminium. Can any reader inform me how steel castings can be produced, capable of being easily worked and tempered, or case-hardened, and possessing great breaking and elastic strength? Is there any work on this subject?—C. H. B.

Answer.—I cannot say how steel castings with alloys of aluminium are produced. Most steel founders have their own special way of mixing and casting. But aluminium is now playing an important part in the manufacture of all kinds of steel, cast or otherwise. I understand that much of the aluminium so employed is supplied by the Cowles Syndicate Company, Milton, near Stoke-on-Trent, from whom "C. H. B." could probably obtain the information he requires.—GLEANER.

94. PORTABLE ELECTRIC LAMP.—Is there a portable electric reading lamp in the market, containing its own battery? Any information, with cost and where obtainable, will be appreciated.—STEAM.

Answer.—The majority of portable electric lamps have storage batteries, which, of course, must be recharged from some source of electricity when run out. A lamp large enough for ordinary use, containing a primary battery such as "Steam" requires, would be far too bulky. The Telegraph Company, Silvertown, London, E., have recently introduced a primary battery, which is said to work very steadily, and suitable for portable lamps. The sphere of action of the lamp will be limited by the length of wire allowed for the purpose. They will give full particulars and prices on application.—ORION.

98. WORKING OUT VALVE GEAR.—Would some of your readers be good enough to inform, me as early as possible, the best book I can get explaining clearly how to draw and work out the following valve gears—Joy's, Hackworth's, Morton's, &c.?—VALVE GEAR.

Answer.—I am not aware of any book giving the information you require respecting Joy's and other valve gears, "Hutton's Engineer's Handbook," "Holmes on the Steam Engine," both give a notice of Joy's gear in the same manner that most details of the steam engine are dealt with in books. Joy's gear was described in the last volume of *The Practical Engineer*—F.

100. PULSOMETER.—What is the reason for giving the upper portions of the condensing chambers their peculiar tapered form?—SHINY BOOTS.

Answer.—The tapered form of pulsometer chambers ensures the entering steam acting on a small area only, thus preventing agitation of the water, which would produce condensation, this being undesirable until the chamber is emptied.—ORION.

101. DIFFERENTIAL PULLEY-BLOCK.—In what way are the parts of these blocks arranged so as to get excessive friction, which must equal half the load, except in some cases where special retaining mechanism is applied? I should be obliged by sketch and description of the last-named arrangement. SHINY BOOTS.

102. PADDLE-WHEELS.—How is the curve of the float obtained, as in the wheels of recent cross-channel boats? And is it a fact, as stated in text books, that a wheel with fixed floats must necessarily be inefficient because of the slip or difference between speeds of vessel and wheel. It would, at first sight, appear that even with excessive slip, the floats would always be in the most efficient position while wholly or in part immersed.—SHINY BOOTS.

103. POWER OF BEAM ENGINE.—I am in charge of a beam engine. Its cylinder is 12¼in. bore, length of stroke 3ft., making 60 revolutions a minute, the air pump 8in. bore, and worked at 50lb. pressure, and I should feel obliged if any of the readers of *The Practical Engineer* could inform me to what amount of I.H.P. it would drive.—SIMPLE.

104. Will some experienced correspondent oblige querist with a rough dimensioned sketch of the most modern double-brass furnace suitable for, say two 46lb. pots?—MECHANICUS.

105. What are the most approved dimensions of a cupola capable of melting four tons per hour, blast pressure; size of wind belt, number of tuyeres and dimensions of same, also whether round or square, thickness of furnace lining, and approximate consumption of coke per ton of iron?—RESURGAM.

106. ANTI-CALCAIRE.—Will you kindly inform me as to what this is composed of, and what action it has on hard water? Would it be suitable for use with feed water?—MARINE.

107. HARDENING MACHINE PARTS.—I have seen machine parts after being hardened which have a very nice appearance, similar to what may be seen on gun barrels. I should be glad to hear of a way of doing this. Potash or case hardening does not give the result desired.—R.

PATENTS AND INVENTORS' QUERIES.

7. Can I obtain protection for an invention which I have had in use, but which I have never sold?—A. H., London.

Answer.—You can patent your invention, although it has been used by yourself only, providing that the use has simply been for experimental purposes. If you have derived a profit by publicly using your invention, you cannot now patent it.

8. If I do not patent an invention, but secretly work it, can I prevent any other person from subsequently taking a patent out for the same thing? W. B, Leicester.

Answer.—By patenting your invention you virtually undertake to instruct the public, and for that consideration the Crown grants unto you certain "Letters," which give to you alone the exclusive benefit of the invention disclosed for a certain period of years. As you do not disclose, and do not instruct the public, your invention may some day be introduced by an inventor who will do so. He will then prevent you from further using the invention.

9. I want to patent an article having two separate parts, each valuable, but having found out that one part has been patented, can I patent the remaining part without danger?—VALVE GEAR, Cheltenham.

Answer.—You can certainly patent any new application of any particular part, combined with ordinary and usual appliances, but you cannot refer to another patent unless it is in your own name.

10. If I take out a patent for two combinations, and one is old, can any person oppose the patent as a whole?—VALVE GEAR.

Answer.—Yes, the patent could be opposed. But you could apply for leave to amend the specification before the action came on.

TO CORRESPONDENTS.

OLD READER.—If you will write to the Secretary of the Board of Trade, Whitehall, London, he will supply you with the information you require respecting weights and measures, and all particulars you may need for the service.

MISCELLANEA.

Mr. Watson Smith, lecturer in chemical technology at the Owens College, Manchester, a gentleman well known to many of our readers, has been appointed to succeed Professor Chas. Graham in the chair of applied chemistry in University College, London.

Mill Accident.—The large weigh beam in the engine-house at Lee Mill, Bacup, belonging to Mr. Henry Maden, suddenly snapped asunder on Wednesday, Sept. 18th, and in a few seconds the massive beam engine, two galleries, and the large window were a complete wreck. The damage is estimated at over £1,000.

The Mersey Docks and Harbour Board has adopted a recommendation to construct six installations for the storage of petroleum in bulk. The cost of the works will be £30,000 and the storage capacity 19,000 tons. It was stated that the petroleum stored in these receptacles would be completely isolated, and no danger need be apprehended from it.

Steelworkers' Wages.—The steelworkers at the West Cumberland Iron and Steel Works are agitating for an increase of wages, the mill men asking for a 15 per cent advance, and the men in the engineering department 10 per cent, with time and a half for Sunday work. The steelworkers at the Mossbay Iron and Steel Works have also applied for a similar advance.

Sir W. G. Armstrong and Co.—From the annual report of Sir W. G. Armstrong, Mitchell, and Co., it appears that, in addition to the dividends of 11 per cent recommended, a sum of £61,546 is carried to the reserve fund. The works at Pozzuoli, in Italy, though not completed, have been in working order, and have turned out important work during the year.

The Largest Gun in Existence.—Messrs. Krupp have shipped a cast steel gun, weighing 235 tons, from Hamburg for Cronstadt. The calibre of the gun is 13¼in., the barrel is 40ft. in length, its greatest diameter being 6½ft. The range of the gun is over eleven miles, and it will fire two shots per minute, each shot costing between £250 and £300. The gun is the largest in existence, and the heaviest yet exported by Messrs. Krupp.

The Sund Tunnel Abandoned.—It is now announced that the idea of constructing a submarine tunnel in the Sund has been quite abandoned, and that an entirely new method of communication is to be adopted in its stead. The new proposal is to connect Elsinore with Helsingfors by means of a submarine bridge. The line will be in the centre of a double tube, the outer of iron and the inner one of steel. These will rest upon piles, and they will be placed at such a depth as to offer no impediment to navigation.

Fatal Boiler Explosion.—A correspondent at Trimdon Grange, Durham, telegraphs that the inhabitants of the village were startled about 5-40 on Saturday evening, September 21st, by a loud report, and an alarm was immediately raised that the Deafhill Pit of Trimdon Colliery had fired. It turned out, however, that a large boiler at the pit had exploded, wrecking the engine-house, and damaging the manager's offices. A number of willing hands promptly set to work to clear away the *débris*, when the body of James Prior was found terribly crushed. Many narrow escapes are reported.

The Largest Engine in Italy.—A Roman correspondent says that the well-known firm of Ansaldo-Bombini, in Sampierdarena, have recently completed the colossal engine and boilers intended for the Italian ironclad Sicilia. The engine is constructed to work up to 19,500 horse power, and it is the most powerful hitherto constructed in Italy. It is constructed on the compound principle, with eight cylinders and four surface condensers. It drives two four-armed screws, which have a diameter of six metres. The weight of the boilers is 500 tons, and the total weight of the engine and boilers is 1,740 tons.

One of the most popular features of the meeting of the British Association was Mr. Baker's description of the Forth Bridge, a triumph of engineering skill, before which the Eiffel Tower almost sinks into insignificance. As a measure of its strength, Mr. Baker mentioned that six of the largest ironclads yet built, weighing each from 12,000 to 14,000 tons, might be safely suspended from its six great cantilevers, while the size of its spans is so great that two Eiffel Towers laid horizontally and joined together at the centre would just span one of its openings. The great work, he said, would be completed at the end of October.

At the British Association, Mr. Preece, chief electrician to the Post Office, held out hopes that London would soon be in telephonic communication with Paris. On the subject of electric light, he said that the dangers of electricity had been greatly exaggerated. As regards fire-risk, it was about as dangerous as gas. He ridiculed the notion that if a man touched the wire he would be killed. He had himself failed to kill a pig with an enormous coil and a spark 20in. long Colonel Armstrong at Chatham had taken shocks that were supposed to be fatal, and only felt the better for them. As to the man reported to have been killed by a shock from a wire at Brighton, it appeared that the current had been turned off two hours before the man was killed.

The steam engines at the Ash Spinning Company's Mill stopped on Monday afternoon, September 9th. It was soon discovered that the cause was due to the patent "detective" which they have attached, and which proved its value by shutting off the steam at the right moment. One of the driving rope strands was flying loose, and the detective caught it. This apparatus has been doubted by some, but the manner in which it has done its work in this case should inspire confidence. The Ash Spinning Company was the first to have them fixed. Since then many others have given orders. They are largely in use in different parts of Lancashire.

Chester and the Electric Light.—A special meeting of the Chester Town Council was held on Wednesday, the 18th inst., to consider the advisibility of applying to the Board of Trade for a Provisional Order authorising the supply of electricity for public and private purposes by the Corporation. In view of the fact that in years gone by the Council allowed the gas and water supply of the city to get into the hands of private companies and thus become a monopoly, there was a general feeling in the Council that they should not fall into the same mistake again, and that whether or not the Corporation would itself eventually undertake the supply of the electric light, they should by the provisional power make themselves masters of the situation. It was unanimously resolved to apply for the Provisional Orders.

In all the dockyards the work of the ships building and to be built under the Admiralty programme is progressing rapidly. At Pembroke the Repulse and Renown, two immense battleships of 14,000 tons burthen, have their keel plates laid, and the frames are being put in position. Over 50 tons of steel are being worked into each vessel per week. At Portsmouth the large cruiser which is to be built on the slip from which the Trafalgar, and later, the Vulcan, have been launched, is fully worked out in the mould loft, and the material is being forged. This vessel will be the longest in the navy, and will have engines of 22,000 horse power. At Devonport, and Chatham, too, equally rapid progress is being made, and if the Administration is equally energetic during the next four years the whole 70 ships will be completed well within the time specified in the Act.

Electric Lighting in Mines.—A New York correspondent says that the mule in the Pennsylvania coal mines is soon to be superseded by electricity. At the Erie Colliery of the Hillside Coal and Iron Company, in Forest City, a dynamo has been set up in the engine room of the breaker, with a view to actuating an underground mine road, and in a short time a portion of the railway will be ready for operation. It is also intended to use electricity for illuminating the mine. This will be the second company in the anthracite coal region to employ electricity for these purposes. If safety from damp can be secured with electricity, its introduction as an illuminant in the black avenues of the dusky workshops, from which the great stream of anthracite flows to the world's marts, will be a boon to the thousands who toil in the dismal coal mines of Pennsylvania.

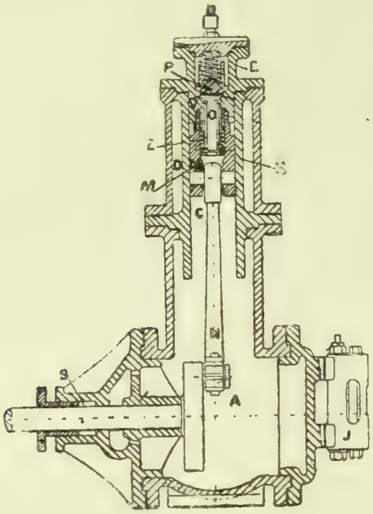
Sir Edward Watkin has submitted a proposal for a gigantic railway project to the Secretary of State for India. It is nothing less than a railway from London direct to India *via* Kurrachee. The Channel Tunnel is a portion of the scheme, though not an absolutely essential part of it, since the start could be made from Calais or Boulogne. The railway would proceed direct to Gibraltar, using the existing lines as far as possible, and here would be introduced the novel feature in the line. This would be a vast broad-beamed boat capable of taking on board the entire railway train, as it arrives at Gibraltar, and delivering it on the rails at Tangiers. Here the line would strike eastward, keeping along the north coast of Africa, touching at Egypt, and proceeding by the Persian Gulf to Kurrachee, where it would join the Indian railway system. Sir Edward Watkin's project is said to have engaged the attention of several eminent engineers and capitalists.

A Powerful Explosive.—A French military writer discourses in the *Republique Francaise* as follows on the subject of melinite: "Our shells for field artillery, as well as those for our forts and siege guns, are charged with melinite. What melinite is we do not know, and if we knew we should be very careful not to tell. Both the Italians and Germans have sent spies to discover the secret and offer money for even the smallest fragment, but they have all been captured. All that can be said is that, according to a treatise published in 1882, melinite is composed of melted picric acid. But in the interval our artillerists have perfected the discovery of M. Turpin. They have made melinite a tractable product. The effects of this explosive were fully demonstrated at some experiments at the fort of Malmaison in 1886. Melinite is so safe that in three years only one accident has occurred, that at the arsenal at Belfort; on the other hand, a hundred accidents have occurred from gelatine alone in thirty years. There has never been an accident in drawing the charges, nor one from bursting in the gun. As much cannot be said for roburite, hellofite, or the other substances employed by foreign states. What will become of a fortification in face of this redoubtable agent? Some think and say they are doomed; others, like General Brialmont, recommend the use of armoured circular forts. It is said that the shell will glance off these without doing any damage. But experiments at Chalons have shown that turrets enjoy no immunity against a close and continuous fire."

ILLUSTRATED PATENTS.

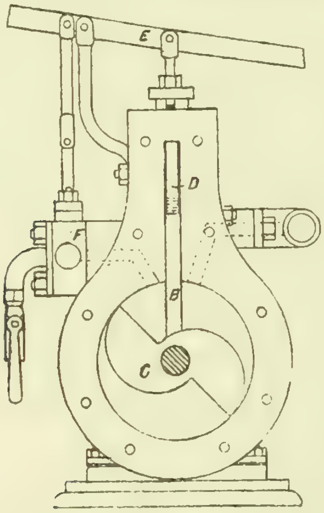
4851. **Gas Compression Pump**, J. K. Kilbourn, Bootle, Lancashire.

The gas is drawn into the pump through a liquid-sealed crank chamber A and through a valve O in the piston M, and is discharged through a valve P in the cylinder cover E. The crank chamber is filled with oil above the level of the crank shaft, and is kept tight by the stuffing-box S. J is an oil gauge. The seating of the valve O is formed on the junk ring V of the piston; the valve being closed by a spring Z, which bears on a washer X on the end of its hollow stem. The lift of the delivery valve can be regulated by a set screw in the top of the cover. The cylinder is enveloped in a water jacket D.—March 31, 1888. [8½d.]



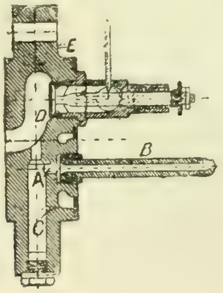
5160. **Rotary Engines**, S. J. Hamblin, Newbury, Berks.

A two-winged piston C is centrally mounted in its cylinder as shown, each wing being formed at its back with a cam surface for the purpose of pushing the abutment B within its casing. The rod D of the abutment is connected to the lever E, which works with the supply valve F, so that this is closed when the abutment is sheathed.—April 7, 1888. [6½d.]



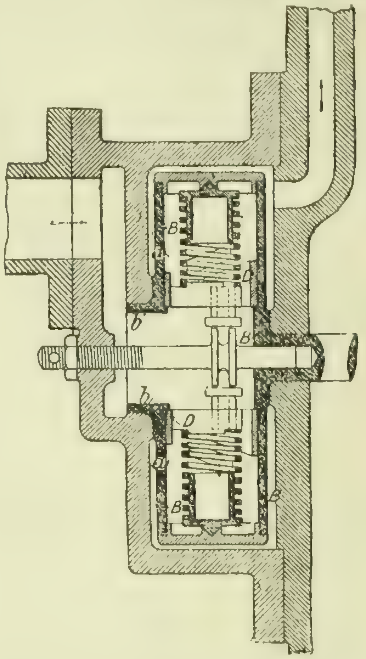
5204. **Gas Engines.** H. H. Lake, London.—*(A. Buegger, Copenhagen.)*

Igniting.—The ignition tube communicates through a chamber C in the cylinder cover E with the admission port D also in the cover. The tube B may be made of porcelain, faïence, or other bad conductor of heat, and heated by a lamp; or a passage A may be filled with pieces of porcelain, &c., and after they have become incandescent through a number of ignitions the lamp for heating the tube may be done away with.—April 7, 1888. [8½d.]



5188. **Engine Governors**, F. W. Dodd, Forest Gate, Essex.

Combined throttle valve and governor.—Consists in a throttle valve working by centrifugal action. Within a casing a cylinder B mounted on trunnions is rotated by the engine to be controlled. The steam supply, on its way to the engine, passes into the cylinders through one of the trunnions *b*, and thence through peripheral ports *d*, controlled by sleeve or piston-valves D. These valves are shifted by centrifugal action balanced by springs. Means are described for adjusting the valves from outside the casing. A modified arrangement, somewhat similar to that shown, is also described.—April 7, 1888. [8½d.]



SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

September 3rd.

13900 **Railway Switches**, W. N. Knight and W. H. Smith, London.
13903 **Furnace**, A. Barker, London.*
13905 **Signalling**, G. W. Cass, London.
13909 **Steering Apparatus**, G. Unden, London.

September 4th.

13944 **Fog-signalling**, I. F. Taylor, Essex.
13949 **Raising Steam**, F. G. Broughton, London.*
13951 **Valve Gear**, E. J. Woolf and J. Peebles, London.*

September 5th.

13968 **Motor Engines**, J. Heaton and G. H. Holden, Manchester.
13983 **Spanners**, J. Winkless, sen., Birmingham.
13985 **Starting Apparatus**, W. S. Easson and R. Thompson, London.
13986 **Smelting Cast-iron Borings**, J. Hansen, London.*
13989 **Ratchet Wheel**, A. J. P. Brown and F. W. Combe, London.
13999 **Gas**, O. Brown, London. (G. A. Goyder, Australia.)
14015 **Cutting Tubular Metal**, A. Greenwood, London.
14321 **Valve Gear**, A. Riedler, London.
14022 **Valve Gear**, A. Riedler, London.
14031 **Carburetting Gas.** J. Loves, London.
14033 **Hot Air Motor**, C. Wells, London.
14335 **Signalling**, R. R. Little, J. Hall, and T. Archer, jun., London.

September 6th.

14047 **Electric Motors**, T. H. Parker, Wolverhampton.
14049 **Coupling**, J. Menzies, Glasgow.
14050 **Consuming Smoke**, W. Russell, Glasgow.
14053 **Steam Boilers**, H. B. Buckland, Newcastle-on-Tyne,
14056 **Sewage Pump**, H. Davey, London.*
14071 **Hydraulic Railways**, J. Needham, London.
14070 **Steam Engines**, W. Dunbar, Liverpool.
14080 **Wrenches**, W. P. Thompson, Liverpool. (W. W. Leggett and Co., United States.)*
14084 **Heat Regulator**, S. Mann, London.
14087 **Disintegrating Grain**, F. Quenehen and A. Vansteenkiste, London.
14095 **Motor**, C. Wells, London.

September 7th.

14098 **Valves**, H. R. Davis, London.
14111 **Match Making Machinery**, E. Paul, Liverpool.
14112 **Crushing Mills**, W. Barford and J. E. S. Perkins, Peterborough.
14114 **Switch**, M. Immisch, London.
14115 **Furnaces**, A. Picasso and G. Peters, London.
14116 **Disengaging Apparatus**, C. Blanke, Manchester.*
14117 **Spring Making Machines**, H. Knipping, and F. Hohage, London.
14121 **Aerial Machine**, G. W. Harper, London.
14123 **Burnisher**, J. Lee, London.
14128 **Carbon**, A. Turley, Leeds.
14129 **Sizing Yarns**, A. Bradshaw, Accrington.
14133 **Feed-water Heaters**, D. Johnston, Glasgow.

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE
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TEST LOADS.

The question which has been raised in our columns anent the test loads of ordinary every-day shop lifting appliances is certainly a most serious one, and should demand the careful attention of all who have in any way to use such recognised and indispensable tools. The responsibility cast upon the employer by the provisions of the Employers' Liability Act is in itself quite grave enough, without his having the anxious and critical question to decide as to how much shall, and how much shall not, be lifted by the pulley blocks and lifting tackle generally which he has purchased for the use of his servants. We are not surprised that the statement appearing in cast letters upon pulley blocks, to the effect that the block has actually been *tested* to a certain point, should, in itself, be understood to give the user a certain certificate, as it were, that such blocks were actually capable of lifting a load not in excess of this test load; whereas the fact is that such blocks are never intended by the makers to *lift* the load at all, and they advise, with a certain air of freedom, that if we want to lift a load equal to the test load we must have the next larger size. We cannot help wandering off to the ridiculous for a comparison in the same logic, the argument savouring somewhat of the complaint from the master jerry builder, that someone had actually been leaning against the new house, or it would never have fallen. In common honesty, we maintain that all lifting appliances should be stated to be safe for a certain load; for what concern is it to the bewildered employer to be told that his appliances have been tested to a load which he himself cannot lift? The factor of safety should be determined by the makers, not by the users, for in nothing is there so much experience required as in defining the limits of loading. Structures absolutely safe under one load are, of course, utterly incapable of carrying the same load when the method of applying it is altered; it being within the province of any person to demonstrate this by applying the brake suddenly to a descending weight from any ordinary crab or lifting winch, such application causing the crab to be violently pulled up, if indeed it escapes without a fractured pinion; while upon the same crab a load of double the weight may be lifted without thus giving trouble. We are quite aware that there is no class of tool more abused than a pulley block, and at the same time we know that nothing in our workshops is capable of doing more harm by its failure. The operations of large industrial manufactories and works generally are assisted by the facility of conveyance of machine parts and heavy articles from one position to another, and the measure of speed by which this is accomplished is also the measure of commercial profit. In nothing, therefore, should there be less of uncertainty than in the lifting tackle actually employed, and the makers of such appliances should fix a certain limit, beyond which they consider injurious effects will be engendered. They know far better than the users possibly can all that may be done to injure such tools, and their knowledge should therefore be employed to protect rather than to bewilder those purchasing their manufactures.

Probably the cheap productions of this period compel the manufacturer to follow the rule established originally, when competition was less severe, and when material was more liberally given to their productions, so that the old test load has become to be known as the commercial size of the pulley block, and that which once was a safeguard has been transformed into a snare.

To introduce any new system now would certainly be difficult, unless the old and the new nomenclature are kept as indications of the character of the work and material employed. This could be very readily done by marking each block tested to so much, and safe for so much; the user would then be protected, and he would have a clear conscience as to his daily practice being no longer dangerous to his workpeople. Nothing short of compulsion, however, from the Board of Trade will, we fear, bring about this desirable condition, seeing that manufacturers are so closely competing one with the other to produce the cheapest article for every particular requirement.

Meantime the user has to guard himself against probable trouble and loss by either purchasing his tools too large or too strong for his requirements, or by placing himself unreservedly in the hands of some firm of manufacturers, who will advise him as to what appliances he should use, and what margin or factor of safety he can thus rely upon.

We trust that this question of correct lifting appliances will not be allowed to rest in its present unsatisfactory condition, and we certainly cannot see why the Board of Trade should be so particular over some means and methods of carrying passengers and goods, while other equally dangerous systems go unchecked.

If it is an offence to carry a passenger in a public street or road without having the conveyance actually licensed and certified by the Government Department, in like manner it should also be an offence for any person to put up a lift, hoist, or elevator without first obtaining some guarantee from a recognised department that his appliance or machine is a safe one, and not liable at any moment to cause loss of life or limb to those who may be using such erections.

We imagine there is no hoist or elevator in existence that has not been subjected at some time or other to some test load by the maker; but so long as that load is misconstrued by the workpeople and attendants, so long will such a system be derogatory to all good practice in actual production, for manufacturers will compete one against the other, and the inclination is to buy that which appears to be identical with another, the price of which is some thirty per cent less. It is greatly to be regretted that some common action cannot be taken by the trade generally, so that test loads should once for all be understood to mean, say, fifty per cent beyond the actual working load; but, meantime, engineers making such appliances will do well to study their clients' and their customers' requirements, by printing on all their lists and catalogues the actual working or safe load in addition to the much abused test load; or this might be perhaps better done by some such general statement being made and understood that all appliances for lifting either passengers or goods should always, as a matter of course, be tested to fifty per cent beyond the maximum load intended to be lifted.

We know that any firm, starting in an isolated way to make this departure, will as a result have some loss at the outset, for so deeply rooted is this idea of testing in the minds of users of lifting machinery and appliances, that nothing short of a serious accident will cause them to disbelieve their old notion. The test load, too, of an engine, is only too often an indication of what splendid results may be obtained by a skilled mechanic from very poor second-rate engines, and the disappointment that the actual working of the same engine produces when away from such nursing-up on the part of the attendant, is a story that only too many owners of engines are familiar with.

Testing should be a standard to guide and assure the user, if it is to be of any service at all; and, as a consequence, such testing should be actually commercial rather than scientific. For it matters but slightly to the owner to be informed that his engine is giving a very high standard of efficiency, and that its motions are as near perfection as can be approached, if after all this elaboration his work is not done, and his daily requirements are not complied with.

MR. EDISON ON THE DOOM OF STEAM.

It is not a little surprising to the uninitiated that electricity is yet some long way behind steam in its daily applications to commercial purposes; the prophecies which have been sounded forth with trumpet tongue having for some years past called attention to what would happen next in the development of electricity. We have, therefore, some pleasure in giving Mr. Edison's latest opinion, expressed to an interviewer in Paris:

"The great development of electricity will be, I am firmly convinced, in discovering a more economical process of producing it. At present we only get from coal consumed about 4 or 5 per cent of its latent electricity. The rest is wasted in heating water, expanding steam, pushing pistons, turning wheels, and finally causing a dynamo machine to operate. A process will ultimately be found for extracting 90 to 95 per cent of the latent electricity directly from the coal. Then steam engines will be abolished, and that day is not far off now. Already we can get electricity direct from coal to the amount of 90 per cent, but only for experimental purposes. When I was on shipboard coming over, I used to sit on deck by the hour, and watch the waves. It made me positively savage to think of all that power going to waste. But we'll chain it up one of these days, along with Niagara Falls and the winds. That will be the electric millennium."

This is a grand idea for electricians to follow up during the coming long winter evenings. There can be no dearth of matter here, and no trouble need be expected in controlling the varying movements of the waves, so that they shall act upon some common centre, and thereby give up their power to the connected mechanism, or rather, perhaps, to the electro-motor attached. The electric millennium is to be devoutly longed for that will give us such cheap agents for our daily use.

ADVICE TO ENGINEERING STUDENTS.

The approaching winter is being heralded with more than usual activity by those engaged in catering for the wants of the engineering student. On all sides, and in large centres especially, we find a great desire to impart technical training to those actually engaged in some daily workshop routine. This desire is greatly to be commended, but at the same time too great care cannot be exercised in the methods and manner of teaching adopted, and we would desire that all young engineers, before joining any class for instruction or practice, should have a clear idea as to what really is to be taught, and what they are expected to know.

Science classes abound, and examinations are the fashion; but so long as the test of actual knowledge is to be obtained from a written series of answers to some eight or at most a dozen questions, so long will the awards be held in distrust by those to whom they should suggest the most value.

Every chief draughtsman, and every engineering manager, is too familiar with the young man who is laden with Science and Art Department certificates, and he hesitates from his actual disappointment in some such learned apprentice or clever youth, introduced to him by his admiring friends, before giving any credence to mere certificated knowledge.

This fact is undoubtedly strongly against our present systems, but it is more unfortunate as regards the student, for the very person to whom he looks for some recognition actually ignores his credentials.

The great blame attending the existing conditions is attached not to the system, but to the student himself. The idea of many young men in entering into evening study is to acquire as much knowledge as can possibly be acquired in several various subjects; and the boast appears to be made as to the number of different classes that can be attended in any one session, the result of this miscellaneous study being that the student knows a little of many subjects, but nothing substantial or helpful of any one of them; so that by the time the results of the examinations are made known the probability is that the smattering of knowledge has actually departed.

We suggest most seriously to our young readers that they should endeavour to make a systematic study of those subjects actually allied to their daily duties, and to their future intended and desired callings or professions; and to strenuously resist the charm of a big bundle of books publicly distributed before an applauding assembly, which would lure them on, by placing their eyes on a more substantially created reward, which is to be given not on one particular night, but which will rather be given in the form of increased comforts and superior positions in the whole future awaiting them.

We admire the science classes, and we greatly encourage students to attend the technological classes in connection with the City Guilds; and it is from the fact of our admiration of these institutions that we counsel young men to use, and not abuse, their privileges. Let each engineering student apply himself to master those primary engineering subjects which are taught in every industrial centre, and he will find that his awards will become valuable to him, for they will appear not only on pieces of pasteboard, or upon the inner covers of some book, but the knowledge gained will show itself in his daily work done, and the favourable attention of those interested will thus be obtained.

HYDRAULIC POWER.

Amidst the discussions now taking place as to the advantage of compressed air in Paris, it is perhaps a little more gratifying, when noting our own tardy and somewhat indifferent results obtained on a large scale in this country, to turn to that wherein we have excelled in supplying a public mechanical power.

The hydraulic system is apparently a most remunerative one in London, where we find a company, only in existence some seven years, doing such work that its shares are standing at a substantial premium, and its operations still extending, without at the same time increasing the maintenance charges. The Hydraulic Power Company has taken London, Hull, and Liverpool in hand with great success, and we doubt not that in large commercial centres equally good results could be obtained by adopting similar methods of power transmission. It is satisfactory to find that in all the instances of users of the hydraulic power in London not one has ever given it up. The pressure actually carried into the warehouses, wharves, hotels, and other buildings is not less than seven hundred pounds per square inch, and with this splendid power laid on to the user, steady and reliable, without any attendant risk, we are surprised that the system has not been more generally followed elsewhere. In case of fire, too, the power becomes available for working on to specially constructed injectors, so that an immense volume of water from the ordinary street mains can be drawn and distributed with ease to the highest building in the neighbourhood.

The great economy of the hydraulic system, in that the power is not being lost when the machines or engines are standing, comes strikingly before the user, seeing that he has but to pay for the actual period he employs the water—the amount being indicated by meter, exactly as if so much gas had been consumed. The engineering difficulty originally raised as to the water joints does not appear to have been met with as a serious trouble or heavy consideration, for in every instance the joints have been easily made, and examined when needed, without interference with the practical success of the scheme.

The chief use to which the power in London is applied is that of lifting passengers and goods, but many instances are set forth in the company's reports showing that there appears to be no demand for power but what can be met by the application of the hydraulic system.

SIR W. G. ARMSTRONG, MITCHELL, AND CO.

The annual meeting of Sir W. G. Armstrong, Mitchell, and Co., of the Elswick Works, held at Newcastle-on-Tyne, on Monday last, demonstrated conclusively the good management and high position of this great company of ordnance manufacturers, shipbuilders, and general engineers. Probably little more can be desired to show how much can be accomplished by a good combination of men specially trained to distinctive duties, and with experience unique in some particular department or branch of science, than is revealed by the success of this comprehensive firm.

In moving the adoption of the report, which recommended a dividend of 11 per cent, Lord Armstrong said it had been fairly earned, and that a sum of £61,000 had been added to the reserve fund. Referring to the question of raising additional capital by the creation of preference stock, his lordship said the fact was that the works had altogether outgrown the capital, and they were not unfrequently compelled to resort to temporary loans to meet deficiencies. This was not the proper position for a great and prosperous company, and the time had arrived when they must either raise money by borrowing or create a preference stock. The latter was the most suitable course to pursue, and the directors recommended the creation of £1,000,000 of permanent preference stock, as a provision to meet not only their present requirements, but all legitimate requirements likely to arise in future. Referring to technical matters, Lord Armstrong said invention and improvement continued to mark the career of this establishment. Continued trials with quick-firing guns of large calibre, and progressive improvements in their manufacture, had firmly established their advantages, and those advantages would be still further enhanced by the employment of the new smokeless powders which were now certain to be brought into use. With ordinary powder it would be impossible to fire these large guns at their maximum rate of some 10 rounds per minute, on account of hanging smoke from the discharge rendering aiming impossible. With the so-called smokeless powder the same hindrance was not experienced. The smoke produced by the discharge was very much less in volume, and dissipated very readily. Excellent results had been obtained; but even with these powders, though much reduced in volume, the smoke was still present as a partial hindrance, and extended operations were now being carried out to endeavour, if possible, to obtain a powder with total absence of smoke. They had lately been experimenting with a new powder, recommended by Sir Frederick Abel, known from its string-like form as a cordite, with much success. As yet it would be premature to say up to what size of gun this powder might be used, and its adaptability for service had of course still to be proved by climatic and other tests, but at present the results were very promising. It was impervious to damp, and above all was absolutely smokeless, and its employment would in all probability work a revolution in modern armaments, and render the use of quick-firing guns not only an advantage but a necessity. His lordship concluded by referring to their continued success in the production of war-ships, and especially of protected cruisers.

THE IRON AND STEEL INSTITUTE.

The autumn meeting of this Institute was commenced on Tuesday morning, September 24th, 1889, at the Société d'Encouragement pour l'Industrie Internationale, Paris, under most favourable auspices. The proceedings commenced with a hearty reception in the Lecture Hall of the Civil Engineers by the Société d'Encouragement and the Société d'Engineers Civils. Sir James Kitson, the President of the Institute, having delivered an inaugural address, Mr. J. S. Vans, the secretary, read the minutes of the last meeting, and the purely business part of the meeting was commenced by a paper on the iron and steel manufacture in France.

The President subsequently introduced the subject of the Channel bridge, which, he said, was of great interest to the members, for it foreshadowed a consumption of 1,000,000 tons of iron and steel. In the discussion he desired them to avoid political questions and the question of navigation, and confine themselves to the mechanical points of the paper.

Mr. Evans and Mr. Percy Gilchrist then read the paper on the Channel bridge.

The paper, which excited great interest, was the proposal of Messrs. Schneider and Co., of the Creusot Ironworks, and Mons. Hersent, to bridge the English Channel between Cape Grisnez and Folkestone. They have had the assistance of Sir John Fowler and Mr. Baker, the chief engineers of the Forth Bridge, and these two gentlemen claim to have furnished data sufficiently minute and correct to enable the scheme to be submitted to the judgment of competent persons. A large number of sectional drawings were distributed among the members. The paper states that the amount of metal and machinery to be provided for the construction of a bridge over the Channel would represent an aggregate weight of about 1,000,000 tons; and the assumption is that each country will have to supply one-half of this amount. A rough estimate of the cost is given as £34,400,000, and £15,200,000 of this will be expended on masonry supports and £19,200,000 on the metallic superstructure. The works for the tunnel and the railways of both countries would have to be planned later on in agreement with the companies whose lines would lead up to the bridge, and the time required for the completion of the works would be about 10 years. The line taken for the bridge is the shallowest part of the Channel, between Cape Grisnez and a place near Folkestone. This arrangement has been adopted so as to take advantage of two banks, and thus avoid working in great depths and diminishing the height of the piers to be erected. The result of the repeated experiments shows that the ground is sufficiently solid to support very extensive works. The sand covering the bottom at certain points, especially near the shores, would have to be removed in order to lay the piers on more solid foundations. Each supporting pier will consist of a block of masonry of good material, set with Portland cement mortar, and laid on the sea bottom. The piers will form a rectangle, terminating in semicircles so as to oppose the least possible resistance to the currents. Up to a certain height the brickwork will extend over the whole surface of the base; and the masonry will be built inside metal caissons similar to those used for ordinary bridge piers, and forced by compressed air down to the solid ground. These caissons will be surrounded by metal cases, and they will serve to float the piers until they touch the ground. The distance between the piers, fixed at 500 and 300 metres for the large spans, will not be less than 200 and 100 metres respectively for the small ones, and will be sufficient to prevent their proving an obstacle to the free navigation of sailing vessels. The main girders of the bridge will be supported on metal columns firmly placed upon the platforms of the piers of masonry. The minimum height of the bridge is 54 metres, and will be amply sufficient for the passage of vessels of all descriptions. There will be a double set of rails, set in grooves to obviate accidents. On the piers lighthouses may be erected. It would have been easy, the authors of the paper say, to establish a bridge with four lines of rails instead of two, but the probable development of the traffic did not warrant any increase of outlay in that direction. The provision of a road for ordinary vehicles is also superfluous, as goods will always be carried by rail. To meet objections from a military point of view arrangements could be made for making the span at either end of the bridge unfit for use; the two end spans notably, which are in contact with the abutments, might be removable or revolve. The authors of the scheme then gave a detailed description of the plans and methods of construction proposed to be adopted. They say that the bottom of the sea can be cleared beforehand by means of special apparatus, enabling compressed air to be dispensed with; and the filling of the compartments and air chambers can be effected, either outside or inside the pillars, without its being necessary for the men to perform any important work below. The size of the pillars and the considerable amount of material required will necessitate the establishment of a port at a point nearest to the spot where the works are begun on either coast. On the French coast the port would probably be provided in the bay of Ambleteuse; and on the English coast Folkestone would form the centre of operations. A network of telephonic cables will connect the different landing stations and the yards on land, and in the offing. The columns will be sunk in the midst of anchored barges, with the necessary moorings, and their position will resemble that of a spider in the middle of its web. The barges will form a sort of protection belt to the pier they surround at the moment of its immersion, and will serve to moderate the height and strength of the waves. It is probable that by mooring rafts to the barges, and by employing oil, the waters around the piers might be made sufficiently smooth to enable materials to be put into position under almost any condition of weather. If it were desired to complete the whole of the works within a period of ten years, about two years would have to be devoted to preparatory works for establishing working yards and buildings, so that the whole would extend over twelve years. The labour would have to be divided between two working yards situated on either coast, so that each yard would have to turn out 2,000,000 cubic metres of masonry, concrete, and caissons. The various parts of the bridge will reach the yard in as complete a condition as possible. A greater or less number of works may be applied to manufacture these different parts in order to avoid the necessity of rapidly calling into existence a regular industrial town in a desert part of the coast. The fitting together of all the pieces can be mainly done in the work yards, as regards the central spans and the overhanging cantilever ends, and these will then be carried on barges to the ultimate position. There would be three barges in the case of the heaviest span, with a nominal capacity of about 3,200 tons. The various barges will be connected by steel cables, stretched crosswise, as is sometimes done in the case of bridges over rivers for the passage of artillery in times of war. The whole of the bridge and barges will be tugged by a large steamer, which is preferable to using several tugs, which might not act with the desirable uniformity. The strains to which the spans on the barges might be subject to are carefully calculated, and it is claimed that every danger from wind and wave in the transport is guarded against.

(To be continued.)

Electrical Engineering Classes at Glasgow.—From a syllabus of Professor Jamieson's classes which we have received we gather that both day and evening classes are carried on by him at the Glasgow and West of Scotland Technical College (Bath Street branch) for young engineers. A two years' complete course of laboratory testing, with lectures upon dynamos, lamps, steam engines, boilers, gas engines, &c., prepares for the college diploma on this subject.

BOULT'S CYLINDER LUBRICANT TESTER.

In selecting a cylinder lubricant from a number of samples of oil, it is desirable that we should be able to ascertain readily which oil will last longest when exposed to the high temperature within the cylinder, and which will reduce the friction of the piston in the cylinder to the greatest possible extent. The lasting of the oil would be readily determined if we could design means of noting the coefficiency of friction from time to time after a given supply of oil has been placed within the cylinder, or when a given rate of supply is continuously maintained. In the case of high pressure steam, but more especially in the case of gas engines, it is important that the oil should leave the cylinder by evaporation or decomposition, without depositing a sensible quantity of solid sediment, or without leaving a gummy residue, which greatly increases friction. In gas engines this is most important, as a bad oil speedily dries up under the influence of the intense heat of the explosive flame, while a good hydrocarbon merely decomposes and evaporates when it has done its work, without leaving any solid residue.

With these facts in view, Mr. W. S. Boult, of Bank Buildings, Castle Street, Liverpool, has designed an oil tester which, in our opinion, is admirably adapted for its purpose, and readily allows oils to be tested under almost the exact conditions of temperature which they must stand in actual use. The principal departure from the lines of previous oil testers consists in the very simple means provided for submitting the oil to be tested to any desired temperature, and also for retaining a measured sample of oil for any necessary length of time under test. By doing this, the staying power of the oil and its lubricating qualities may be accurately observed with rapidity and convenience.

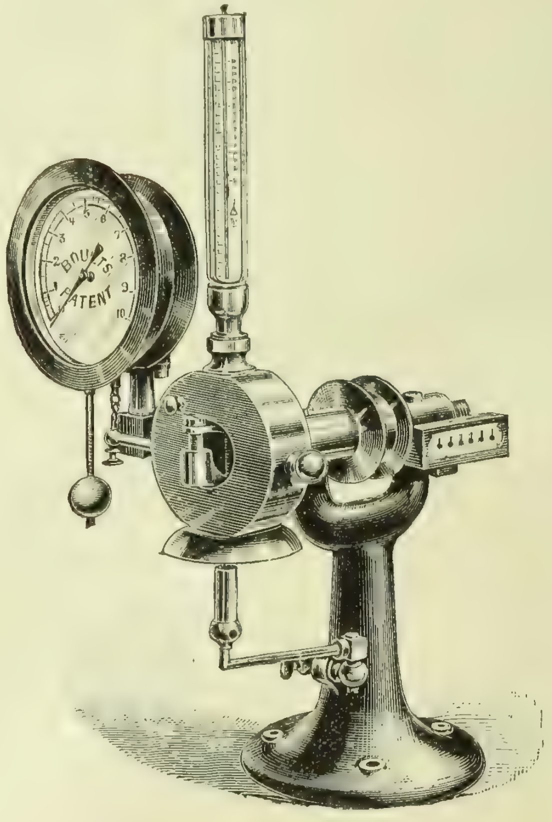


Fig. 1.

The instrument is very simple, and will be readily understood by referring to our illustration. Fig. 1 is a perspective view of the tester ready for work; figs. 2 and 3 are sections, and fig. 4 shows the measuring tube used in connection with the tester. The instrument consists of a flanged hollow cylinder, within which rotates an expanding bearing, expanded by a spring or springs. The hollow contains any oil suitable for an oil bath, and the oil to be tested is measured into the flanged interior. In figs. 2 and 3 E, E is the oil bath recess or channel, A is the internal surface against which the expanding bearing blocks B, B are pressed by the spring C^1, a is the flange which prevents the oil from leaving the tester, and M, M are the screws causing the parts of the expanding bearing to revolve together. The heads, however, are adjusted to clear the bearing, so that the spring may be free to thrust the rubbing surfaces against the interior surface. The thermometer G is immersed in the oil contained in the oil bath E, and this oil bath may be heated to any desired extent by means of a Bunsen burner placed under F. The arm E is firmly attached to the cylindrical bush or case E, E, and transmits the pressure due to the friction of the rubbing surfaces of the spring indicator, with pointer and dial seen in the complete external view, fig. 1. The Bunsen burner is also shown in fig. 1 in its proper position. The spindle D is driven by pulley, also shown, and its revolutions are registered by a counter attached to it.

The mode of testing is as follows: See that the friction surfaces are perfectly clean, and then pour in a measured quantity of the lubricant to be tested from the small measuring tube R, fig. 4. This measuring tube is an ingenious little detail, which greatly assists accurate testing. The rod S, carrying the piston packed end S^1, is pushed into the bore of the tube down to the aperture R^1; then the tube end is dipped in the oil to be used, the rod is pulled up, and the oil charge measured by the graduation in the tube. This measured charge is then expelled by pushing down the piston to the mark required. The charge is then placed in the bush E, in the channel formed by the flanges *a*. So soon as the machine is set in motion the whole interim surface is covered with the oil, which cannot escape because of centrifugal force and because of the projecting flanges. The heat is maintained to any desired temperature, as indicated by the thermometer G, by adjusting the Bunsen flame. The pull is clearly indicated by the dial plate and points, and by combining the readings, together with the surface speed and the known thrust of the spring C, the coefficient of friction is obtained.

We give here a series of tests made with this instrument, which are very interesting, and show clearly the great varieties of quality of the different samples.

CYLINDER OIL TESTS.

The following are a series of tests of cylinder oils made by a Boult's patent "cylinder-lubricant" tester. The distance travelled by the friction surfaces was 655ft. per minute, the load 34lb. per square inch, the temperature 350° Fah., and the duration of each test lasted until the dynamometer pointer indicated a 50 per cent increase of friction. Two tests of each oil were made, and the average result is here given. In every case the same carefully-measured amount of oil was used. In determining the appearance of an oil, a ⅝in. glass tube was filled and held between the operator and a window :—

Rerence Letter.	Appearance in a ⅝in. Glass Tube.	Consistency at 60° Fah.	Nature.	Duration.		Average Co-efficient of Friction.
				Minutes	Feet Run.	
A	Completely opaque : black	Thin	Mineral	71	46,505	·0165
B	,, ,, ,,	Nearly solid	,,	149	97,595	·0229
C	Very dark reddish brown	Thick	,,	122	79,910	·0216
D	Red; slightly cloudy	Very thick	Mixed	175	114,625	·0201
E	Completely opaque ; black	Solid	Mineral	124	81,220	·0232
F	,, ,, ,,	Nearly solid	,,	120	78,600	·0254
G	,, ,, ,,	Very thick	,,	50	32,750	·0186
H	Dark orange; very cloudy	Solid	,,	69	45·195	·0236
I	,, ,,	Nearly solid	Mixed	247	161,785	·0236
J	Brown ; bright	Thin	Mineral	155	101,525	·0156
K	Dark amber ; bright......	,,	,,	237	155,235	·0156
L	Dark orange ; cloudy	Nearly solid	,,	210	137,550	·0178
M	Amber ; bright	Extr'm'ly thin	,,	118	77,290	·0119
N	,, ,, ...	,,	Mixed	35	22,925	·0108
O	Dark red ; clear	Thick	Mineral	360	235,800	·0203
P	,, not quite clear	,,	Mixed	222	145,410	·0172
Q	Completely opaque ; black	,,	,,	70	45,850	·0197
R	,, ,, ,,	Thin	,,	126	82,530	·0182
S	Dark orange ; very cloudy	Solid	,,	183	119,865	·0220
T	,, ,,	,,	,,	206	134,930	·0188
U	Milk-white	,,	Tallow	96	62,880	·0156

There can be no doubt whatever as to the value of such tests, especially where high temperatures are to be resisted, as in high-pressure steam and gas engines. The apparatus seems to us a most useful and convenient one, inasmuch as it allows of hot tests without in any way disabling it for use in cold tests. Such instruments should be much more frequently used by engineers than they are, as after all the cheapest oil is often the dearest lubricator. What we require is not so many gallons of oil, but so many gallons of the best lubricant, and testing is the only mode of discovering this.

FIG. 2.

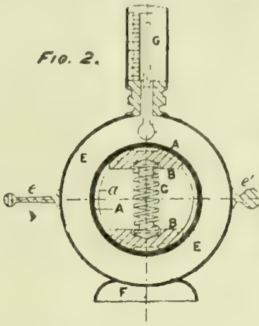


FIG. 3.

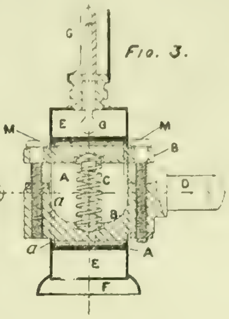
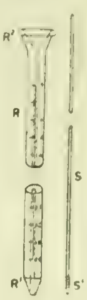


FIG. 4.



POSITIVE PISTON PUMP.

(Continued from page 660.)

WE are now brought to mechanical methods of construction which develop these reactions. The usual form of reciprocating pump, for large masses of water, is that in which a plunger, closely fitting in its travel through the cylinder or water chamber, or through a partition dividing it in two, draws the suction and forces the discharge, alternately at each direction of the travel, acting by displacement. Water can pass into one end or the other of the chamber, to follow the retreating plunger, only through valves opening inward, of which two sets, each for its own end, control the current. A similar arrangement is made with the outlet valves, which are placed at the opposite side of the chamber, and open outward. As the plunger retreats in its motion, one set of outlet valves close upon their seats, and atmospheric pressure forces the suction column into the space left for it in the chamber through the opposite inlet valves, while the advancing side of the plunger, having first arrested the suction, presses forward the discharge column. A stroke completed, not only is the motion of the plunger stopped, with weight belonging to itself and connecting parts, but also motion of the water on either side of it and in the pipes; momentum directly opposes this stoppage, and the immediately following change in motion of the plunger. At this critical moment for the exertion of power by reciprocation, reaction from momentum is only prevented from becoming a destructive blow through the use of air chambers. This action and reaction are repeated with every stroke.

Were the valves few and large, they would require a full movement from their seats to admit a sufficient volume of water, and would cause much loss, through "slip," before a closing could be effected. Consequently they are often small and numerous, with but little lift, to secure quick closing. The partition containing them, when they are closed, offers a complete impediment to the flow, and when open they remain directly in the way of a subdivided current, while the partition is still an obstruction, together causing not only friction in proportion to the velocity of flow, but also conflicting and churning counter currents, as the streams impinge against the valves, to be deflected radially at sharp angles and to come in contact with each other.

Because impact from momentum increases as the square of the velocity, the limit of speed at which a reciprocating pump, handling large masses of water, can be run safely and economically is soon reached. This necessitates the use of much larger pumps, at much lower speed, than would be necessary were momentum an aid instead of an obstruction.

The *centrifugal* system of pumping completely avoids obstruction by valves, and develops no concussions through resistance to momentum. Consequently, it permits the movement of large volumes with high rates of speed. A centrifugal pump, however, as the name sufficiently indicates, does not apply power directly to the lifting and moving forward of a column of fluid, and unless water flows to it, or the pipe is first filled, it will draw no suction beyond a very trifling height. The power necessary to drive it increases in a much greater ratio than the heights of delivery. A well-known maker of these pumps has given the following rule for determining the application of power to them: "The amount of power necessary is a function of the height to be attained, multiplied by its square root, or $h\sqrt{h} = \sqrt{h^3}$."

E.g., a pump requires 10 H.P. to raise water 6ft. It will require, if the height is increased to 54ft, $9\times\sqrt{9}\times10=270$ H.P., and not simply the original power multiplied by 9, which would be 90 H.P.

Although centrifugal pumps depend, for efficient work, upon a high rate of speed, yet there is a limit of speed beyond which their efficiency decreases. This limit, for the outer ends of fans, is stated by different makers to be from 12ft. to about 25ft. per second. By comparing the best authorities regarding the efficiency of work done by these pumps, we find it to vary from 24 to 60 per cent of the whole power applied, when working against the moderate lift at which they perform their best duty; this for small sizes is about 15ft.; very large sizes carry their efficiency to higher lifts.

A centrifugal pump is the same in principle, and essentially in construction, as a fan blower. The well-known disproportion of power to useful effect in running fan blowers for any but a very low pressure of air, is repeated with the pump, except that the pump, as it deals with the greater mass, has the advantage of momentum. Discharge from the blower may be completely stopped by a moderate obstruction, notwithstanding a rapid movement of the fans. With the pump, water moving at high speed, through its momentum, would prevent such obstruction without great resistance; but, let the discharge opening be firmly closed, and then full motion may set up, while water can fill the pump, but none be discharged from it, and there will be but little force developed from movement of the fans, for they, with the water contained within their periphery, then form a nearly solid and balanced mass, meeting but little resistance to its motion other than that caused by friction with the surrounding parts. This will illustrate the reason why there is always a limit of lift beyond which a centrifugal pump can yield no efficient duty and at last effect no discharge at all. The fact that a fan blower can increase or decrease the pressure of air only within a pound to the square inch, at its best work, sufficiently accounts for the inability of a centrifugal pump to draw its own suction without priming.

Pumps which have been known under the general title of "Rotaries," also avoid, in most of their methods of construction, reaction from momentum and resistance from valves. They contain one or more sets of rotary vanes or buckets; sometimes intermoving with each other in a similar manner to that of the teeth of gears; sometimes running concentrically with the chamber, like a paddle-wheel in its box; and sometimes sliding in and out of a hub or drum having its periphery in contact, or nearly so, with one side of the chamber. Provision is usually made for automatically closing a radial section of the passage or passages through which the vanes or buckets move, in such manner that they shall not be obstructed, whilst the current can be carried around through the open portions from the inlet, placed at the outer circumference of the chamber, to the discharge at the opposite side.

There have been various modifications of these general designs, but the greater part of them involve similar principles. The volume of water moved by them is relatively large, but they have not competed successfully with the reciprocating system. There have been several causes for this; such as the difficulties, with their peculiarities of construction, in making their action positive enough without great loss through friction; the paddling effect only of the buckets or vanes following each other, and, when they intergear, the loss of action and the conflicting currents at the retreating parts of the rotation; "pocketing" of water and consequent resistance against the vanes when passing the closed portion of the chamber—often quite serious; a sharp deflection of the current at both inlet and outlet; also resistance to the flow, caused by receiving it against centrifugal force, which, with high speeds, becomes a serious obstruction, and the outlet is rarely at a tangent to the circumference of motion, as with centrifugal pumps. Such and other causes have prevented economy in power, and many of these pumps, when under full duty, develop troublesome concussions at even moderately high rates of speed, resulting in much wear and tear.

In 1885 a series of tests were made by the Philadelphia Water Department, upon one of the most successful of the large-volume rotary pumps then in use. Water flowed to the pump; therefore no suctional lift was carried. The static head to be overcome was about 129ft. The results were as follow:—

Test.	Revolutions per Min.	Theoretical Discharge. Gallons.	Actual Discharge. Gallons.	Per Cent Attained.	Indicated Horse Power.	Effective Horse Power, calculated from Water raised.	Per Cent Effectual Horse Power.
A	20·3	101·5	11·3	10·8	4·26	0·33	8·
X	86·6	433·	452·	104·4	23·06	14·6	63·3
Y	104·7	523·5	536·	102·3	29·82	17·65	59·2

It will be seen that at the lowest speed A the effectual percentage of result was very small in both volume of water and power used. This was doubtless caused by pressure from the column to be raised, 55·86lb. to the square inch, which was sufficient to cause much loss of water at this low speed through the loosely fitted moving parts of the pump, while they were obliged to rotate against the pressure. At the next rate of speed X a very different result is attained. The speed has now become sufficient to bring momentum into a useful relation to the flow, which is increased even beyond what displacement in the chamber would indicate. The power applied has also greatly increased in effectiveness. Both appear to have reached their best efficiency.

At the last rate of speed Y new conditions come into action, and the efficiency in both volume and power is again decreased. This is caused by peculiarities of construction. The speed has increased enough to bring centrifugal force, at the inlet, with the sharp angle at both openings, to bear against the current; also enough to cause an impact of pocketed water against the vanes. These resistances, and consequent loss of power, would, doubtless, have grown at a rapidly-increasing ratio with higher rates of speed. At the most effective velocity the loss sustained in effective power was 36·7 per cent.

(To be continued.)

INSTITUTE OF MARINE ENGINEERS.

Radial Valve Gear.

A meeting of the Institute of Marine Engineers was held in the premises occupied by the institute (the Langthorne Rooms, 17, Broadway, Stratford), on Tuesday evening, the 24th September, presided over by Mr. J. McFarlane Gray (vice-president), chief examiner of engineers, Board of Trade. Mr. Bruce (member) read a paper on "Radial Valve Gear," with special reference to Morton's improvements of recent date. The paper was illustrated by a large number of excellent diagrams and several working models, one of the latter showing the valve gear in all its details, with valve, piston, and crank motions. The author briefly referred to the various older gears of a character similar to Morton's, and proceeded to point out the details, with the motions peculiar to each. In adopting the radial system of valve gear it was shown that a shorter crank shaft, without shortening the bearings, much less weight of engine and a more compact engine-room are required as compared with the ordinary eccentric and link motion; the gain to the shipowner being more cargo-carrying capacity for the same power of propelling machinery, along with less dead weight, involving less expenditure of coal.

Messrs. Marshall and R. W. Weighton (Hawthorne, Leslie, and Company, Newcastle) were quoted by Mr. Bruce as having, in a paper read before the North-East Coast Association of Engineers, referred to the average weight of engine (including all the propelling portion of the machinery); and, basing his calculations upon this and on the data furnished him by Messrs. Barclay, Curle, and Company, in connection with the steamship Circe, engined by that firm, he considered that the saving in weight by the adoption of radial valve gear was at least 10 per cent. The greater comfort and ease of mind enjoyed by the engineer in charge of engines fitted with radial valve gear were also referred to, inasmuch as the eccentrics were entirely dispensed with, eccentrics and their connections being frequently a source of worry and anxiety at sea, and of hard work in port, overhauling and refitting the liners and parting pieces.

The discussion was opened and maintained by Messrs. Rowe, Adamson (hon. sec.), J. H. Thomson, R. Leslie, and J. Hawthorn, dealing with the questions of engine-room space, length of crank shaft, weight of engines, number of working parts, motion of the valves for opening and cut-off, lead of valve at various parts of the stroke, with full steam and early cut-off in the various types of valve gear, including Hackworth's and Joy's.

Mr. McFarlane Gray illustrated on the black board the rudimentary principles in all forms of valve motion, pointing out the aims of all those who sought to invent a perfect valve gear, whether radial or other. He questioned the author of the paper closely as to the object of having earlier port openings on the bottom, and on several other matters of detail in connection with the gear under discussion.

Mr. Bruce replied very readily to the questions put before him, and the proceedings closed by a vote of thanks to the author, proposed by Mr. Leslie, and seconded by Mr. Thornton, and to the chairman, proposed by Mr. Roberts (superintendent engineer General line). These were heartily accorded.

On the motion of the hon. secretary, the discussion was arranged to be continued on Friday, 27th September, at 7-30 p.m., when Mr. Joy was expected to be present to enter into the discussion with reference to his own gear.

It was intimated that a handsome model, with movable parts, showing the gear, and valve, and piston in relative positions, had been presented to the institute by the proprietors of the Morton gear.

It was also intimated that the next paper would be read by Mr. Joseph Williams (member), on Saturday, the 19th October, at 7 p.m., on "Forced Draught," followed by one by Mr. A. Beldam, on Friday, November 1st, on the "Progress and Development of the Marine Engine."

NEW TORPEDO BOAT.

On Saturday, the 14th ult., Messrs. Yarrow and Co., who may well be described as the pioneers of torpedo boat construction, exhibited on the Thames a torpedo boat which is likely to become the standard for the British and other Governments. The design and capacity of the vessel have indeed been so much approved that six of the type have been ordered by the Admiralty, while others are being made for nations abroad. The boats are similar in all leading particulars to one constructed as a sample three years ago by the same firm, giving particularly good results, on account of her very high speed, combined with remarkable manœuvring power. They are 130 feet long, by 13½ feet beam. Galvanised steel is used in their construction, and they are propelled by triple-expansion engines, indicating about 1,150 horse power. All six boats have been tested by the Admiralty, the trial for speed being a run of three hours' duration without stoppage with a load of 20 tons, and the speed attained varied from 22½ to 25 knots in the hour. This shows an improvement of four knots an hour on the torpedo boats built during the last Russian scare, although the latter carried exactly half the present weight.

The armament of this terrible engine of modern warfare consists of one torpedo gun for direct head fire, placed below the turtle deck, and secured into the stern of the boat. Near the stern is a turntable, on which are placed two other torpedo guns. These are, in accordance with Yarrow's patent system, placed at an angle of five degrees with one another, so that, if fired simultaneously, they would take slightly divergent courses, and thus ensure much greater certainty of hitting the enemy's vessel. The machine gun armament consists of three 3-pounder quick-firing guns—one amidships, and one on each beam in echelon. Steering gear is fitted at two points, one within the conning tower (which would be mainly used in time of war), and one on the after deck, protected by a movable brass shield. The boats, apart from their torpedoes, would thus be able to inflict considerable damage when steaming at a high speed, while their marvellous manœuvring power—enabling them to turn within a circle the radius of which is only slightly in excess of their own length—will make them exceedingly difficult craft to hit. For the defence of the coasts and harbours the naval authorities of this and other countries have come to the conclusion that torpedo boats are invaluable, and, though it is possible by a larger expenditure of money to build boats which will attain a still greater speed, our own and other Governments incline to the opinion that the type of vessel exhibited so successfully by Messrs. Yarrow and Co. will answer all possible requirements.

Is the Eiffel Tower a financial success? Here are some figures: The tower cost less than seven million francs, and already, on September 24, the earnings amounted to no less than five million forty-five thousand one hundred and forty-six francs !

REPORT OF ENGLISH WORKMEN ON THE PARIS EXHIBITION.

An interesting little book has been issued by the Midland Counties Trades Federation, being a report of the deputation sent by that association to the Paris Exhibition in July last. The observations are presented as the united opinions of the delegates. It was noticeable that the nuts and bolts in many of the principal machines in the Exhibition were hand-made, and probably came from the heart of the Black Country. The difference in make between the hand-made and machine-made nuts and bolts was very marked. The fit and finish of the machine-made article is by no means so good as that of the hand-made, and even in some very special exhibits, where the rest of the work was good, the fraise was left in the nut, disfiguring the whole machine. They were also badly fitted, as much as the thickness of the thirty-second part of an inch being apparent in the screwing up; even the best bright polished (finished) nuts would, if turned out of Darlaston or Smethwick in such a fashion, be considered very unsatisfactory. There were several exhibits made by Belgian, French, and other firms, and not a little English work with foreign names attached. Some of the work, notably in the axle-bolts, was very good, but other work was much inferior to the exhibits of the Patent Nut and Bolt Company, London Works. The majority of the work was machine-made, there being apparently little or no hand labour in this respect, except in one or two instances where the work had been hammered up after leaving the machine. The English nut and bolt maker had nothing to fear from foreign competition, unless it be with regard to price; and as to what the wages were they had no means of ascertaining. There seemed to be a good demand for nuts and bolts to be used instead of coach-tire rivets, as used in England, and it is pointed out that it might be worth while to cultivate that branch of industry, which is now somewhat neglected: the demand was there, and English manufacturers might try to supply it. With regard to anvils, there were none in the Exhibition except of the kind known as "crickets," and those, in the opinion of the delegates representing the trade, were not to be compared with the English-made goods, either in workmanship or quality. Some of the samples shown as finished goods would not be passed in any English shop, on account of their rough and unfinished state. Again, in this trade there was nothing to fear from foreign competition. The English workman only required to make his work as he did at present and get it sent into the foreign market, when he could beat his competitors on their merits. The vices shown were unequal in finish and strength to the English goods, which could most favourably compete with them in every respect. There was a good show of spades and shovels of foreign manufacture of various shapes, and these proved the need there was for English manufacturers keeping abreast of the times, so as to adapt their shapes to the various uses for which they were intended. There were many shapes not common to England, and one which struck the miners' representative was a kind of shovel-shaped gigantic screw-driver or chisel, with a long iron handle. This was called a "trepan" or "borer," and its use would therefore seem to be to drive headings in pits in place of the present system. The English exhibits of spades, shovels, and forks were superior to all others. In the tube and fittings department few English firms exhibited, which was regrettable, as comparison with any of the large English makers would have been in their favour.

In castings the French were marvellously clever, and some of the fine work scarcely needed dressing. The opinion of the deputation with regard to locks was that, to compete successfully, English makers must pay more attention to outside show and finish. English work was more substantial in many respects, but not so "eyeable." In the agricultural department an inferior quality of Walsall and Cradley Heath chains seemed to be used even on good articles. The moral was obviously to push the better class of goods, and their superiority could not help but be manifest. French wire-nails were certainly superseding the English hand-made nails, but they were largely made by Nettlefolds and other firms and sent out to foreign makers. The horse-nail trade was of a uniformly good quality, but opinion was unanimous that the nails themselves were not better than the home-made nails; for while the English-made nails cannot be broken by hand, as much could not be said of the French production, which was altogether lighter and more fragile, the advantage in the appearance being in the trimming. Of the French chain proper, the general opinion was that there was no finish about it, and it looked as if it had been cast in a mould. The Englishman was far superior to his French

MESSRS. B. AND S. MASSEY'S EXHIBIT AT THE PARIS EXHIBITION.

(For description see page 681.)

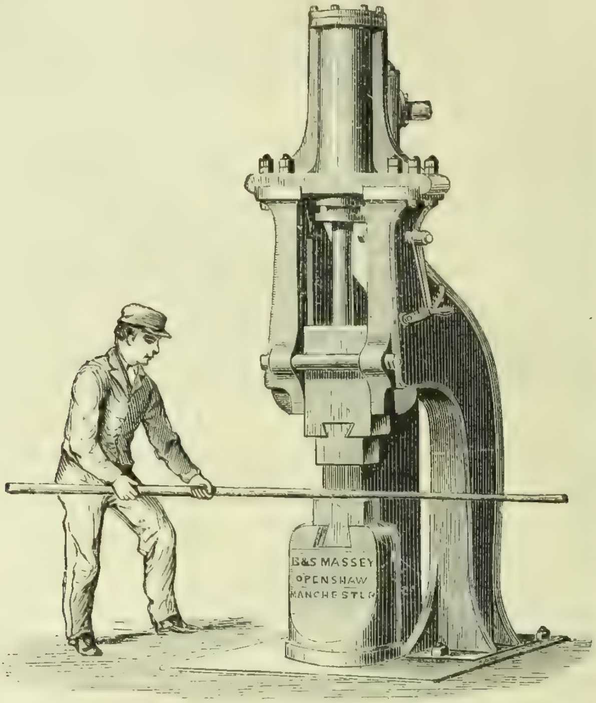


Fig. 2.

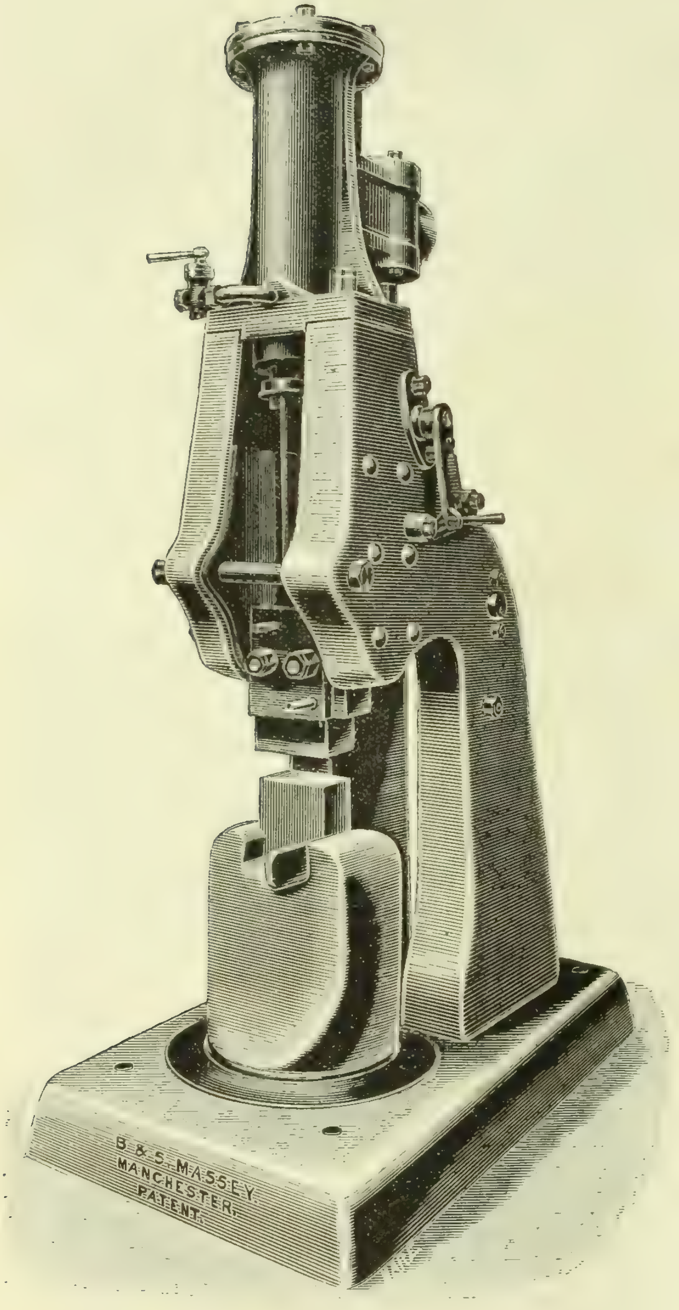


Fig. 1.

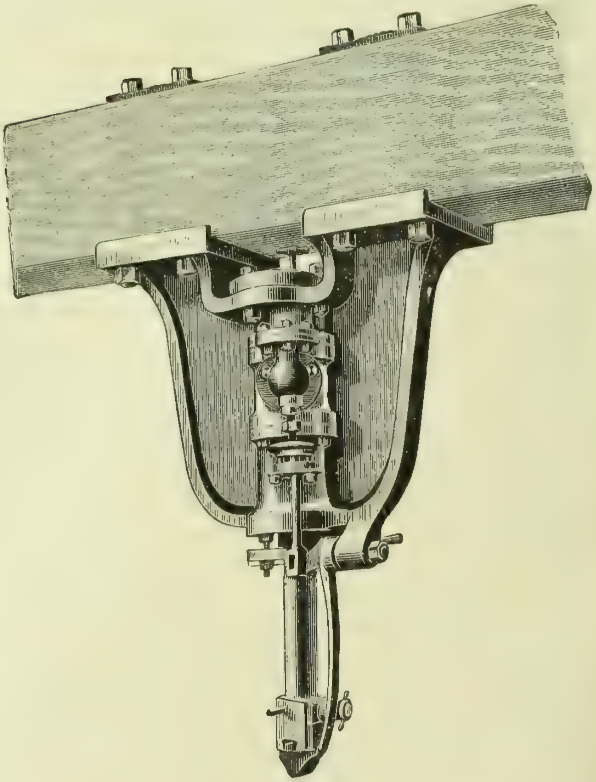


Fig. 3.

competitor, and if the workmanship alone were considered, his work would be in greater demand than the foreign article. A French firm exhibited coupling chains for trucks and carriages, and trace chains, which were evidently of Staffordshire make. In the opinion of the deputation, anchor work was not so well understood as in England, the specimens shown being too shallow across the crown, and too short in the arms, according to the length of shank, to be as effective as home work. Cable chains were not so strong as English, and much more clumsily made. The files and rasps were beautifully cut and finished, and in this department Englishmen must look to their laurels. As a nation, England had little or nothing to learn or fear from the French, or from any other nation, in respect of science or its application to industrial purposes; but in regard to the best and most useful adaptations of high art for every-day uses, it had to be confessed that England was still behindhand when placed in comparison with the French. They were nevertheless of opinion that in their own particular trades English workmen could meet the French on their own ground with equal excellence all round.

MESSRS. B. AND S. MASSEY'S EXHIBIT AT PARIS.

Messrs. B. and S. Massey have a very interesting exhibit at the Paris Exhibition of their well-known specialties. One hammer is specially interesting, and is called "The Age of Steel." The two side frames and the base plate are entirely of steel, each in one piece, without welding or riveting. The work is done in a single operation with the steam forging press of Massey's patent. The cylinder cover is also of steel, as well as the piston rod, the hammer head, and the smaller pieces.

We illustrate this novel hammer at fig. 1, page 680. At fig. 2 we illustrate also a hammer (exhibited) of Messrs. Massey's ordinary construction, which type is usually made in sizes from cwt. to 20cwt. The anvil blocks are separated from the base plate, and in all hammers below and including the 10cwt. size the anvil blocks are turned and accurately fitted into bored openings in the base plates. The framing consists of two standards with a wide clear opening between them, allowing long bars to be laid across the anvil from front to back, as well as from side to side. Fig. 3 is a suspended hammer for use by coppersmiths, boiler-makers, and others. The hammer is simply bolted underneath one of the beams of the roof or of the upper floor, or a beam fixed for the purpose into the walls of the building. It is useful to get at large copper vessels, boiler tubes, or boiler work generally, where a small steam hammer is required.

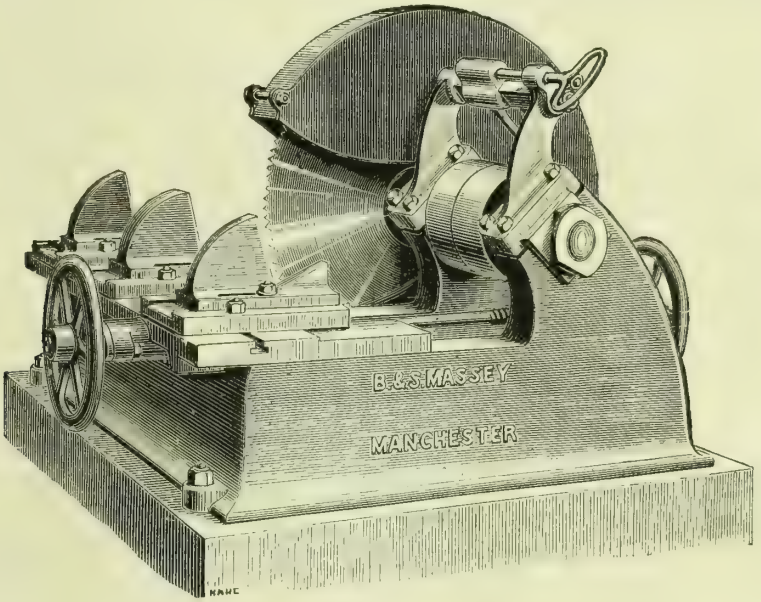


Fig. 4.—MESSRS. B. AND S. MASSEY'S HOT IRON AND STEEL SAW.

Fig. 4 is a useful circular saw for hot iron and steel, intended for smithy work, at which it is found to effect great economy in wages. The saw is of the finest steel, and is fixed upon a steel shaft running 1,400 revolutions per minute. It is securely cased to prevent accidents, and the table which carries the bar to be cut is moved by a quick threaded screw either from the front or back of the machine. Sometimes a lever is used instead of a screw.

Messrs. Massey's exhibit is a most admirable one, and well sustains our reputation for such work in France.

STEAM PLANT FOR ELECTRICAL SERVICE.

(Continued from page 631.)

Two important advantages are claimed for the system using large slow-speed engines. First, the long-stroke engine, with four independent valves, represents the highest known steam efficiency, and requires smaller boiler plant and less outlay for fuel. Second, the use of shafting and clutch pulleys admits of the greatest interchangeability. Any dynamo can be run from any engine, and a dynamo or engine can be thrown in or out of service without affecting the rest of the plant.

On the other hand, the advocates of direct connected engines claim, first, that no power is lost in driving shafting; second, that as stations are actually run under widely varying loads, the small engines can be operated at or near their best point of cut-off, and will, therefore, do the work at less fuel cost per lamp hour; third, that one or two dynamos to an engine offer all necessary interchangeability; fourth, that one small engine affords ample reserve; fifth, that electrical conditions demand close regulation of speed, from stroke to stroke, and under changing load and steam pressure, and that experience has shown that this is best secured by high-speed engines; sixth, that a short circuit in a dynamo would slow down a small engine, thus giving warning of danger, while a larger engine would pull it through, regardless of results; seventh, that the plant occupies the least space; and last, but by no means least, the first cost, including erection and foundations, is less than for low-speed engines with shafting, &c.

That there is wide difference of opinion among prominent engineers on this question, is shown by the fact that there are now being erected stations costing hundreds of thousands of dollars on both principles. Let us examine the claims made in the light of the requirements already laid down.

First, as to reliability. Both plans claim simplicity of construction, but in my opinion "honors are easy." Two engines are, of course, easier cared for than a dozen, but as each of the large engines is not only much heavier than one of the smaller ones, but is more complicated in its valve gear, and the plant is further encumbered by the shafting, with its necessary bearings, couplings, and clutch pulleys, we see no difference in the two. The large countershaft is a source of weakness, however; an accident to it means a suspension of the whole plant. The service required of it is severe, and it is not always easy to preserve the alignment. When out of line it consumes great power, and is a source of constant worry and danger. An accident to one of the large engines means a serious loss of capacity, while it is insignificant if the engines are small. In the latter case a reserve engine means a much smaller investment of idle capital and space. It appears, therefore, that independent engines are preferable on the score of reliability

Second, as to the electrical system. If the plant can be located where there is abundant space, it may be planned with a view to the highest efficiency. If other conditions permit, all the advantages of high expansion and condensing engines may be utilised. On the other hand, if ground is valuable, the use of direct belted high-speed engines are necessary. In those systems requiring close regulation of speed, they are also preferable, although slow-speed engines are being greatly improved in this respect by new designs, better workmanship, and the use of heavier flywheels.

Third, as to their fuel economy. It is here that the advocates of long stroke machinery make their strongest claims. I have been unable to secure exact and reliable data as to the water consumption of the two types of engines, per horse power per hour. From the best information I can get, however, I am inclined to place the water consumption of the low speed at about 20 per cent less than the high speed under similar average working conditions. Where fuel is expensive, and where the other limiting conditions mentioned above do not prevent, the low-speed engine should therefore be adopted.

There are, however, two important points which must be considered in this connection. The useful power delivered to the dynamos is always less than that exerted by the engine, by the amount of the friction of the engine and power-transmitting devices. In direct connected engines this loss is from 7 to 10 per cent of the total, while with the shafting system it is usually from 20 to 25 per cent, and if the shaft is out of line, may be much more. It thus appears, therefore, that a large part of the superior economy of the low-speed engine is offset by the increased friction loss.

The economy is further affected by the amount and hours of loading. If the work done is large and constant, as is the case with plants operating contracts for city lighting, the low-speed engine has still a good balance in its favour on the score of fuel economy. If, however, the load is subject to wide fluctuations, as it is with commercial lighting—especially incandescent plants—the case may be different. The *real* efficiency can not be measured under the best conditions but for a whole day's run. The sketch exhibited may be taken as typical of the work of all incandescent plants doing commercial lighting. The lower curve represents the net output of the dynamos measured in lamps burning; the next line shows the additional work done in friction, which is constant for all loads. It will be noticed that a single large engine doing this work must, for three-fourths of the time, cut off at points decidedly unfavourable to its economy. That is to say, that the steam required to operate the engine under these conditions, would, if used in an engine cutting off nearer its point of maximum efficiency, do a great deal more work. The upper line represents the work which the steam consumed is capable of doing, if properly used. You will, no doubt, be struck by the amount of steam used wastefully, as shown by the irregular space between the upper and lower curves.

By dividing the work among several smaller engines, which can be shut down and started up as required, but one engine, at most, works at a disadvantage. The friction loss is also less, and when each engine shuts down its proportional amount of friction ceases. It is evident, therefore, that independent engines have a decided advantage in net economy under variable loads.

I had intended to submit sketches of a plant of say 1,000 H.P., arranged in both ways, making a calculation of the efficiency of each, under variable load. On investigation, however, I found that the ground had already been covered in an able paper by Mr. W. L. Church, read before the National Electric Light Association, at its meeting at Pittsburgh in February, 1888. Mr. Church presents data from two actual stations in which the ratio of fuel per lamp per hour is as 70 to 126, in favour of independent engines.

Summing up, it appears that long-stroke engines are to be preferred where the load is approximately constant, provided sufficient space can be had, and provision is made for reserve. But for variable loads, and where space is valuable, as well for greater reliability and closer regulation, the use of high speed appears to offer most advantages. The most prominent promoters of incandescent lighting in this country have adopted direct connected engines for their central stations.

A brief discussion of the integral parts of a steam plant for electrical service may be of interest.

The engine we have already considered at some length. The advantages of compound, triple-expansion, and condensing engines are well known, and these principles may be applied with benefit to both low and high speeds types. It must not be forgotten, however, that their recognised fuel economy is secured by greater complication of parts. A higher degree of skill is, therefore, required to operate them, and the liability to accident and derangement is increased. The full benefit of these principles can only be obtained where the load is large and approximately constant. It is evident, therefore, that these high types of engines cannot always be used with benefit. The success of stations now being equipped with high-pressure boilers, and triple-expansion condensing engines, will be watched with interest.

All sorts of boilers have been used, from the long cylinder, where fuel is cheap, or the water bad, to the water tubular. Each has its advantages. The horizontal tubular boiler is a quick steamer, occupies little room, is not high-priced, and is fairly efficient. Among these, my own preference is for the boiler with four-inch tubes, as it seems a happy mean between the flue boiler and the multitubular. The water-tube boiler is being widely adopted in electrical plants. Its advantages are: high efficiency; small space occupied; capacity for over-work; quick steaming, and safety. The type of boiler to be selected is usually determined by the quality and price of fuel, the space available, and the scale-making properties of the feed water; although it is claimed the latter has now been eliminated by the invention of purifiers guaranteed to keep boilers free from scale.

The design of furnace and grate is also determined by the fuel. The furnace is modified by the question of whether *capacity* or *fuel economy* is of more importance. Rocking grates and mechanical stokers have points of value, but cannot be used successfully with all fuels. The use of petroleum as a fuel is increasing, as was shown by the interest in the subject at the recent meeting of the National Electric Light Association at Chicago. Comparing Illinois coal, a pound of which evaporates six pounds of water, and which costs 8 cents per bushel in St. Louis, with petroleum having an evaporative efficiency of 16 to 1, the oil must be furnished at less than 2 cents per gallon to make the fuel cost of evaporating 1,000 pounds of water the same in both cases. When we consider the greatly reduced cost of handling petroleum, and the exactness with which it can be regulated and controlled, and the fact that it is smokeless, it seems destined to wide adoption.

(To be continued.)

Fast Steaming.—A Union steamship has just arrived from the Cape, after a voyage of a little under 18 days. This is good work. But when it is calculated that the average speed was a little over 14 knots, and when comparison is made with the voyages of crack Atlantic liners, it will be found that there is room for better work still in the passage to that great country in South Africa.

THE STEVENS RUDDER CONTROLLER.

Maritime disasters involving serious loss of life and property have occurred from time to time through the carrying away or breaking of some part of the steering gear on board vessels.

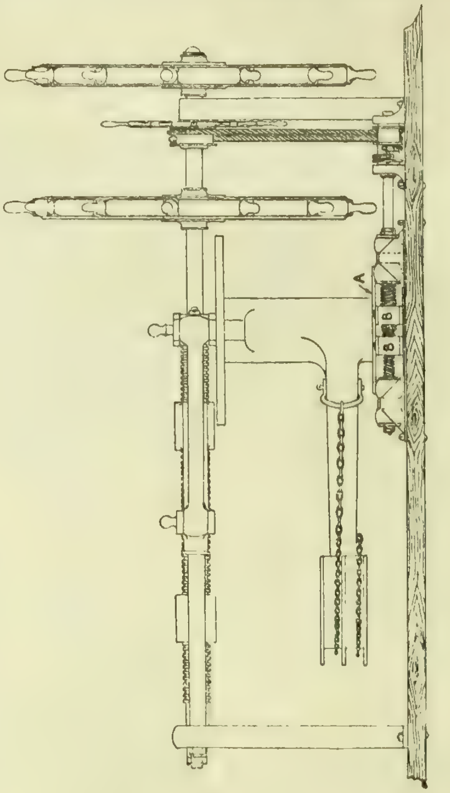


Fig. 1.

In order to lessen the strain on the steering gear in heavy weather, "relieving tackles" improvised by means of ropes and blocks, attached to the quadrant and to the sides of the vessel, are in general use, while the same means are usually resorted to in order to secure the rudder when an accident to the gear takes place. Such tackles have often been found totally inadequate, while their application entails the constant attention of a number

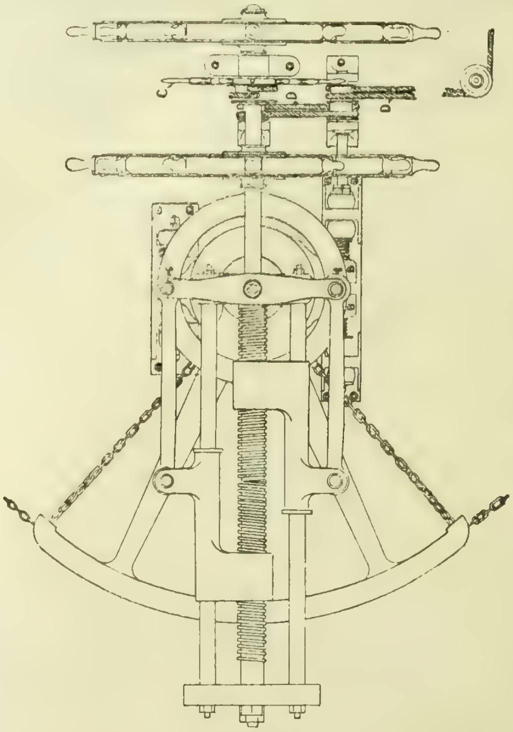


Fig. 2

of hands at a time when their services are wanted for other work. Some of the finest vessels in the naval and mercantile marine have been lost through accidents to the steering gear, and the great difficulty and delay experienced in securing and retaining control of the rudder by these means.

We have recently inspected an apparatus intended to obviate these difficulties, at the Paris Exhibition, termed the Stevens rudder controller, introduced by the Stevens Rudder Controller Company Limited, 37, Walbrook, London, E.C. It consists of a friction band fitted to the rudder head, and so contrived that the man at the wheel can, with perfect ease, apply the friction with sufficient force either to steady the rudder or to hold it firmly in any position, as may be desired. The action of the controller is instantaneous and unfailing, while in construction it is simple, strong, and not liable to get out of order. By means of indiarubber cushions or buffers, the controller is rendered sufficiently elastic to "give" gradually when the rudder is violently struck, so as to minimise the possibility of damage to rudder or steering gear.

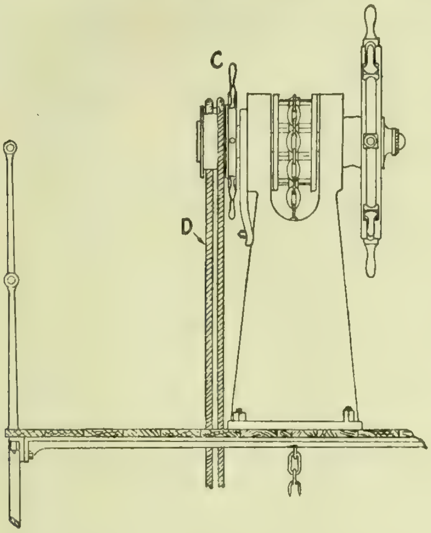


Fig. 3.

The apparatus is equally applicable to vessels steered by a tiller or wheel aft, or by hand or steam gear from the bridge.

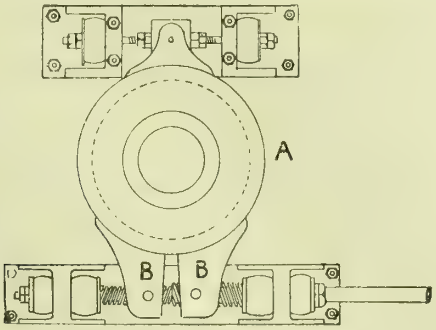


Fig. 4.

When adapted to steam-steering gear, the action of the wheel giving steam to the steering engine is effectively controlled, so that the application or release of the friction band on the rudder head, and the opening or closing of the valve giving steam to the steering engine, are automatic, and, therefore, simultaneous.

Referring to our illustration, fig. 1 is a side elevation and fig. 2 plan of the arrangement when applied to a wheel aft. Fig. 3 is an elevation showing its application on the bridge; and fig. 4 is a plan showing the friction band applied to the rudder head. The small wheel C between the steering wheels in figs. 1, 2, communicates with the controller screw big ropes, and when it is moved the screw rotates and causes the friction band in two halves to close upon the disc keyed on the rudder head by acting on the right and left hand nuts B B. When applied from the bridge the controller wheel C transmits the motion from the bridge by the ropes D to the screw at the rudder head. We are informed that this apparatus is now largely used for vessels both large and small with perfect success.

BRITISH ASSOCIATION.

Mechanical Science Section.

Mr. W. Anderson presided over this section, and Mr. Beauchamp Tower read a paper on an apparatus for providing a steady platform at sea. He described an apparatus large enough to carry a 3-pounder gun, which he had constructed and mounted on a 25 ton steam yacht, and which, he said, kept perfectly steady, even when the vessel was rolling and pitching violently, and said that his experience with it seemed to justify the belief that the abolition of angular movement alone would prove a great mitigation of sea sickness.—Captain Noble, of the Elswick Ordnance Works, said he had seen the machine at work, and as far as he could see Mr. Tower had succeeded perfectly in what he proposed to himself. As far as its application to ships of war was concerned, he thought that was a question which would have to be left entirely to those who had to use the guns. He was glad to hear that the Admiralty had decided to test the value of the apparatus in the matter of gun mountings and search lights. He thought it important that this should be done. Professor J. Milne exhibited and explained two new instruments for recording vibrations in railway trains. Mr. H. M. Ashley read a paper on the manufacture of bottles by machinery. Mr. Hastings, M.P., bore testimony to the importance of the process described by Mr. Ashley, both as regards the amount of output and health of the glass blowers, which would be infinitely better, he said, than under the old system. Mr. J. A. Loudon read a paper on the utilisation of fibrous peat for the manufacture of brown paper, wrappers, and millboards. Mr. Loudon said the machine which he used for treating peat fibre was a "willow" or "devil," consisting of one drum, 3ft. diameter by 12in. on the face. The drum was covered with a concave. Both the drum and the concave were furnished with cone-shaped teeth, so that the fibre could not adhere to the teeth; but the principal advantage was that the teeth could be set to fibrise to any degree of fineness. Owing to the speed at which it ran, no fibre hung about the machine, and it would fibrise or tear the peat fibre in either a wet or dry state. By this machine the cost of production was lessened by about £2 per ton.—Mr. C. E. Carr read a paper on hydraulic apparatus for railway signalling.

EXPERIMENTS ON A STEAM ENGINE, THE CYLINDER OF WHICH WAS HEATED EXTERNALLY BY GAS FLAMES.*

By Bryan Donkin, Jun, M.Inst.C.E.

In the following experiments an attempt has been made to determine how far cylinder-condensation can be prevented, and an economy of steam realised, by heating an engine cylinder externally by gas flames, so as to raise its temperature considerably.

The engine was of the horizontal single-cylinder type. Diameter of cylinder, $8\frac{7}{16}$in.; stroke 14in. It was coupled direct to a rotary gas exhauster used merely to pump air so as to absorb the power. One set of experiments were made non-condensing, and one set condensing. In the latter case communication was made with the condenser of a factory engine, so that the air-pump discharge of the experimental engine could not be measured. The feed water was carefully measured in all the trials, and indicator diagrams were taken frequently from both ends of the cylinder.

The arrangement of the gas jets was necessarily somewhat imperfect; but every care was taken to ensure accuracy in recording the results. Several experiments were made both with and without the gas flames. When using the gas flames the quantity of gas burned was varied. The Bunsen burners were placed quite close to the cylinder externally, and the flames reached about halfway round the cylinder. External radiation was prevented as far as possible, by sheets of asbestos, the products of combustion passing away through holes left in these sheets. The expansion was constant in all the experiments, as there was no separate expansion valve.

Results of the Experiments.—These are given in the following tables. It will be seen that the temperature of the cylinder wall when the gas flames were used was generally much above that of the steam admitted.

There is a decided economy of steam when the gas-flame jacket is used, but against this must be set the cost of the gas used. This will vary in different localities, and the commercial gain will be the difference of cost of the fuel saved and the gas used.

Since these experiments were made, a better mode of burning the gas has been adopted.

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*Proceedings Inst. C.E.

TABLE I.—SUMMARY OF EXPERIMENTS ON A 6 HORSE POWER NON-CONDENSING STEAM ENGINE, WITH AND WITHOUT GAS-FLAME JACKET, AT BERMONDSEY, 1888.

		Without Gas Jacket.	With Gas Jacket.		
	Experiment......	No. 3.	No. 6.	No. 9.	No. 8.
	Date, 1888........	July 26.	July 28.	July 31.	July 31.
	Duration.... hours	4	4		3
Feed water.	Feed water per I.H.P. per hour........ lbs.	44·4	34·1	33·8	34·8
I.H.P.	I.H.P. by diagrams.	6·26	6·17	6·33	6·31
Ordinary London gas	Gas burnt in Bunsenburner per hour cub. feet.	0	49	40	35
Temperature.	External temperature of cyl. walls at top ...... °Fah.	248	414	..	336
Steam-pressure above atmosphere	Boiler pressure ..lbs.	35·5	35·0	35·5	34·5
	Initial pressure in cylinder.... "	31·7	34·7	34·7	33·8
Speed	Revolutions per min. (by counter).	90·73	90·79	89·7	90·1
	Total revolutions..	21,776	21,790	16,147	16,218
Steam from diagram. ..	Steam per I.H.P. per hour calculated from diagrams at $\frac{8}{10}$ths stroke lbs.	35·87	34·42	34·37	..
	Percentage of steam used shown on diagrams at $\frac{8}{10}$ths. stroke	80	101	101¾	..

TABLE II.—SUMMARY OF EXPERIMENTS ON SAME 6 HORSE POWER STEAM ENGINE, BUT CONDENSING, WITH AND WITHOUT GAS-FLAME JACKET, 1888.

		No Gas Jacket.	With Gas Jacket.	
	Experiment	No. 4	No. 3	No. 2
	Date, 1888	August 9	August 9	August 8
	Duration ....hours	3	3	3
Feed water	Feed water per H.P. per hour .... lbs.	38·5	30·7	30·3
I.H.P.	I.H.P. by diagrams..........	5·61	6·05	5·47
Ordinary London gas....	Gas burnt per hour in Bunsen burners .... cub. feet	0	35	28
Temperature ..	External temperature of cyl. walls taken at top.............. ° Fah.	213	239	240
Steam-pressure above atmosphere.	Boiler pressure	35·0	34·5	34·5
	Initial pressure in cyl. .. lbs.	14·8	15·3	13·2
Speed..........	Revolutions per minute (by counter).................	92·27	92·66	90·16
	Total revolutions............	16,610	16,680	16,230
Steam from diagram....	Steam per I.H.P. per hour calculated from diagram at $\frac{8}{10}$ths stroke lbs.	28·3	27·3	27·3
	Percentage of steam used shown on diagrams at $\frac{8}{10}$ths stroke	73½	89	90

Professor Dwelshauvers Dery, of the University of Liége, was much interested in this novel way of heating the cylinder, and, at his request, copies of the results were sent to him. He has carefully analysed these results, and compared them with experiments in which two other ways of reducing cylinder condensation were used. In Mr. Willans' experiments the amount of cylinder condensation, reckoned per indicated H.P., is reduced by increasing the speed of the engine. In Professor Hirn's experiments the condensation is diminished by superheating the steam. The comparison of the economy obtained by these three methods is instructive.

CHIEF RESULTS OF THE EXPERIMENTS.

TABLE I. WITH AND WITHOUT GAS, NON-CONDENSING.—Comparing experiments No. 3 with No. 9, there is an economy of 24 per cent in feed water indicated horse power per hour, and this with practically the same pressure of steam, power, speed, and expansion. It will be noticed that the external temperature of the cylinder walls was much greater with the gas burning than without. The initial pressure of steam of the indicator diagrams was also about 3lb. greater, say 10 per cent, with the gas than without. As to the steam calculated from the diagrams at $\frac{8}{10}$ of the stroke, 80 per cent only of the total steam supplied appeared in experiments without the gas-flame jackets, and 20 per cent was missing; while on the other hand, with gas jacket on, the diagrams showed that at $\frac{8}{10}$ of the stroke all the feed water was present as steam, there being no missing quantity.

TABLE II. WITH AND WITHOUT GAS—CONDENSING.—Comparing experiment No. 4 with No. 2, there is an economy due to the gas-flame jacket of 21 per cent in feed water per indicated horse power per hour, with about the same pressure of steam, power, speed, and expansion.

The temperature of the external cylinder was greater with the gas.

The initial pressure of steam was also greater with the gas. In the steam calculated from the diagrams at $\frac{8}{10}$ths of the stroke, 73 per cent only was shown on the diagrams in the experiments without the gas-flame jacket.

In the experiments with the gas-flame jacket 90 per cent of the total steam used was shown on the diagrams, or a diminution of condensation of 17 per cent.

Comparing the two sets of experiments, Table I. and Table II, the jacket gives a rather greater effect in the non-condensing set than in the condensing. The experiments made with increased quantities of gas show that after the cylinder metal had been raised to a certain temperature the extra quantity of heat seemed to have no beneficial effect whatever. Probably the extra heat was partly radiated externally, and partly passed away with the exhaust.

A few trials were made at 45 revolutions, and there was still an economy due to the gas-flame jacket, but not nearly so marked as at 90 revolutions.

STEAM ENGINES AND BOILERS.

AT the Trades Union Congress, Sep. 4th, Mr. Swift (Manchester) moved—

> That this Congress is of opinion that no person should be placed in charge of steam engines or boilers (on sea or on land) who has not undergone an examination to prove his practical fitness for such employment, and instructs the Parliamentary Committee to render all the help they can to secure legislation in this direction during the coming year.

He said that as the outcome of the last Congress a conference had been held, and a bill to effect the objects desired had been drafted. This Mr. Fenwick had promised to introduce in the House of Commons next session. The bill was not retrospective, but it would provide that no person should be placed in charge of a steam engine exceeding five horse power, or steam boiler, or any closed vessel for the generation of steam, unless he was in the possession of a first-class certificate. Another provision made it necessary for anyone in charge of a steam-engine, &c., under five horse power to have a second class certificate. One of the best arguments in favour of the proposition was a report issued by the Board of Trade, which stated that a competent engine or boiler attendant would be able to discover and point out defects which, to the mind of a man without knowledge and experience, would present no danger and receive no notice. Were all engine boilers and attendants duly qualified, the experience of the Colonies and America proved that the number of accidents and explosions would decrease.

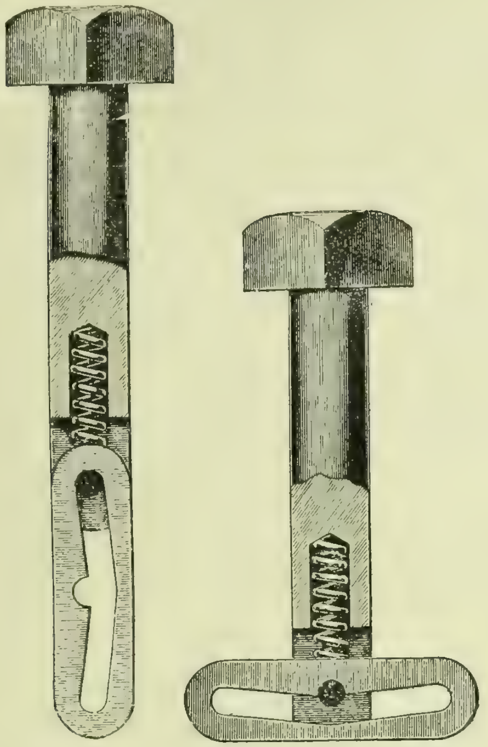
Mr. T. Ball (Leeds) seconded the resolution on behalf of the enginemen of the United Kingdom, and it was, after a short discussion, carried unanimously.

THE FRICTIONLESS ENGINE PACKING COMPANY.

WE are pleased to learn that the Frictionless Engine Packing Company, of Cable Mills, Oldham Road, Manchester, have received an award at the Paris Exhibition for their electric frictionless packing, upon which we have already commented favourably.

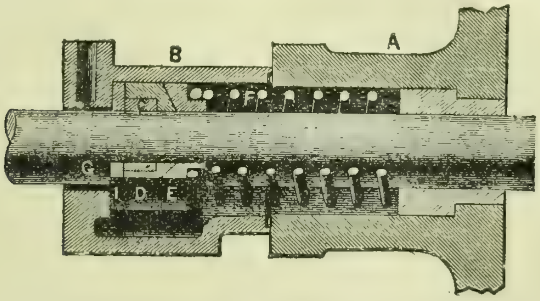
WRIGHT'S FASTENINGS FOR BOLTS.

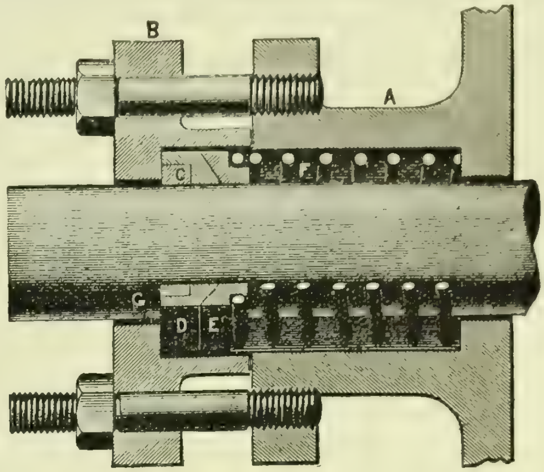
The bolt fastener shown herewith is designed as a substitute for the old style split key and cotter pin. It consists of a slotted retaining plate in connection with a spiral spring. The sectional view shows the mode of construction. The movable retaining plate or key is punched out of steel, while the spring is made of the best brass spring wire, to prevent rusting. This bolt can be put in place and removed in an instant without the use of tools of any kind, and is especially useful upon railroad cars, locomotives, and all work requiring loose bolts. The fastener has been introduced by the Wright Manufacturing Company, of Philadelphia.—*Master Mechanic.*



THE EXCELSIOR ANTI-FRICTION METALLIC PACKING.

In the accompanying engravings is shown the Excelsior anti-friction metallic packing, as applied to piston rods and valve stems. As will be seen by a reference to the illustrations, it consists of two anti-friction rings, C and D, held in place by a brass ring E, and a light spring F. The stem enters the stuffing box around the piston rod, and, the packing being smaller in diameter than the box, closes the rings about the rod during the forward stroke of the piston. During the back stroke, when there is no steam pressure on the rings, they are released, and the light springs suffice to hold the parts in place. The gland makes a steam tight joint on the face of the stuffing box by means of a copper gasket. Among the advantages claimed for this packing are the following: It has fewer parts than any other metallic packing, and is said to be the only packing which employs the steam pressure to make it tight on the rods, the rings closing up as they wear. It relaxes the pressure on the rod when the engine is shut off and running on a down grade, and is not surrounded by a retaining or compressing cone to tighten it on the rod, which keeps it there when steam is shut off, and the rod is running dry. There is a cellar in the valve stem case of horizontal rods, which allows the packing to settle with the rod, and so prevents touching and causing leakage without being too large in diameter. This packing when applied to a parallel rod will keep it true. It is made by Messrs. Watson and Stillman, New York. —*Master Mechanic.*





HEAT ENGINES OTHER THAN STEAM.—III.

(*Continued from page 637.*)

In an engine of either class, a fresh charge of air may be drawn in for every stroke, the air may be used under an initial pressure, or at atmospheric pressure, and may be exhausted from the engine when it has done its work, or the same air may be used continually, the power then being obtained by heating and cooling it for each stroke.

These hot-air engines of Stirling's and of Ericsson's—the earliest as they were—contain all the elements of practical success which, so far as we now know, are capable of being usefully employed in similar engines.

If this is so, you may ask me, Why did they fail to become more popular? Well, they failed from practical reasons—practical difficulties arising from working and manufacture; and as these practical difficulties and practical reasons are those which limit the usual effect to be obtained from any hot-air engines—popularly so called—it may be as well to briefly consider them at this stage.

As I have said, Stirling's engine had the heat transmitted to the working agent—the air—through the thickness of the cast-iron air vessel shown on the diagram.

Now, air is, practically, very difficult indeed to heat; it is one of the worst conductors of heat we know, and it is impossible in such an engine to transmit the necessary quantity of heat to the air sufficiently rapidly, unless the surface exposed is very large.

Very low maximum temperatures, as a fact, are obtained with engines such as the "Stirling," where the heat is transmitted through the thickness of a metal plate. In a Stirling engine, indicating as much as 37 horse power, the maximum initial temperature was only about 650 deg. Fah., and the final temperature only about 160 deg., and to obtain this difference of temperature a machine, or engine, was required so bulky as to weigh a little more than one ton for each indicated horse power that was obtained. In the steam engine of a torpedo boat the indicated horse power is obtained from as small a weight as 45lb., including in this the proportion of weight of the boiler and of its water.

Further, the high temperatures to which the heating vessels of such hot-air engines must be subjected, in order that the temperature of the air shall be raised as high as possible, cause these vessels to be rapidly burnt out and destroyed.

You may say that, if this plan of working of Stirling's, where the heat was transmitted through a metal plate, was a failure, why not let the fire burn directly in the air which has to be heated, still using this air under an initial pressure, as Stirling did? This plan has been tried in the Wenham engine—one of the most successful of the more recent hot-air engines—and in other similar engines; but, on consideration, you will see that this plan has also its disadvantages. You will see that the air, after it has passed through the fire and has done its work, must be exhausted from the engine, for fresh air is required to support combustion, thus losing that portion of the heat taken away in the air when it is exhausted. You will also see that as the fire must be stoked—or, in other words, as fresh fuel must be supplied to it—this must be done without permitting the air which is under pressure to escape. Further, it is found, in practice, that where the fire is directly in contact with the air used for a working agent, this air takes up, in its passage through or over the fire, grit and ashes, which cause friction and rapid wear in the metal surfaces in moving contact.

This brings me to the question of lubrication, which has been a source of great difficulty. With the high temperatures which can alone be economical, either lubrication is insufficient, with the result that the friction is great, or if lubrication is at all satisfactory, then it can only be carried out at great cost, and with some such material as plumbago.

One further and almost insuperable practical difficulty connected with this class of hot-air engines has been found, and that is the difficulty of keeping the various joints tight, and avoiding leakage. The high and constantly varying temperatures cause unequal expansion of the metals of which the heating vessels and working cylinders are composed, with the result that these are warped and twisted. Further, it does not at all follow that a joint which is satisfactory when the metals in contact are cold, and is then capable of standing sufficiently high air pressures, will be equally satisfactory when the metals are hot, or when they are subjected to numerous and rapid variations of temperature. In addition to this a leakage of air, which is (unlike a leakage of steam) invisible, is not so simple a matter to detect; and thus the leak may only make its presence known by the lessening of the pressure and of the speed of the engine, or by its stoppage altogether. Again, in this class of hot-air engines, where the air is used under initial pressure, valves of some kind are absolutely necessary, and these are great sources of trouble, the difficulty being to keep them tight. The high temperatures cause warping, and the ashes and grit cause scoring of the surfaces in contact.

Professor Rankine, in his work on the steam engine, discussed very fully the various advantages and disadvantages to be obtained from the use of hot air in motive power engines. The theoretical conclusions at which he arrived were strongly in favour of such engines, but the practical difficulties I have enumerated, and other minor practical difficulties which exist, have up to the present prevented an extended use of hot-air engines except for small powers.

In the two forms of hot-air engines which are most generally in use now-a-days in England, the design is such as to eliminate most of these practical difficulties, but even in these the power obtained is small in comparison with the weight of the engine.

I have thought it well, in order to enable you the more readily to follow the description of these two forms of hot-air engine, to provide you not only with diagrams, but to have working models prepared, showing the relative movements of the pistons and displacers.

The "Rider" engine is one which is, as I have said, at present largely used for small powers. It illustrates very satisfactorily the various advantages obtained in those engines where the air is used over and over again, and is never exhausted from the engine, being heated by the external application of heat to a vessel or cylinder in which the air is contained.

I have here a working cardboard model of this engine. You will see from this that there are two vertical cylinders, each of which has in it a piston, or plunger, their strokes and diameters, however, not being equal; that in the power cylinder, in which the air is heated, being the larger. One of these (that to the left) may be called the compression plunger, or displacer, and the other to the right may be called the power plunger. You will see from each of them a connecting rod is taken, these rods being coupled to two cranks, one on each end of the crank shaft, this shaft carrying the flywheel in the middle of its length. The cranks are placed at such an angle with regard to each other, that when the one is at the bottom of its stroke, the crank of the power plunger is slightly above the middle of its stroke. You will see that under the power cylinder there is the fire, and surrounding the cylinder in which the displacer works there is a water jacket for cooling.

Let us now move this working model, and let us place the plunger at the bottom of its stroke.

You will see that the plunger is now slightly below the half-stroke upwards. You will also see that between the two cylinders there is a passage open at all times to both the cylinders, and having in it a series of thin wrought-iron plates placed very close to each other, so as to form "the regenerator"—the air in passing backwards and forwards from one cylinder to the other having always to pass through this regenerator. We have here, therefore, two vessels, one kept hot, the other kept cold; the capacity of these vessels capable of regular variation (not only as regards each vessel, but, in some parts of the stroke, as regards each other) by the movements of the plungers, and in the passage between the two vessels there is the regenerator for storing up and giving out the heat from the air passing to and fro.

(To be continued.)

THE LEEDS AND LIVERPOOL CANAL.—GREAT IMPROVEMENT SCHEME.—At the half-yearly meeting of the Leeds and Liverpool Canal Company, held recently, at the offices, Liverpool, Mr. A. Harris, the chairman of the company, moved a resolution that the company should take Parliamentary powers for the improvement of the canal. The scheme proposed includes the deepening of 103 miles of the canal to a depth of 5ft. 6in. at a cost of £750,000; the erection of reservoirs and the construction of large barges, making a total of £833,000. By this means flats carrying 80 tons will be able to use the canal, and in addition to the increase of traffic thus gained, it is estimated that a saving of over £13,000 a year will be effected on working expenses and repairs. The resolution was adopted by the meeting.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

PULLEY BLOCK LOADS.

To the Editor of "The Practical Engineer."

SIR,—We are not surprised that your correspondent, "Engineer," should write you as to the difficulty of his position, for it is an anomalous one, brought about in great measure by the competition of different pulley-block makers. Perhaps you will permit us to explain, as makers of pulley blocks and lifting machinery, that the term test load is one very well understood by the trade generally and by users who have had a little experience in purchasing such appliances. We do not undertake to guarantee to every purchaser that his pulley block shall lift whatever load he likes to apply to the hook, and how he may wish to apply it, but what we do will give him a certain responsibility in the methods of his working, so that there shall be a check upon carelessness and ignorance. The pulley blocks, as we make them, are marked as your correspondent has pointed out, and that surely is plain enough for anyone. It is following out the well-known rules of all engineering practice to test an appliance with a greater load than its actual working load. Every bridge, every viaduct, every crane, and every boiler even, is thus tested. Because we test a boiler up to 120lb. per square inch, it certainly would never be expected that such was to be the working pressure; and, in like manner, when applying, as we often do, to Government cranes and lifting appliances a test load of 50 per cent in excess of the actual working load, no one imagines hereafter that such will be a safe working load. In fact, we should repudiate all responsibility in the consequences were such to be the case. We will grant your correspondent his point that it might simplify matters to mark on the working load, but at the same time we meet his objection by pointing out to our customers, whenever they tell us what they are going to do with our pulley blocks, that the test load is simply the experimental, not the actual working load.—Yours, &c.,

Ryland Street Works, Birmingham. YOUNGS.

FIRE BRIDGES.

To the Editor of "The Practical Engineer."

SIR,—I should like to have an expression of opinion from some of your practical contributors as to the utility of fire bridges in the furnaces of steam boilers. Do they serve any purpose other than that of preventing the fuel being thrown beyond the fire grate? What considerations should regulate their height or breadth? Is there any disadvantage in building them too low, for instance? That evil may result from their being built too high—that is, too near the crown of furnace—I know from experience. Some years ago, a bricksetter engaged to build up the bridges of one of my boilers after the annual thorough inspection, left a space of only about six inches between the top of the bridge in the centre and the furnace crowns, and the boiler was put to work without this being noticed. The result was that the draught was interfered with, and the fireman required to be continually poking up the fires, the work of the boiler was done principally in the furnaces, and a set of bars was completely destroyed. The insurance companies recommend the removal of fire bridges at each thorough inspection, which it seems to me is quite unnecessary; and if the bridges are of no use, it would be an advantage not to build them higher than the bar level.—Yours, &c., ENGINEER.

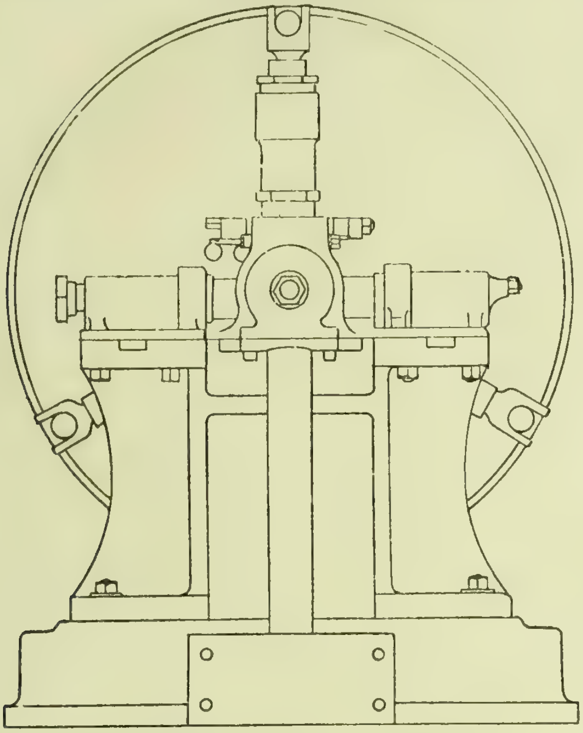
QUERIES AND REPLIES.

97. CORROSION IN STEAM CYLINDER.—I have recently seen an old steam cylinder in which a deep groove is corroded into the metal of the cylinder at each end of the piston stroke. The groove is so deep and completely round the circumference, that the metal is almost eaten through. Can any reader explain this?—E. H.

Answer.—Without further particulars, I should assume that the grooves in the interior of the cylinder are caused by the use of adulterated tallow or unsuitable oil in the cylinder oil cup, the acids or other impurities from which often eat into the cast iron in a peculiar fashion. I have seen internal details nearly corroded through attributed to this cause. There are no end of troubles occasioned by the use of unsuitable cylinder lubricants, some of which make the cast iron in contact with the steam and the oil nearly as soft as lead; others eat away the threads of the piston rod and nut, or the piston plate studs. I have used Englebert's cylinder oil for years, and have had no trouble with cylinders or details since its introduction. There are doubtless other mineral oils equally good in the market, but I have had no experience with these.—F.

96. STROKE OF HYDRAULIC ENGINE.—What is the advantage derived from making the stroke of a hydraulic engine variable? How is it done? A sketch will oblige.—J. S.

Answer.—The object of making the stroke of a hydraulic engine variable is to overcome the objection so frequently raised to the application of hydraulic power, viz., that it was impossible to vary the consumption of pressure water in proportion to the power given out; for instance, the average load on a crane or capstan is only about one-half the maximum load, and consequently, as a rule, one-half of their power is expended to no purpose. This difficulty has been overcome in the engine designed by Mr. Rigg, of which the appended is a rough sketch, intended only to illustrate the method employed. In this engine there are three single-acting cylinders which turn round on a stud, the piston rod ends being connected with crank pins on the rim of a steel disc, carried by a shaft at the back connecting it to the capstan by gear as required. If, then, the centres of the cylinders and the centre of the steel disc be coincident, as shown in the sketch, then there would be no movement were the water turned on; if now the central stud on which the cylinders revolve be moved either to the right or left, the pistons will move in the cylinders, and on admission of water the engine would turn, the direction of rotation being governed by the way in which the central stud is moved; and as the divergence of the centres increase so does the stroke until it reaches the designed limits, thus enabling the power exerted to be regulated according to requirements. The movement of the stud is effected by means of a supplementary hydraulic engine consisting of two rams, one being of twice the area of the other (shown in the sketch), the smaller one being under constant pressure, whilst the full pressure can be admitted behind the larger ram, or communication can be made with the exhaust. The water enters at the union A, passes through the fixed cylinder and its ram to a port in the bearing, carrying the central stud. The admission and discharge of the water to the working cylinders are regulated and effected by their own angular motions, the ports being at the bottom of the cylinders. —B. R. G.



98. **Working out Valve Gear.**—Would some of your readers be good enough to inform, me as early as possible, the best book I can get explaining clearly how to draw and work out the following valve gears—Joy's, Hackworth's, Morton's, &c.?—Valve Gear.

Answer.—I know of no book treating of these gears which would suit "Valve Gear," but he will find an article under the heading of Radial Valve Gears in *Engineering* of September 17 and October 8, 1886, explaining Joy's, Hackworth's, Marshall's, Angström's, and Brown's gears. Morton's is more recent, and a description of it will be found in *Industries* of July 29, 1887; also in its application to the engines of the steamship Circe (see *Industries*, February 1, 1889) it is again described. A paper was read at the last meeting of the Institution of Marine Engineers, Tuesday, September 24, by Mr. R. Bruce, on Morton's Valve Gear and its advantages. A very clear and full description for setting out Joy's gear was given in *The Practical Engineer* of December 7, 1888.—Radial.

99. **Strut.**—I want to find what a round rod of wrought iron, say 3ft. long and 2in diameter, will carry with safety when acting as a strut. Again, given the length of a rod (round), and the load it has to carry, to find what the diameter should be.—Luton.

Answer.—As "Luton" does not state in his query whether his strut is fixed at both ends, jointed at one end and fixed at the other, or jointed at both ends, we give below the formula to be applied in each case, as deduced from the experiments and investigations of Mr. Hodgkinson for round wrought-iron struts, 4 being used as a factor of safety.

Then, if fixed at both ends,

$$L = \frac{7{,}068\,d^2}{1 + {\cdot}0003\,\frac{l^2}{d^2}}$$

and jointed at both ends,

$$L = \frac{7{,}068\,d^2}{1 + {\cdot}0012\,\frac{l^2}{d^2}}$$

or fixed at one end and jointed at the other,

$$L = \frac{14{,}137 \times d^2}{2 + {\cdot}0015\,\frac{l^2}{d^2}}$$

in which L = the safe working load in pounds
l = the length of the strut in inches
d = the diameter of the strut in inches

So that in the case given in the query of a round wrought-iron strut 2in. diameter and 3ft. long, the safe load it would carry, assuming it to be fixed at both ends, would be—

$$L = \frac{7{,}068 \times 4}{1 + {\cdot}0003\,\frac{1{,}296}{4}} = \frac{28{,}272}{1{\cdot}0972} = 25{,}767\text{lb.} = 11{\cdot}5 \text{ tons.}$$

And given the length l and the load L it has to carry, the diameter would be given by the formula

$$d = \sqrt{\left(\frac{\sqrt{(8{\cdot}48\,Ll^2 + L^2)} + L}{14{,}136}\right)}$$

—Strut.

103. **Power of Beam Engine.**—I am in charge of a beam engine. Its cylinder is 12¼in. bore, length of stroke 3ft., making 60 revolutions a minute, the air pump 8in. bore, and worked at 50lb. pressure, and I should feel obliged if any of the readers of *The Practical Engineer* could inform me to what amount of I.H.P. it would drive.—Simple.

Answer.—"Simple" does not give the point of cut-off, nor the vacuum obtained. I have assumed that the engine is cutting off at half stroke, and I have taken the vacuum as 10lb. per square inch. And with these particulars added to the information supplied by "Simple," by the usual calculations I make out that the engine should be capable of developing 48 I.H.P. These figures are approximate, the exact power depending upon the state of the engine. For instance, if the engine is a long way from the boiler, and the steam is conducted through a small pipe, the initial pressure in the cylinder may be considerably less than the boiler pressure. This will reduce the power. If the steam is very much wiredrawn on admission, owing to a throttle valve or to contracted steam ports, or if the piston is leaking, an allowance must be made for these defects. "Simple" should have his engine indicated with the present load. He would then be able to see if all these matters were satisfactory. The power given off could be calculated, and it could readily be ascertained whether the engine was working up to her maximum power or not.—W. F.

107. **Hardening Machine Parts.**—I have seen machine parts after being hardened which have a very nice appearance, similar to what may be seen on gun barrels. I should be glad to hear of a way of doing this. Potash or case hardening does not give the result desired.—R.

Answer.—After the parts have been case hardened, clean off any roughness from the surface, wipe the details all over with oil, and hold them over a smoky fire until dry. I have seen this plan used, but I am not sure whether it is the usual method of producing gunmakers' black surfaces.—F.

---

100. **Pulsometer.**—What is the reason for giving the upper portions of the condensing chambers their peculiar tapered form?—Shiny Boots.

101. **Differential Pulley-block.**—In what way are the parts of these blocks arranged so as to get excessive friction, which must equal half the load, except in some cases where special retaining mechanism is applied? I should be obliged by sketch and description of the last-named arrangement. Shiny Boots.

104. Will some experienced correspondent oblige querist with a rough dimensioned sketch of the most modern double-brass furnace suitable for, say two 46lb. pots?—Mechanicus.

105. What are the most approved dimensions of a cupola capable of melting four tons per hour, blast pressure; size of wind belt, number of tuyeres and dimensions of same, also whether round or square, thickness of furnace lining, and approximate consumption of coke per ton of iron?—Resurgam.

106. **Anti-Calcaire.**—Will you kindly inform me as to what this is composed of, and what action it has on hard water? Would it be suitable for use with feed water?—Marine.

108. Will any reader kindly show me how to work out the following problem? If a weight of one ton falling from the height of 15ft., what would be the force it would have on the ground?—T. M. P.

109. Will some reader kindly give me particulars of the motor employed by the French officer who recently constructed a very large and elaborate balloon? Perhaps some reference to the description, if it has been published, can be given.—F. B.

110. Will any reader kindly inform me what is the best varnish for varnishing mechanical drawings; also how it is made?—C. A B.

111. **Paddle-wheels.**—How is the curve of the float obtained, as in the wheels of recent cross-channel boats?—Shiny Boots.

PATENTS AND INVENTORS' QUERIES.

11. If I license a firm to make and introduce, on royalty, my invention, what steps should I take for my own protection?—E. L., Liverpool.

Answer.—You should have an agreement on stamped paper, or bearing a sixpenny stamp, setting forth what royalty is to be paid you, when it is to be paid, and the minimum amount that is to be paid you in any given time to keep the license in force; you should also have a right to examine the books relating to such sales periodically.

12. Can I sell my invention outright during the provisional stage, and what course have I to pursue? Must it be registered at the Patent Office?—E. L.

Answer.—You can draw up a memorandum agreeing to sell when the invention is completed, and it will virtually be perfectly valid between you, but it cannot be registered until the patent is sealed. Great care is required in this matter of licensing.

13. Having obtained provisional protection for an article, can we stamp them "Patented," and offer them for sale before completing patent, without infringing the law?—B. and H.

Answer.—You are not actually in possession of a patent until it has been sealed. You therefore commit an offence by putting the word patent on before that time. You should put "Prov. Patent," or "Pl. Patent," until sealing.

TO CORRESPONDENTS.

A. W. L, Saltley.—The arrangement and details of construction of automatic brakes were illustrated fully in *The Practical Engineer* of August 30.

J. B. W., Newton-le-Willows.—If you write to the Secretary of the Science and Art Department, South Kensington, London, and enclose three stamps, you will no doubt get all the information you require.

MISCELLANEA.

☛ During the recent successful runs of the City of New York the record of fast travelling was established. At one time during the passage she made 100 knots in four hours and fifty minutes.

The Junior Engineering Society.—We are informed that Professor John Perry, D.Sc., F.R.S., has accepted the presidency of this society for the ensuing 9th session. He will inaugurate the proceedings by delivering an address on "Mechanical Engineering in Electrical Industries."

The Lighting of Barnsley.—The Barnsley Gas Company have given notice to increase the price of gas from 3s. to 3s. 4d. per thousand. The increase is exceedingly unpopular, and a meeting of the consumers has been called, to decide what course shall be taken in respect to it. The electric light, and a resolution not to use gas at the enhanced price, are spoken of.

About Flexible Metallic Tubing.—Considerable interest was shown at the Brussels Exposition in 1888 in a form of flexible metallic tubing exhibited by the Belgian and Colonial Flexible Metallic Tubing Company, at Brussels. The tubing was formed by wrapping strips of metal spirally around a mandrel. The metal strips were bent over at both sides, and a thin narrow rubber band was inserted to prevent leakage. The tubes could be bent in any direction, were perfectly tight, and were claimed to possess great resistance to both internal and external pressures, and to be easily handled and repaired. They were designed to compete with rubber hose in its various applications, and according to present accounts have met with a fair share of popularity. The tubing shown at Brussels was of brass, and of a wide variety of sizes.

Why does Oil Calm Troubled Waters?—In the Mathematical and Physical Science Section of the British Association, on Saturday week, Lord Rayleigh, speaking on the extensibility of liquid films, made incidental reference to the extraordinary effect of oils in calming waters. It had long been a matter of wonder, he said, how a minute quantity of oil could produce the effect it did by taking the energy out of great hollows on the ocean. The explanation given by Aitken was that in the case of pure water the surface is the same as the interior. Accordingly, the surface is subjected to alternate stretching and contraction. But if you have a skin on the surface of the water, and that was the effect of adding the oil, the skin would refuse to be stretched in one part and contracted in another. Thus the skin formed a great obstacle to the formation of waves, and so the mystery of calming the troubled waters was explained.

The Electric Light and Marine Animals.—In the Biological Section of the British Association at Newcastle, on Monday week, Professor Herdman read a paper on the electric light as a means of attracting marine animals. The first application of this important method of collecting appeared to have been made, he said, by the United States Fish Commission in 1884, and that and subsequent experiments had been attended with good results. In May, 1888, the Liverpool Marine Biology Committee made submarine electric light experiments on board the steamer Hyæna, when illuminated nets put down at one side of the vessel yielded good results, while nets without any light put down at the other side yielded practically nothing. He also detailed further experiments, and said the results showed that the submarine electric light was an important addition to the collecting methods by the marine biologist. As to the practical application of this method to fisheries, while the electric light acted powerfully in attracting many free-swimming animals, and especially crustacea, there was no good evidence that it attracted marine fishes, and he was inclined to think the method was of more value to the scientific biologist than to the practical fisherman.

The New Docks at Swansea.—The siding accommodation of the port of Swansea is now said to be equal to any traffic that may be offered for some time to come. For the Prince of Wales Dock coal traffic the trustees have standing room for 10,000 tons, and the Great Western Railway at the Burrows 6,000 tons, and 6,000 tons on the Danygraig sidings, making a total of 22,000 tons, exclusive of the accommodation made by the Rhondda Railway Company, which will be about 3,000 tons. For the North and South Docks, the Great Western Railway have room for 6,000 tons, the Midland 5,000, and the London and North-Western 3,000 tons, making a total for the three docks of 36,000 tons of coal. The tin-plate, pig iron, copper, iron, and other ores, bar, and general goods traffic is also well provided for, having standing room at the Prince of Wales Dock for 700 wagons, and at the North and South Dock for about 350. On the north side of the dock gangs of men were busily engaged in constructing the new Great Western Railway line leading to their new tip, No. 5, which will accommodate the largest class of steamers, being 10ft. higher than any existing tip in the port, and thus supplying a want which the traders have long pressed for. The Midland Railway Company has but one tip at the East Dock, situate on the north side, adjoining the Great Western Railway Wharf, where they have 420ft. On the west end they have 620ft., which at present is only partially employed, the appliances consisting of one crane only.

Boiler-makers and Shipbuilders.—The report of the United Society of Boiler-makers and Iron Shipbuilders for the past month has just been issued by the general secretary, Mr. R. Knight. It says: We are pleased to see that the same briskness of trade still continues in most of our shipbuilding districts. On the Clyde, for instance, there are on hand 140 vessels, which represent a gross tonnage of 270,000, which looks healthy, and means work for our members for many months to come. Trade in the Hull district has somewhat fallen off, but we are in hopes that it will be of short duration. In the Mersey district, we are glad to see that trade is better than when last reported. Trade in the inland towns is very good, and no one requires to be out of employment. While trade is so good, we are sorry at having to complain of our members losing so much unnecessary time, but we cannot help drawing the attention of our members to this fact, as nearly every post brings complaints of this evil, which we trust will soon be cured.

The Corporation of Bradford has just opened works for the supply of electric light in the centre of the town. The experiment will be watched with interest for two reasons. In the first place, Bradford is the only corporation which has undertaken to supply electric lighting at its own risk; and in the second place, the corporation is the owner of the gas undertaking, with which the electric light must necessarily compete. The result of a year's working of the experiment should, therefore, furnish useful guidance for other municipal authorities who have the control of gas monopolies, since it will show how far the gas revenue is likely to suffer, and also to what extent the electric light can be profitably supplied under corporation management. The Bradford experiment is not arranged on a very large scale; the amount of expenditure authorised by the order being only £25,000, of which the present installation has absorbed a little more than £20,000. The plant laid down is equal to the supply of 5,000 incandescent lamps of 16-candle power; and the price fixed for the light is double that charged for an equal amount of gas. It is not intended to light the streets by electricity, but only to supply the illuminant to shops, houses, &c. With reference to a point which has been already discussed in Birmingham, it may be mentioned that the corporation are not employing overhead wires; the "leads" are laid in underground trenches on each side of the streets. As to the competition with gas, the corporation have come to the conclusion that no danger is to be apprehended, as the experience in Bradford is that the use of gas continues to steadily increase, especially as a motive power and for house-warming and cooking purposes.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

September 7th.

14134 Flying Engine, J. K. Smythies, Colchester.
14142 Fire Engine, J. C. Merryweather and C. J. W. Jakeman, Kent.
14149 Gas Lamps, W. P. Thompson, Liverpool. (F. Stellwag, Germany.)
14151 Motors, V. A. Duda, London.
14154 Motive Power, J. Bennett and R. S. Best, London.
14160 Locking Nuts, W. H. Mirfin, Manchester.
14161 Pulleys, R. Morris and J. Wood, London.*

September 9th.

14166 Steam Engines, A. Gough, London.
14175 Ventilators, J. A. Beattie, Glasgow.
14190 Steam Boilers, G. G. Rhodes, J. S. Critchley, and A. Johnson, Bradford.
14193 Rotary Engine, C. J. Fletcher, London.
14197 Heating Water, E. E. Sheldon, A. Mills, and S. Pym, London.
14199 Ammoniacal Engines, H. E. Black and L. Mason, London.*
14216 Motors, W. W. Dunn and W. L. Watson, London.
14221 Air-heating Apparatus, H. J. Sieprath, London.*
14224 Buffers, I. Widdop, London.
14229 Furnaces, H. H. Lake, London. (Tommaso G. B. de Ferrari di G. B., Italy.)

September 10th.

14232 Magneto-electric Machines, H. J. Allison, London. (A. S. Fitch, United States.)*
14233 Tool Handles, W. A. Sadler, London.
14241 Automatic Cut-off Engines, I. F. Thompson and W. L. Palmer, London.*
14247 Valve Gear, C. Day, Manchester.
14252 Screws, C. D. Rogers, London.*
14259 Steel Pipes, G. H. Lloyd, Birmingham.
14261 Compressing Copper Bands, J. S. Taylor and S. W. Challen, Birmingham.*
14268 Recording the Pressure of Gas, W. R. Chester and J. Selby, London.
14271 Girder Fish Plates, F. C. Winby, London.
14279 Magnetic Separator, H. J. Haddan, London. (G. Conkling, United States.)*
14286 Pipe Coupling, W. H. Slinn, London.
14289 Furnaces, W. P. Powers, London.
14290 Elevated Railways, H. H. Lake, London. (L. J. Cody, United States.)*

September 11th.

14318 Valves, J. Hamilton, Glasgow.
14338 Furnaces, C. A. Sahlström and J. C. Bromfield, London.
14339 Valves, H. Trott, London.
14348 Boring Machines, R. Stanley, London.

September 12th.

14374 Arc Lamps, G. E. Dorman, Stafford.
14378 Gas Motor Engines, J. Shaw, Leeds.
14398 Compressed Air, H. J. Allison, London. (C. Cummings, United States.)
14404 Motors, J. Murrie, Glasgow.
14408 Foundary Sand, J. Patrick, London.
14416 Furnaces, F. Radcliffe, London.

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE
PRACTICAL ENGINEER,
OCTOBER 11TH, 1889.

WHY DOES STEEL HARDEN AND TEMPER?

THE very peculiar and special properties of steel are of the most vital importance to the engineer, and it is difficult to imagine the condition to which the practical mechanic would be reduced if steel were suddenly annihilated, and only soft iron allowed to remain in existence. We are so familiarised with steel and its properties, that we feel it the most natural and common matter to produce tools of varying hardness by very simple manipulation, and to change the entire properties of the material we handle simply by heating to various temperatures and cooling more or less quickly.

The thoughtful mechanic must often be struck by the hardening and tempering of steel, and the great effects produced by apparently trifling changes in condition. Not only so, but the various kinds of steel and iron, each well adapted for different uses, are now so numerous that we cannot but admire the success of metallurgists in producing materials so nicely graduated to the purposes of the engineer.

Practical engineers have but little time to investigate the causes of these wonderful properties, although, from necessity, we are very familiar with the modes of utilising them in daily work. Like every other practical detail, the mode of working proper to each kind of steel has only been discovered by actual trials, and by repeated failures. We have groped about in the dark until we have hit upon the facts we searched for, and, provided steel or other metal can be worked and suited to our purpose, we do not trouble ourselves much to inquire the why and wherefore. Why does steel harden and temper? This is a question which many of us have asked without being able to get a satisfactory reply. We are, accordingly, very grateful to the scientific investigators who make experiments, and endeavour to answer it. The answer may be practically useful, or it may not; but, in any case, intelligent men prefer to understand as fully as possible the true nature of the operations which they conduct.

Accordingly, we read with great interest the lecture delivered by Professor W. C. Roberts-Austen, F.R.S., before the members of the British Association, in Newcastle, on Sept. 13. Professor Roberts-Austen describes very clearly the leading facts and theories regarding the hardening and tempering of steel, and although he fails to arrive at thoroughly definite and satisfactory explanations, yet he makes many mysterious phenomena a little more plain, and suggests reasons which may be further developed in the future. Steel is defined as modified iron; and, according to an old writer, "Its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water, the hardness produced being greater in proportion as the steel is hotter and the water colder. The colours which appear on the surface of steel slowly treated direct the artist in tempering or reducing the hardness of steel to any determinate standard."

In these two sentences we have a very complete account of nearly all that was known regarding hardening and tempering for many years. Indeed, the knowledge of the average engineer on the subject does not extend beyond these limits even now, except in the special details of the means of obtaining the temper required for the articles usually handled by him. There is still considerable confusion between the words "temper," "tempering," and "hardening," and according to Prof. Austen the word "tempering" should be employed in the sense of softening. Hardening is the result of rapidly cooling a strongly heated mass of steel. Tempering consists in reheating the hardened steel to a temperature far short of that to which it was raised before hardening, and this heating may or may not be followed by rapid cooling. Annealing consists in heating the mass to a temperature higher than that used for tempering, and allowing it to cool slowly. These statements very briefly but very comprehensively define the principal results obtained by heating and cooling steel. We do not intend to traverse the whole ground covered by the lecturer, but merely to discuss so much of it as is necessary to clearly understand the nature of the theories advanced to account for tempering and hardening.

The chemical difference between iron and steel is very slight, and consists in the presence of a small proportion of carbon, some part chemically combined with the iron, and some considered to be present in solution only. At the end of last century it was surmised that steel differed from iron in containing carbon, and this fact was conclusively proved early in this century. But although this made a step in advance, and it was shown that the greater the proportion of carbon present the greater was the degree of hardness which could be imparted to the steel by rapid cooling, yet this fact did not offer anything like a complete explanation, as it was found that if a certain percentage of carbon be exceeded a steel was produced which became softer at an intermediate high temperature; that is, the steel was harder at a high temperature immediately after it left the furnace than after cooling somewhat.

Professor Austen performed a remarkably telling experiment, which was fully visible to his large audience. He heated a bar of steel containing a considerable quantity of carbon to a good red, in a gas furnace, and then he withdrew it from the furnace, firmly fixed one end, and upon the other end he hung a considerable weight, but not enough to bend the bar appreciably. The bar remained apparently straight without yielding at a red heat, but immediately it cooled considerably it at once became much softer, and yielded a good 6in. Instead of continuously becoming harder as it cooled, it became softer at a certain point, after which it again hardened. Mechanics have long been aware that some steels become harder to work when highly heated, and considerable judgment on the part of the smith is necessary when dealing with hard tool steels, in order to work the metal at just the right heat. This experiment places this peculiar quality of hard steel before us in a clear way, and one which it is almost impossible for us to forget.

Many experiments have been made upon soft and comparatively pure iron, which prove distinctly that the nature of iron changes with the change of temperature. Iron at low temperatures is powerfully magnetic, but when heated to a certain point, about 700 deg. C., its magnetic properties entirely disappear. At the same temperature its specific heat undergoes a sudden change, and Hopkinson has proved that the phenomena of recalescence occurs at the temperature at which iron ceases to be magnetic. Recalescence is a peculiar property, and consists in the faculty of glowing again when cooling after iron has passed the point of blackness. Many substances have this property, and in some powders it is readily observed by heating the substance in a crucible; at a certain temperature the substance suddenly passes from a black heat to a good red, without oxidation or other change of chemical composition. In the case of soft iron, if it be heated red and allowed to cool slowly, at a certain temperature, when it has gone black, it suddenly evolves heat and glows red again without apparent cause. These changes have caused observers to infer that iron exists in more than one modification, like many other elements.

Carbon, for example, exists in three distinct forms—charcoal, graphite, and diamond—which are nothing but pure carbon, but in chemical and physical properties are as widely different as separate elements could be. Sulphur also exists in two well-defined forms, viscous and ordinary crystalline sulphur. Phosphorus, too, exists as yellow and red. The yellow is soft and extremely inflammable, while the red is harder and by no means so easily ignited. In these cases of sulphur and phosphorus the change in properties is brought about simply by heating, and heating again under certain conditions changes the unstable modifications to the stable. Modifications of elementary substances, produced without combination with any other element, are known as "allotropic" by chemists. Some compounds behave in a similar way—principally carbon compounds—and their modifications are known as "isomeric." If iron, then, is capable of existing as an element in various allotropic states, or as a compound of carbon in isomeric states, which states are produced by change of temperature, then many of the phenomena of hardening and tempering are readily explained.

The iron combined with carbon may have its state of combination changed by heating, and rapid cooling from the high temperature may cause this change to be permanent, so that allotropic or isomeric modifications may be produced which have the property of extreme hardness. In the same way carbon may be separated from the iron by heat, and caused to remain in a separate condition by rapid cooling.

Experiments referred to by Professor Roberts-Austen seem to prove that all this does occur, but still hardening and tempering remain a mystery, and we must meanwhile depend upon our every-day experience of the details of those important operations without understanding them thoroughly.

Science has not yet given us conclusions sufficiently definite to admit improvements in practice based upon them. Still the mystery is extremely puzzling, and we are grateful for any light thrown upon it.

COMPRESSED AIR SCHEMES.

PROFESSOR KENNEDY's paper on the Popp compressed air system, in successful operation at Paris, has given rise to some comment and discussion in the *Birmingham Daily Post.* The *Post* considers it humiliating that we should have so much to learn from French engineers on that subject. It considers the comparative failure, or rather tardy success, of the Birmingham compressed air scheme as an evidence of superior knowledge on the part of the French of the means of distributing power by means of compressed air. Mr. Sturgeon, one of the engineers for the Birmingham Compressed Air Company, naturally objects to this view, and in a letter to our contemporary he seems to infer that because the Paris company commenced operations later than the Birmingham company, they have taken advantage of the latter's plans. He also accounts for his company's present want of commercial success by the restrictions imposed upon them, and the difficulty of obtaining an accurate compressed air meter. Professor A. B. W. Kennedy defends the Popp company, and asserts that the Paris people are not necessarily indebted to him, inasmuch as they commenced on a small scale, and so gained the experience which enabled them to apply the system to motors as well as clocks. We cannot help agreeing with Professor Kennedy. There is no great novelty in distributing power by compressed air, and the details are known to many who have utilised such power for mining and other purposes. We fear, however, that the difficulty, so far as concerns the use of compressed air in this country, is much deeper than Mr. Sturgeon evidently believes.

It is no mere question of a successful meter, but the purely commercial one of relative cost. Motive power is much cheaper in this country than in France, because coal is cheaper, and here we do not restrict its use. In Paris, not only are coal and coal gas more expensive than with us, but the restrictions upon the use of steam engines are much more onerous. Consequently there is more room for a comparatively expensive motive power possessing the advantages of compressed air. From Professor Kennedy's paper, we observe that under ordinary circumstances existing compressed air engines in Paris use about 800 cubic feet of air per indicated horse power per hour, which costs about 3d. Now, 3d. per horse power per hour is a figure which may pay in Paris, but so long as motive power can be obtained for less than one halfpenny per horse power per hour where not less than 30 H.P. is used, and for small powers by gas engines at 1d. per horse power per hour in Birmingham or any other city in Britain, it is most improbable that compressed air can ever be a commercial success.

The question is purely commercial. If compressed air could be proved cheaper in this country than other forms of motive power, the difficulties are by no means considerable enough to prevent competent engineers from carrying out the scheme with perfect success. Hydraulic power is much more expensive than steam or gas power, but it can be applied direct to cranes, lifts, and other special purposes, and, as we noted in our last issue, it is most successfully applied by the Hydraulic Power Company in London, Liverpool, and Hull. As the difficulties faced were much more formidable than any due to compressed air, it will be readily seen that the engineering skill of our country is not at fault, but the commercial foresight of the promoters of compressed air.

WESTINGHOUSE AND WILLANS ENGINES COMPARED.

EXPERIMENTS have been recently made in America upon a Westinghouse high-speed compound engine, running at 300 revolutions per minute, and indicating at that speed 107 horse power, from which it appears that the engine uses 23·6lb. of water per indicated horse power per hour. The boiler pressure was 100lb. per square inch, and the ratio of expansion was 4·71. The economy of the engine was again tested with an expansion ratio of 5·38, but the consumption of water increased slightly, being now 23·71lb. per indicated horse power, notwithstanding that the speed of the engine was slightly higher than in the first test, and the boiler pressure remained unaltered. The consumption per brake horse power per hour was 26·28lb. The dimensions of the engine are—cylinders 12in. and 20in. diameter by 12in. stroke.

These results are not so good as tests published by Mr. Alley,* of Glasgow, where the best result was 19·6lb. of water per brake horse power per hour, but here the engine had cylinders 14in. and 24in. diameter by 14in. stroke, and the steam was condensed. The best result with this larger engine exhausting into the atmosphere was 23·91b. per brake horse power per hour. The engine gave, however, 200 horse power on the brake. Much better results have been obtained in this country by Mr. Willans with a compound engine of smaller dimensions and less power; the water used was only 21·36lb. per indicated horse power per hour. The initial steam pressure was 109lb. per square inch. Mr. Willans' advantage lies in the very small clearances which he obtains by the use of the central valve system. In the Westinghouse engine the valve arrangements allow of considerable loss of steam by long ports.

STRENGTH OF BRASS AND GUN METAL WHEN HEATED.

Some time ago we had occasion to construct a gun-metal exhaust valve of the conical seated type for an engine in which hot air was used. We found, somewhat to our surprise, that although the temperature of the valve did not greatly exceed 700 deg. Fah., yet after a short time of work at that temperature we found that the valve broke up and fell into pieces. We have often puzzled over this. Prof. W. C. Unwin, F.R.S., has recently made experiments on the subject of the tenacity of brass, gun metal, and such alloys at various temperatures, which he has submitted to the British Association, and his experiments throw great light upon our difficulty. He found, in some experiments upon gun metal, that at a temperature of only 400 deg. Fah. the tenacity abruptly fell to one-half. Upon repeating the experiments with other samples, he failed to find this peculiarity; in most cases the tenacity diminished very regularly with increase of temperature.

With common yellow brass at ordinary atmospheric temperature, the tenacity was 24·09 tons per square inch, which fell at 640 deg. Fah. to 14·49 tons per square inch. Delta metal tenacity, cold, 31·16 tons per square inch, and at 650 deg. Fah. 16·04 tons; Muntz metal, cold, 24·68 tons, and at 650 deg. Fah. 17·15 tons; gun metal at 210 deg. Fah. 11·66 tons, and at 615 deg. Fah. 4·82 tons; cast brass at atmospheric temperature, 12·45 tons, and at 645 deg. Fah. 3·23 tons per square inch; phosphor-bronze, cast, at atmospheric temperature, 16·06 tons per square inch, and at 600 deg. Fah. 8·17 tons.

All these metals lose strength enormously by very moderate heating, more especially gun metal and cast brass. In those two cases the ultimate tenacity is reduced to nearly one-third, and in the others to about one-half of that when cold. This is a serious fact, and should be borne in mind when designing valves of brass or gun metal to be exposed to the high temperatures now commonly used in steam, gas, and air engines.

Important Government Contract for Hull.—It is stated that Earle's Shipbuilding and Engineering Company, Hull, have succeeded in obtaining an order from the Admiralty to construct one of the first-class cruisers which are included in the new scheme for increasing the strength of the navy. The new vessel will be of 7,500 tons and 12,000 indicated horse power. She will be 350ft. long and 60ft. broad. The work will be commenced forthwith, and it is expected that the vessel will be completed within two and a half years.

MATHEMATICAL OBSCURITIES.

By Francis Campin, C.E.

It is an obvious fact that a man who is under the necessity of earning his living from an early age has not an opportunity of obtaining a complete mathematical education in an academical sense, and what is more unfortunate than this is that there are too many who take it for granted that mathematical studies during such leisure as they have are beyond their abilities. The difficulties are magnified. It is easy to understand the perplexity of a man who takes up for the first time any standard work on pure mathematics with the view of studying it unaided. He cannot see to what it leads; what, in fact, is the use of it when learnt. A boy at school learns his lessons because they are lessons, and he has to learn; the student at college studies for honours; but the man or boy at the bench wants some practical and immediate outcome to reward his efforts at self-improvement when, already wearied with a day's labour, he turns in the evening to his books.

Our object is to encourage by showing that to those who take up the right clue the difficulties are not nearly so great as they appear at the first glance. The incentive to study in this case arises from the student seeing a condition of things—say the working of a steam engine—and he naturally desires to know the laws upon which they depend. An intellectual youth will not be contented with a set of rules learnt parrot-wise, or kept in a notebook for reference. His mind thirsts for that knowledge that shall enable him to understand, improve, invent, and make him the absolute master of the work he executes.

Once let a habit of logical reasoning be adopted and cultivated, and the mists surrounding mathematical method will melt, and the unity of its various processes become evident. In our opinion, much of the trouble has arisen from the drawing of such strong lines—or rather, apparently strong lines—of division between the different headings of algebra, geometry, trigonometry, &c., when the whole science is one continuous chain of reasoning, firmly interlaced, and establishing its inflexibility by the identity of results, no matter by which path they are reached.

There is little that cannot be done by the arithmetic of figures and lines—for so geometry may be termed. The processes may be tedious, but the results are reached, and in a very convincing way; every step is held in the mind, and the analysis is finished with a sense of conviction unclouded by the doubt that arises when a method is used of which the basis is forgotten. The gravity of the results that hang upon the exercise of practical mathematics keeps the mind in constant tension. An error in calculating the time of an eclipse leads to no material result; nothing is altered, because the computation is not a creative calculation; but an error in a machine or a structure may lead to catastrophes of appalling and disastrous character. Therefore it is that the engineer requires a theory the whole of which can be held in a glance. Let us take a comparison of two methods to illustrate the point we have raised.

There is, for instance, a strain upon a beam carrying a load. It is not the same all along, but beginning at nothing increases to a maximum, and again decreases until it disappears. To find out what the beam will carry, the greatest strain must be found from the formula which gives it at any point. The most elegant mode is by means of the differential calculus, but to be able to use that an acquaintance with that development of mathematical knowledge must pre-exist, and there are few in the ranks of business men who can retain all the fundamental processes of the infinitesimal calculus in mind, the rules only being committed to memory. The following method is more obvious, and carries its own proof on its face. The leading stress on a beam, uniformly loaded and supported on each end, is, at any point distant x from one support, equal to $\frac{w\,l\,x}{2} - \frac{w\,x^2}{2}$, in which $w =$ the load per foot, and l the distance between the points of support, the lengths being measured in feet. The value of x, at which the stress is at a maximum, is required. In that case the stresses for values immediately each side of x will diminish, and therefore there is a point at which the stress may be said to stand still. It is on the turn, and we may imagine it constant for a very small distance. Call this small distance a. Then, as one term is to be subtracted from the other, it is evident that if the remainder is unaltered the addition to each term must be the same. If x becomes $(x + a)$, the first term becomes

$$\frac{w\,l}{2}\left\{x + a\right\} = \frac{w\,l\,x}{2} + \frac{w\,l\,a}{2};$$

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* See *Practical Engineer*, vol. iii., page 534.

the second term becomes

$$\frac{w}{2}\left\{x+a\right\}^2=\frac{w\,x^2}{2}+\frac{2\,w\,a\,x}{2}+\frac{w\,a^2}{2}.$$

The value of a is taken very small, and therefore a^2, being necessarily much smaller, may be neglected (the same as final decimals are dropped in arithmetic). Then the equal additions are $\frac{2\,w\,a\,x}{2}=\frac{w\,l\,a}{2}$, whence $x=\frac{l}{2}$, and therefore the maximum stress is at the centre of the span.

The maximum or minimum, as the case may be, could be instantly found geometrically by plotting a curve of strain, and ruling a line parallel to the base and touching the curve, when the point of contact will be that sought. The graphic method, that of working by lines, has some peculiar advantages, one being that the whole argument is at once under the eye; and another—probably the greatest—that if you make an error you are sure to detect it. Some have objected to this method on the ground of difficulties of scaling accurately, but this can be done quite nearly enough for all practical purposes, and that with only the ordinary drawing instruments. Nearly every draughtsman's instrument case has in it a diagonal scale, reading to one 400th of an inch. If the strains are plotted 20 tons to the inch even, they can be read to within 1cwt., which is quite near enough for structural work, and if dimensions are thus calculated on a diagram at ¾in. per foot, the measurement will scale to $\frac{1}{45}$lb. inch. All that is required is a fine lead pencil, smooth paper (cream laid foolscap is very good for this purpose), and a steady hand and eye, and excellent results will be expeditiously attained.

As soon as the student begins to work graphically, all confusion about negative signs will vanish. Of course we know there is no such thing as a minus quantity arithmetically speaking, but when dealing with lines, if the base is a horizontal line, the plus quantities are plotted upwards and the minus quantities downward, and in reference to a vertical line the plus quantities are plotted to the right, and the minus quantities to the left.

Another source of mystification, on its first statement, is the property of an asymptote—a straight line which is always approaching a curve, but can never touch it. The demonstration of its existence is simple enough. If a straight line be given, and from a fixed point at one side radiating straight lines be drawn crossing it, and of such lengths that they all overhang the given line by the same length, the ends will constantly get nearer the given line, because the angle gets smaller as we get farther from the fixed point; but as no line drawn from the fixed point can ever coincide with the given line, none of its radial lines can ever touch the given straight line with their extremities, and therefore the given line will continually approach, but never touch, a curve drawn through the ends of the radiating lines. The distance between the curve and straight line is limited by the overhang of the radial lines, which is its maximum distance, and occurs when the radiating line is perpendicular to the given straight line. In the other direction the limit is zero, for as the point fixing the curve cannot touch the straight line, it cannot pass over it, and make the distance a negative quantity.

There is in arithmetic a similar case, where, however, the quantity under consideration is increasing for ever, but yet cannot exceed a certain definite value. It is found in any circulating decimal; for instance, in the decimal $0\cdot33\dot{3}$. The last figure we can write can never become a 4, because there is never anything to carry. So in any case of circulating decimals, if they are carried to the desired number of places, and the last increased by one, we are certain that we have included the outside limit; and thus the difficulties referring to infinite series disappear on very little consideration.

We have yet to speak of trigonometry, which to some beginners is a bugbear of formidable dimensions. Trigonometric formulæ certainly do not possess a pleasant aspect for the uninitiated; but, once explained, their simplicity becomes evident. The whole nomenclature is nothing but a system of symbols indicating the relations of the parts of a right-angled triangle to each other, all of which relations depend upon the properties demonstrated in the 47th proposition of the first book of Euclid; and all the formulæ relating to the calculation of triangles are but methods of writing the values so clearly and simply shown in Euclid's Elements.

In conclusion, we would impress upon the minds of students, of whatever age, that mathematical knowledge does not consist of distinct branches, but that it is one concrete system of logical reasoning, which admits of being expressed in several different ways, but that, certain data being given upon which to start, only one result can be reached, whatever method of investigation may be chosen to attain it.

HOTEL ENGINEERING.

PROBABLY the most complete and most efficient—if not the largest—electric light installation of its kind is that which has just been finished at the Savoy Hotel, on the Thames Embankment. This magnificent building, which is scarcely out of the hands of the contractors, is eight storeys high, and occupies a large area of ground.

The boiler-house is located in the basement on the western side of the hotel, and contains four large boilers on the Livet system. Two of these are of the Lancashire type, 27ft. long by 7ft. 2in. in diameter, the other two being Cornish boilers, 27ft. long by 5ft. 2in. in diameter. They are made for a working pressure of 150lb. to the square inch, but are usually only operated at 120lb. The steam from these boilers is conveyed by means of large main pipes to the engines driving the dynamos to pumps and other engines, to be referred to subsequently. The engine-room is also in the basement, and occupies a space of about 90ft. long by 50ft. wide, this allowing of plenty of spare room. There are in all four high-speed compound central valve engines of the Willans vertical type. Three of these are of 160 I.H.P. each, and run at 350 revolutions per minute, whilst the fourth is of 75 I.H.P., running at 400 revolutions.

Four dynamos are installed, all of them being of the Siemens type. Three of these run at 350 revolutions, with an output of 900 ampères at 110 volts pressure, whilst the fourth runs at 400 revolutions and has an output of 400 ampères, the E.M.F. being 110 volts. In each case the dynamo is coupled to the crank shaft of the engine and driven direct from the flywheel of the engine; and for this purpose each dynamo and its corresponding engine are securely bolted to a large cast-iron bed plate, the foundation being composed of concrete. The small engine and dynamo are mainly run during the daytime for the purpose of supplying current to the glow lamps fitted in the basement, at the bottom of the staircases, in the offices, &c. One of the large dynamos is retained as reserve, whilst the remaining two, which are run in parallel, are worked in the evening and night for supplying current to the lamps in various parts of the hotel and to those installed in the Savoy Theatre. (It may here be mentioned in parenthesis that the dynamos formerly employed for the lighting of this theatre were taken away, and the theatre supplied from the new machines without the slightest interference with the lighting.) An electric motor of about 4 H.P. has been erected in the engine-room for the purpose of driving a fan for the ventilation of the engine and basement rooms.

The hotel has its own supply of water, which is obtained from an artesian well, the mouth of which is in the engine-room. The well is 420ft. deep, and for 200ft. the boring is through chalk. On the roof of the hotel is fixed a series of water tanks, and a plentiful supply of water is raised in these by means of two triple sets of 5in. pumps and two 8 horse power horizontal engines arranged in duplicate. There are also two large Worthington compound pumps for pumping water for the hydraulic lifts or American elevators, of which there are six. Four of these are for luggage, &c., whilst the other two, which are 8ft. square and have beautifully furnished cars, are for passengers. There are provided four large heaters, each about 4ft. in diameter, and 16ft. high. These are for heating, by means of the exhaust steam, water for general purposes, baths, &c., for warming the building in winter, and for providing hot feed water for the boilers.

SPIRAL SPRINGS FOR SAFETY VALVES.

THE diagram herewith, giving the size of steel of which the spring should be made, the diameter of the safety valve and the working pressure of steam being given, is constructed from the rule laid down by the Board of Trade, which is, that the size of steel of which the spring is made is to be found by the following formula:

$$\sqrt[3]{\frac{S \times D}{c}} = d$$

In which S = the load on the spring in pounds, or area of valve in square inches × pressure of steam by gauge in pounds per square inch

D = the diameter of the spring (from centre to centre of wire) in inches

d = the diameter, or side of square of the wire, in inches

c = 8,000 for round steel

c = 11,000 for square steel

and from the above formula we get

$$D = \frac{d^3 \times c}{S} \text{ and } S = \frac{c \times d^3}{D}$$

If now we make the ratio $\frac{D}{d}$ constant, and there appears no reason why it should not be so, and writing r for this ratio, then

$$r \times d = D$$

Then $$\frac{S \times r \times d}{c} = d^3 \therefore d = \sqrt{\frac{S \times r}{c}}$$

In constructing the diagram, this ratio r has been taken as $= 5$, which makes a well-proportioned spring, so that we may write out formulæ for the size of steel—

$$d = \sqrt{\frac{S}{1.600}} \text{ for round steel}$$

and $$d = \sqrt{\frac{S}{2,200}} \text{ for square steel}$$

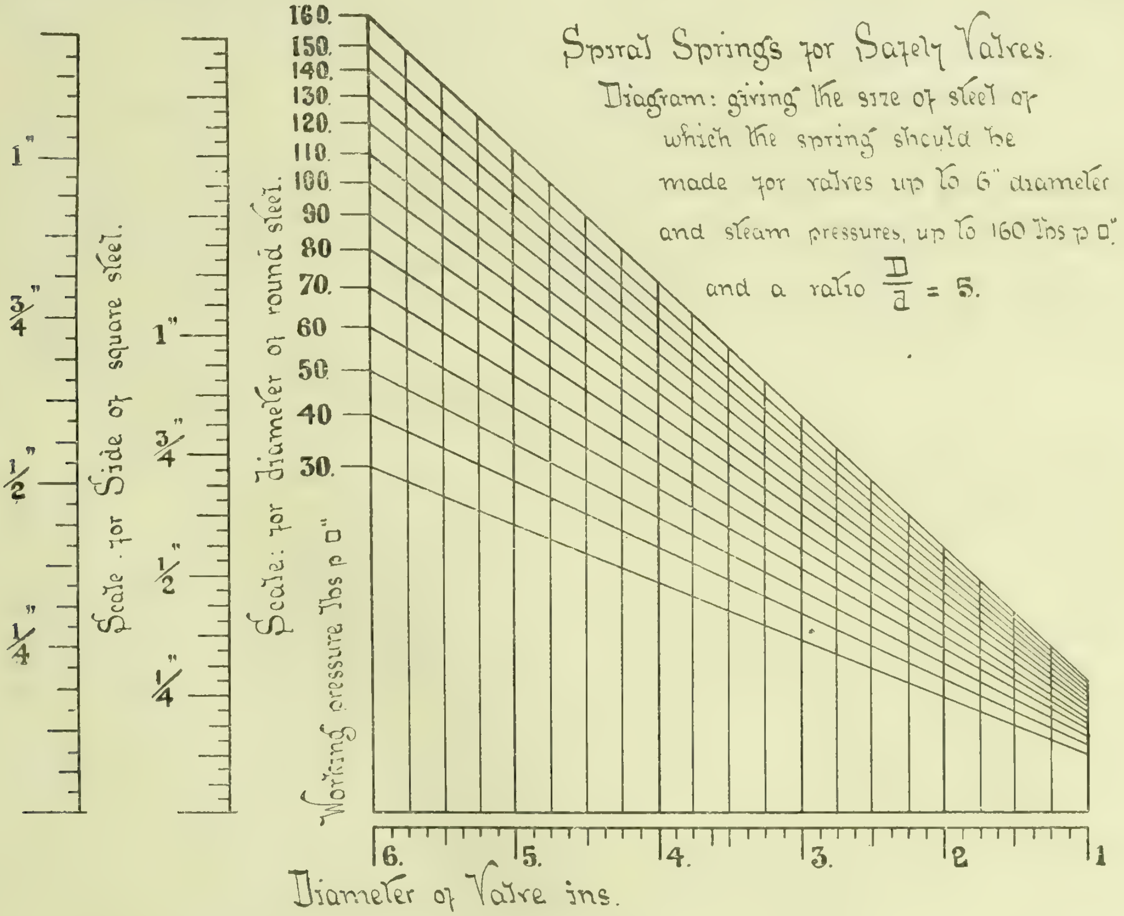
and $$S = 1,600\, d = S \text{ for round}$$
$$S = 2,200\, d^2 = S \text{ for square}$$

from which we see that the safe working load varies as the square of the diameter (or side) of the steel of which the spring is made when the ratio $\frac{D}{d}$ is constant, but if D be constant, then the safe working load S varies as the cube of the side or diameter of the steel.

As an example of the use of the diagram, suppose we have a valve 4½in. diameter equals 15·905 square inches area, for which we require to know the dimensions of a spring suitable for a working pressure of 130lb. per square inch.

SAFETY VALVE AREAS.

Boiler Pressure.	Area of Valve per square foot of firegrate.	Boiler Pressure.	Area of Valve per square foot of firegrate.
20	1·071	90	·357
25	·937	95	·340
30	·833	100	·326
35	·750	105	·312
40	·681	110	·300
45	·625	115	·288
50	·576	120	·277
55	·535	125	·267
60	·500	130	·258
65	·468	135	·250
70	·441	140	·241
75	·416	145	·234
80	·394	150	·227
85	·375		



With a pair of dividers, at the point marked 4½in. on the scale of diameters of valve, measure the length of the ordinate from the base line up to the line marked 130 on the scale of working pressure of steam to the left of the diagram. Transferring this to the scales of sizes of steel, read off 1⅛in. and $\frac{13}{16}$in. as the size of of steel if round or square respectively, or by the formula $d = \sqrt{\frac{S}{1,600}}$, which in this case would be $\sqrt{\frac{15{\cdot}905 \times 130}{1,600}} = 1{\cdot}125$ for round, and $\sqrt{\frac{15{\cdot}905 \times 130}{2,200}} = {\cdot}812$ for square; and since the ratio $\frac{D}{d} = 5$, then mean diameter of round steel spring = 1⅛in. × 5 = 5⅝in., and mean diameter of square steel spring = $\frac{13}{16} \times 5 =$ 4 $\frac{1}{6}$in.

NOTES.—The Board of Trade do not allow of valves being fitted of a less diameter than 3in., unless the case be submitted for the consideration of the Board. The conditions to be complied with which more particularly apply to spring safety valves, are—

1. That at least two separate valves are fitted to each boiler, except in the case of donkey or other small boilers, in which the grate area does not exceed 14 square feet, in which case a single safety valve may be passed, provided it is not less than 3in. diameter.

2. That the springs and valves are cased in so that they cannot be tampered with.

3. That the springs be protected from the steam and impurities issuing from the valves.

4. That when the valves are loaded by means of direct springs

the compensating screws abut against metal stops or washers when the safe working loads are on the valves.

5. That screw lifting gear be provided to ease all the valves.

6. That provision be made to prevent the valves flying off in the event of the springs breaking.

7. That the valves have a lift equal to at least one-fourth their diameter. This is a point that should be carefully looked to, for it is obvious that, unless there is sufficient lift, the effect will be the same as reducing the area of the valve, or increasing the load.

8. That the area per square foot of grate surface of Government safety valves, or (when there is more than one) their combined area, should not be less than that given in the preceding table opposite the intended boiler pressure.

POSITIVE PISTON PUMP.

(Concluded from page 678.)

As percussive action and loss of power, beyond its necessary application to overcome gravity and the small percentage of friction in properly arranged pipes, appear, as we have seen, to arise with the systems considered, except the centrifugal, from structural causes, is it possible to avoid these losses, and the destructive strains which accompany them, by practical changes in construction? Obstructed momentum and excessive friction from sub-division, with conflicting currents, caused by necessity for valves and their sustaining partition, to control the changes in direction of the applied power, are the chief causes of disturbance with reciprocation. We have seen, however, with the other two systems, that momentum may be made a friend instead of an enemy; but they do not exhibit the definite character of work sustained by the reciprocating pumps, which depends upon the direct application of power of the piston, or plunger, acting by displacement within its chamber; it is, therefore, evident that in the construction of a pump for full efficiency this feature must be retained. But it cannot reciprocate without rapidly increasing reaction from momentum; its motion must be in one direction, and this can only be about an axis within the bounds of the chamber. It must still retain full control of displacement, as when in reciprocation, but having made a friend of momentum, it may safely attain a high rate of speed, and thus greatly increase its capacity. Speed will develop centrifugal force, which must also be prevented from becoming an enemy; it may be an aid. To accomplish this, the inlet or suction must be around the axis of motion, as with a centrifugal pump, and the outlet at the periphery of the moving parts as nearly as possible in line with a tangent produced from them. The inflow, being around the axis, will pass between it and the piston, and may be carried into the centre of the pump through a cylinder, which will be, in effect, a revolving continuation of the suction pipe, upon which the piston may be placed, and around the outside of which will be the chamber, although annular in shape, practically the same, for the action of the piston, as that contained in the reciprocating pump. Centrifugal force will now aid in filling the chamber, the flow being outward from the revolving cylinder, much as water passes from centre to periphery of a centrifugal pump, except that there will be but one opening, and that placed so that it may fill the chamber through the retreating side of the piston, while its advancing side forces the discharge. Without reaction, there can be no action; therefore, no work can be done by the piston, unless the annular chamber be provided with a partition, completely closing a section of it, to stand in its office as does the head of the cylinder with a reciprocating pump. It must be so constructed as to permit a passage of the piston, without friction, or impact from entrapped water, and to close immediately and firmly behind it. This is effected by a revolving abutment in rolling contact with the cylinder, to which the piston is attached, and with a portion cut away through which it may pass. One piston, as described, moving about a central axis, would be unbalanced; therefore we have two annular chambers, each with its own piston, one balancing the other, and all parts of the pump must have their movement by revolution, and be balanced in action. This construction avoids valves. Water, owing to its momentum and consequent persistence of flow, will not require any, even while the piston passes the abutment. To draw the suction, however, particularly from a considerable depth, the pump then being filled only with air, which is exceedingly elastic, a valve is needed at the outlet to hold the gain in vacuum attained by each stroke of the pistons, until the flow of water is established, when, being hinged at the top, it moves from its seat and can be fastened entirely out of the way, leaving an unobstructed channel. Having secured a free and continuous flow through the pump, which has enlisted as its assistants all the physical forces involved, it will need no air chamber, and will safely attain any desirable speed, against any desirable pressure, with full efficiency of power.

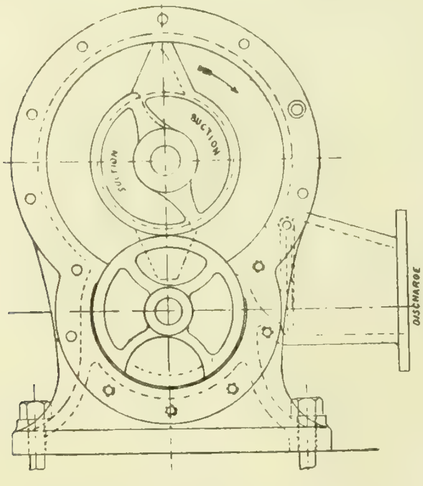


Fig. 1.

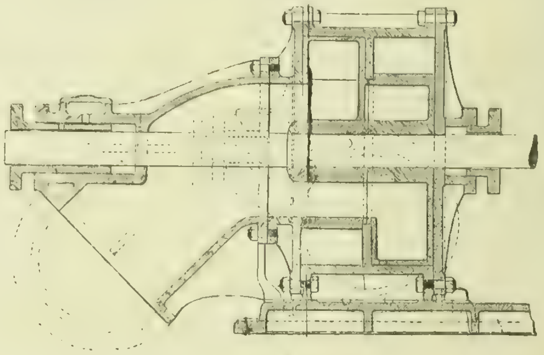


Fig. 2.

The pump thus described and herewith illustrated in its working parts (see sectional views, figs. 1 and 2) is now being introduced by the Kensington Engine-works Limited, of Philadelphia, under the name of the "Positive Piston Pump." It has repeatedly been put into practical and daily use, with both large and small volumes, high and low lifts, and shows great economy of power, with steady and quiet flow, at high or low speeds. It can be run for moderate lifts without frictional contact of the working parts, the water itself, in grooves, supplying a packing, and momentum preventing slip, or it can be packed with a self-lubricating packing to prevent slip at any speed or pressure. It will readily establish its own suction, through use of the suction valve in the discharge, and yet leave the passage perfectly free for the flow of water. It is a small pump, relatively to the large volume of fluid moving through it, which may be increased with every accession of speed.

The same construction, with little modification, has been used as a pressure blower and air compressor, with very satisfactory results. It has the great advantage not only of fast movement, but no trouble arising from condensed and entrapped water.

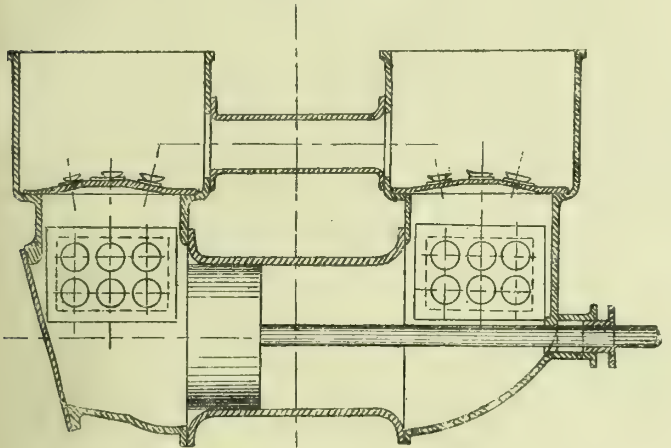
British Engineers in France.—A party of British engineers recently visited the Montgolfier Works at St. Chamond and were subsequently entertained at a luncheon served in a marquee erected for the occasion. M. Montgolfier presided, having Sir James Kitson on his right and M. Eiffel on his left. The party arrived at Lyons in the evening to visit the steel and machinery manufactory in the town of Rêve de Gier. The inhabitants welcomed the foreign visitors very cordially, many of them clapping their hands as the Englishmen went by. Senator Brunon, the mayor, caused an artillery salute to be fired in their honour. Another party of engineers went to Creuzot to see the great Schneider works. Sir Lowthian Bell took the opportunity to present the Bessemer gold medal to M. Henri Schneider, who thanked him for the honour done him. M. Schneider afterwards entertained the visitors at luncheon.

HORIZONTAL AIR PUMPS.*

In considering the arrangement of new engines, difficulties frequently present themselves which could be most easily solved by the adoption of horizontal air-pumps. Yet many engineers hesitate to recommend them, and many millowners refuse to accept them, in the belief that they will not maintain so high a vacuum as vertical single-acting pumps. And, speaking generally, this belief is warranted, for horizontal air-pumps do not, as a rule, maintain so high a vacuum as their rivals. Yet there seems no reason why they should not be made to do so, for, if properly designed and suitably applied, the two pumps will be identical in action. Suppose the plunger at the right end of the barrel as shown, and about to move towards the left, and suppose the water between the plunger and the delivery valve to be replaced by mercury, always remaining in contact with the plunger. Then, as the plunger retires, the surface of the mercury in the valve chamber will fall, leaving a space into which the air and water will flow from the condenser, and, as the plunger returns, the surface of the mercury will rise and force that air and water through the delivery valve.

Thus the pump is really vertical in action, the working ram or piston being the surface of the mercury. Further, if we increase the area of this surface sufficiently as compared with the area of the plunger, we can reduce the speed at which it rises and falls to that usually given to the buckets of vertical pumps. Thus the ram or piston moves not only in the same direction as the bucket of the vertical pump, but with the same speed.

And, lastly, if we make the displacement of the plunger equal to the displacement of the bucket, the capacity of the horizontal pump, measured by the area of the surface of the mercury into the distance through which it falls, will be equal to the capacity of the ordinary pump. In fact, the two pumps, as pumps, are identical in all respects; both are vertical in action, both move at the same speed, both have the same capacity, and both the same facilities for discharging all the air through the delivery valves. Both must therefore produce the same effects. Nor will the similarity of action or effect be any way altered if the mercury in the horizontal pump be replaced by water, which is also incompressible, *provided the water remain always in contact with the plunger*, as the heavier fluid has been supposed to do. This seems to be the condition essential to the success of horizontal air pumps. If it be not fulfilled, if the water do not follow up the plunger without break of continuity, not only will the displacement of the water level in the valve chamber, and, consequently, the effective capacity of the pump, be reduced, but a space will be left between the plunger and the water in which air expelled from the water and drawn through the gland can accumulate and remain, passing from one side of the plunger to the other as soon as the wear of the packing rings allows a passage between the top of the plunger and the barrel.



Do horizontal air pumps, as usually made, fulfil this essential condition? In many instances they certainly do not. The plungers of such pumps are usually connected to the tail ends of the piston rods of the engines, and have a mean velocity of from 500ft. to 700ft. per minute, and a maximum velocity about the middle of the stroke 1·57 times the mean. Also the ends of the barrel generally project into the valve chambers, and are not enlarged to prevent contraction of the entering stream of water. Hence the effective area to the openings at each end of the barrel is only about 66 per cent of the apparent or measured area. If, therefore, the bucket run at a mean speed of 600ft. per minute, the speed at the middle of the stroke will be about 942ft. per minute, and the speed of the water across the area of contraction must be $942 \times \frac{3}{2} = 1{,}412$ft. per minute *if the water is to follow up the plunger.* Now, the only force which can impart velocity is the weight of water itself, or the head above the centre of the plunger, and the head required to produce a velocity of 1,412ft. per minute is 8·6ft., that is to say, the water surface in the condenser must be 8·6ft. above the centre of the plunger when the latter is at mid-stroke. It is needless to say that, in ordinary circumstances, no such head of water is available.

To make the horizontal type of pump efficient, it seems clear, then, that the velocity of the water must be reduced by the addition of conoidal mouth-pieces to the barrel, or if these be not sufficient, by reducing the speed of the plunger also.

By way of illustrating the subject, let us consider the design of an air-pump for an engine developing 800 I.H.P., at a speed of 50 revolutions per minute, with an initial pressure of 80lb. per square inch, and consuming 18lb. of steam per I.H.P. per hour. The first thing to be done is to calculate the quantities of water to be dealt with. Suppose the temperature of the injection water to be 60 deg., and that of the ejection to be fixed at 100 deg. The quantity of heat sent into the condenser per revolution will be the difference between the heat supplied by the boiler and the heat converted into external work by the engine.

The consumption of steam per revolution would be $(800 \times 18) \div (50 \times 60) = 4·8$lb.; and since each pound of steam at 80lb. pressure contains 1,213 units of heat, the heat supplied by the boiler is $4·8 \times 1{,}213 = 5{,}822$ thermal units per revolution.

The work done by the engine per revolution is $800 \times 33{,}000 \div 50 = 528{,}000$ft. lb.; and since each unit of heat produces 772ft. lb. of work, the heat absorbed by conversion into work is $528{,}000 \div 772 = 684$ thermal units per revolution.

Hence the heat discharged to the condenser per revolution is $5{,}822 - 684 = 5{,}138$ thermal units. If, then, W represent the number of pounds of ejection water per revolution, $W \times 100 = (W - 4·8) \times 60 + 5{,}138$, and W = 121lb., or 1·94 cubic feet. Hence the pump (being double acting) will have to discharge 0 97 cubic feet—say 1 cubic foot each stroke.

Let us make the displacement of the plunger 6 cubic feet. This displacement may be obtained in an infinite number of ways, by varying the diameter and speed of the plunger; but, as it is always desirable to keep speeds low when direction of motion has to be reversed, we will fix the mean speed of the plunger at 200ft. per minute, as we should do for the bucket of a vertical pump, if free to choose.

The stroke and diameter of the plunger will therefore be 2ft., and the maximum velocity (acquired about mid-stroke) will be 314ft. per minute. We should make the plunger 12in. deep to avoid the necessity for packing rings, and add a conoidal mouth-piece to each end of the barrel to prevent contraction of the inflowing stream of water.

The maximum velocity of the water will then be 314ft., the same as the maximum velocity of the plunger. The head required to produce this velocity is 0·42ft. Therefore, if the water level in the valve chamber be 0·42ft. above the centre of the plunger when the latter is at mid-stroke, the water will fill the barrel, and the displacement of the water in the chamber will be 6 cubic feet. If we make the chamber 2ft. long by 3ft., the area of the water surface will be 6 square feet, and the rise and fall of the surface, due to the motion of the plunger, will be 10in., since 1 cubic foot of water is received from the condenser every stroke. In order, therefore, that the plunger may be always sealed by water, the delivery valve must be placed at least 10in. above the top of the barrel. Let us fix it 12in. above. Then the head of water upon the centre of the plunger will never be less than 14in., which is more than is absolutely necessary to impart the required velocity to the water. Thus the dimensions of the barrel and chambers are determined, and it only remains to fix the areas through the delivery and foot valves.

The first is arbitrary, as we can give the water any velocity we like by increasing the pressure on the plunger; but as it is better to keep the pressure low, we will fix the velocity at 5ft. per second, or 300ft. per minute. As discharge only takes place during the last one-sixth of the stroke of the plunger, the speed of the latter when the discharge begins will be approximately equal to its mean speed, or to 200ft. per minute. Therefore, since a speed of 300ft. per minute is permissible through the valves, the area through these last may be two-thirds the area of the plunger, or 2 square feet.

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* The Engine, Boiler, and Employers' Liability Insurance Company's Chief Engineer's Report, 1888.

The delivery valve should be placed on top of the valve chamber, as shown in the sketch.

The area through the foot valves depends upon the head of water allowed to stand in the condenser, as the velocity of flow through them is produced by this head. The time available for the discharge of 1 cub. ft. is 0·6 of a second. Therefore, if we give 1 sq. ft. area through the grids, the velocity of flow will be 1·7ft. per second, which can be obtained with a head of only 0·04ft. above the water level in the valve chamber.

These valves may be placed at the side of the valve chamber, and should by preference be nearly drowned, the highest part of the openings being an inch or two above the lowest water level in the chamber, or about 9in. below the delivery valves. In fixing the diameter of the plunger, we have restricted the speed to 200ft. per minute, because, in general, a modern engine, developing 800 I.H.P., at 50 revolutions per minute, would have too high a piston speed to admit of the plunger being cottered upon the piston rod. Therefore, a lever or counter crank would have to be used, and this being the case, it is well to make the best use of the additional mechanism to reduce the speed as much as possible. In cases where the mean piston speed does not exceed 400ft. per minute, the plunger may be driven by the piston rod direct; for if the ends of the barrel be enlarged to prevent contraction, the head required to produce the maximum velocity of 628ft. per minute would be only about 18in., a manageable height. But even in such cases it would generally be better to employ reducing motion, as the power required to set the dead water in the valve chamber in motion increases as the square of the velocity imparted. The exception to this rule is the case of a single cylinder engine, working with a high ratio of expansion, where absorption of power at the begining of each stroke might sometimes be advantageous.

THE IRON AND STEEL INSTITUTE.

(Continued from page 676.)

WATER GAS.

SIR LOWTHIAN BELL said he had consented to read a paper on a gaseous fuel known as water gas, because natural laws had been to some extent lost sight of in the recommendations advanced in favour of water gas. They were told of the immense services which the natural gas in the United States had rendered to industry. But gaseous fuel was not a stranger to members of the Institute. He calculated that something like 4,000,000,000 cubic feet of gases were daily consumed at the blast furnaces of Great Britain. As regarded the American gas, which he saw in use so long ago as 1876, at Pittsburg, any comparison between it and a factitious gas was entirely illusory. In Pennsylvania a mere hole was bored in the ground. This tapped the subterranean store, which rushed to the surface under a pressure of 200lb. to 300lb. on the square inch, and the gas was then impelled along a pipe by its own elasticity to the very furnaces at which it was to be consumed. To obtain producer gas and water gas a much larger and infinitely more expensive hole or holes had to be dug and fitted with powerful and costly machinery. Besides the coal worked at great cost, vast volumes of air, and great weights of water had to be set in motion. The coal had then to be transported, often for many miles along a railway, and converted into gas, mixed with an enormous volume of inert nitrogen, instead of an almost perfectly pure combustible substance like that found in America. Sir Lowthian then dealt with the loss of heat involved by gasifying the fuel before using it. It was no uncommon thing for fuel to evaporate 60 per cent of its theoretical quantity of water, and as regarded English blast furnaces, 90 per cent of the full power of the fuel was accounted for by the duty performed. In cases, where an intense temperature was required in order to do the work in hand quickly, water gas might be highly advantageous. Then it was said that water gas was important for illuminating purposes. Well, water gas itself was destitute of any power in this direction, but it was made to heat filaments or stems of magnesia. These become so brightly incandescent as to vie, it was alleged, with the electric light, and in consequence the water gas was largely used in the United States instead of coal gas. Then it was said that water gas would be applied to the manufacture of open-hearth steel, but he doubted whether, in an operation where a moderate heat, comparatively speaking, sufficed, it would be worth while to produce one of a more intense character. It seemed clear that nothing could be gained in a calorific point of view by the gasification of our fuel, and that to the loss in this respect had to be added a very sensible amount to the cost of the operation. The limit of its application would be the opportunities in which a more expensive form of intensely hot fuel like water-gas was wanted, and where doubtless there would be opportunities enough of utilising the producer gas. For general use solid coal was not likely to be superseded by any factitious gaseous fuel.

A discussion followed, which was adjourned.

The members then visited the Exhibition, and were entertained by the French Society of Engineers.

The Institute resumed its deliberations on Wednesday, September 25th, at the Société d'Encouragement pour l'Industrie, under the presidency of Sir James Kitson. Messrs. Martell and Parker attended on behalf of Lloyd's Registry. The lecture hall was again filled, and great interest was taken in the resumption of the discussion of water gas, a paper read by Sir Lowthian Bell on Tuesday.

Mr. Sampson Fox (Leeds Forge) said that Sir Lowthian Bell ought to have had before him the facts of the working with water gas at the Leeds Forge for the last two years with great success. The application of water gas was most successful as they used it at Leeds when mixed with producer gas. There were many reasons why they should not use water gas alone, because it would destroy some parts of the furnace if it were unmixed. They had arranged to supply a small town and some adjoining villages with water gas for lighting purposes; and they proposed to carry the water gas as far as seven miles. There was no difficulty in distributing the gases. There was no doubt that lighting can be done very much cheaper with water gas than with coal gas, and it was much cheaper than the electric light. They did not require so much atmospheric air in the room. He had lit up his own house for the last eight months for 1s. 1d. per 1,000, including the cost of interest and depreciation.

Mr. Edward Riley asked whether any of his furnaces were worked with water gas?

Mr. Fox replied that they had not yet, but they would have several shortly.

Mr. Edward Riley asked how Mr. Fox proposed to get rid of the poisonous carbonic oxide which came from water gas. Coal gas gave off a bad smell and was not so poisonous as water gas, which latter again did not give off a bad smell, and it might result fatally if it escaped.

Mr. Fox said he would have such good gas fittings as to prevent leakages.

Mr. Kupelwieser criticised water gas adversely, but allowed that it would be advantageous in certain applications.

Sir Frederick Abel said that water gas was no new thing. He had known it for more than 25 years, and Sir Lowthian Bell went into the whole subject, for a specific purpose, some five or six years ago. He doubted whether water gas would be much more economical than solid fuel itself. Great caution would have to be exercised before water gas could be used for lighting purposes.

Mons. Pourcell said a pure coal and coke would have to be used for this water gas.

Mr. Frederick Siemens having spoken,

Sir Lowthian Bell replied, stating that he had applied to Mr. Fox for data, but did not get it, and that was his answer to not having English practice to go upon.

Mr. Fox said he would give Sir L. Bell every opportunity of going through all the processes at the Leeds Forge.

Sir Lowthian Bell said he should avail himself of this offer, and give the result to the institute at their next meeting.

THE THOMSON ELECTRIC WELDING PROCESS.

Mr. W. C. Fish (London) read a paper which described the fundamental principles of the art of electric welding, first brought into application by Professor Thomson, who had the questionable misfortune of accidentally short-circuiting an induction coil, which resulted in the fusion of the copper wire of the coil. Professor Thomson first publicly exhibited this process in New York in 1887, and it is now among the growing applications of electric energy. The electric weld was generally made by the passage of a suitable current through the pieces to be welded, combined with the application of pressure forcing the pieces together. The different fluxes employed in the electric process are similar to those used in the ordinary methods of welding. It is claimed for the electric welding process that it has the ability to unite most commercial and precious metals and alloys, and several combinations of different metals and alloys. Most of these substances have hitherto been unweldable by other processes, chiefly owing to the inability to nicely regulate the supply of heat to the weld and to the impurities existing in the forge fire and other commercial sources of heat. The process can be used in those places where a large fire would be a source of annoyance and danger. The nicety and certainty of the work is obtained chiefly through the cleanliness of the heat employed, and also because the pieces to be welded are held in correct relative position during the entire operation.

Mr. Alex. Siemens confirmed the general results of the paper, remarking that they had made joints for sheathing wires by electric welding, when their firm took out an Atlantic cable, twelve years ago.

Mr. Daniel Adamson had some doubt about the cost of the process. There was no doubt it would be very useful in welding a shaft in a cotton mill.

INSTITUTE OF MARINE ENGINEERS.

Radial Valve Gear.

An adjourned meeting of the Institute of Marine Engineers was held in the Langthorne Rooms, 17, Broadway, Stratford, on Friday evening, 27th September, at 7-30, presided over by Mr. J. McFarlane Gray, when the discussion on radial valve gear was continued from Tuesday, 24th September.

The Chairman referred to the several questions which were partly discussed at the previous meeting, and as Mr. Joy was present, he would ask him to give a description of his gear, or, as the meeting was called for the purpose of instruction, if he could give any information of a useful or interesting character, as no doubt he could, regarding his own design of gear, such would be much appreciated. Before asking Mr. Joy to speak, the claims advanced by Mr. Bruce at last meeting in favour of radial valve gear, as compared with the ordinary eccentric gear, were pointed out: (1) less weight of engine; (2) shorter engine room, involving more cargo space and less displacement; (3) a better steam admission; (4) a more perfect distribution of steam, both in the go-ahead and go-astern gear. Most, but not all, of these improvements are found in the older forms of radial gear, as well as in Morton's. Great credit is due to Mr. Joy for what he did in bringing to a practical issue the ideas which were floating about regarding radial gear many years ago.

Mr. Joy, in response to the invitation, expressed his regret that he had not been present at the previous meeting to hear the paper read—owing to detention at a trial trip—and he was not, therefore, in a position to take much part in the discussion. He had brought a few diagrams at a venture, to illustrate a few remarks he might make on radial valve gear. The gear which he had been instrumental in bringing out, and which was now largely in use both in marine engines and locomotives, was the outcome of his endeavour to bring the engines into a more compact form by keeping the cylinder covers close together and placing the valves out of the centre line, thus saving fore and aft space. Mr. Joy stated that some of the locomotives fitted with this style of gear run 19 miles in 17 minutes during periods of their journeys, and nearly 1,000 engines have been fitted with it, which is quite a sufficient guarantee of the success of radial valve gear as designed by him.

Several diagrams were exhibited by Mr. Joy to illustrate the application of and results from his own gear, as fitted both to marine and land engines.

Mr. Roberts spoke in favour of the radial valve gear, which is fitted in one or two of the Glen Line steamers, on Mr. Joy's principle.

Several members engaged in the discussion, pointing out the probable and possible advantages as well as the disadvantages of the gear. Mr. Joy and Mr. Bruce replied to the various questions which had been raised during the evening, and the general impression seemed to be that valve gear of the radial type is an improvement on the ordinary eccentric gear, and that, theoretically at least, Mr. Morton has made a step nearer perfection than the original gear as designed and patented by Mr. Joy.

Amongst the interesting statements made by the latter gentleman, there was one to the effect that the coal consumption and mileage run by locomotives was very carefully and minutely recorded, so much so that in some of the Midland Railway engines the placing in order of economy—judged from a comparative analysis—hinged upon the figures in the second or third place of decimals.

The discussion was continued with considerable vigour, and much information was elicited, the whole tending very greatly to the improvement and benefit of those who were present to hear the proceedings and see the illustrations.

Votes of thanks were heartily accorded to Mr. Joy, Mr. Bruce, and the chairman, and were duly responded to.

It was intimated that a paper on "Bilge Pumps and Connections" had been prepared by Mr. Wymer, and arrangements were being made to have it read on Friday, 11th October, at 7-30 p.m.

The Chairman expressed great pleasure that Mr. Wymer had come forward to contribute to the literature of the institute, and hoped that the younger members would learn from Mr. Wymer's paper and discussion the importance of the bilge pump connections, and be able to produce at their examinations better representations of some of these connections than had in many cases been placed before him.

STEAM PLANTS FOR ELECTRICAL SERVICE.

(Concluded from page 682.)

A handsome brick stack seems to me a desirable feature of any plant. Its solidity, strength, beauty, efficiency, and absence of repair bills are worthy of consideration.

I have found the following formula useful in stack calculations:

$$a = \frac{100\,w}{d\sqrt{2\,g\,\mathrm{H}\,\frac{\mathrm{D}-d}{\mathrm{D}}}}$$

in which

H = height of stack in feet.
a = area of stack in square feet.
w = pounds fuel to be burned per second.
D = weight of one cubic foot of air.
d = weight of one cubic foot of chimney gases.
g = 32·2, the acceleration due to gravity.

If the outside temperature be 100 degrees F. and the inside 450 degrees F., the formula becomes

$$a = \frac{460\,w}{\sqrt{\mathrm{H}}}, \text{ or } \mathrm{H} = \frac{211{,}600\,w^2}{a^2}$$

In non-condensing plants the exhaust steam should always be used for heating the feed water. The quality of the latter is the determining factor in selecting a heater. There should be ample settling capacity, and the water should be outside of the tubes, which should be of brass or copper. There should always be a relief valve on the feed pipe near the heater, so that over-pressure cannot injure the tubes. If the water is very bad it should be further purified by live steam. Heaters and purifiers should be so arranged that they can be frequently blown off, and also examined and cleaned without interrupting the service of any part of the plant.

For boiler feeding I prefer a direct acting, single pump, brass fitted. It should pump cold water through the closed heater, and if the water is gritty, should have outside packed plungers. The boiler-feeding apparatus is perhaps the most sensitive part of the plant. Instead, however, of providing two pumps and heaters, a first-class injector can be used. It is not only perfectly reliable, but ties up very little capital, occupies little space, and can, when called upon, take the place of either the pump or heater, or both.

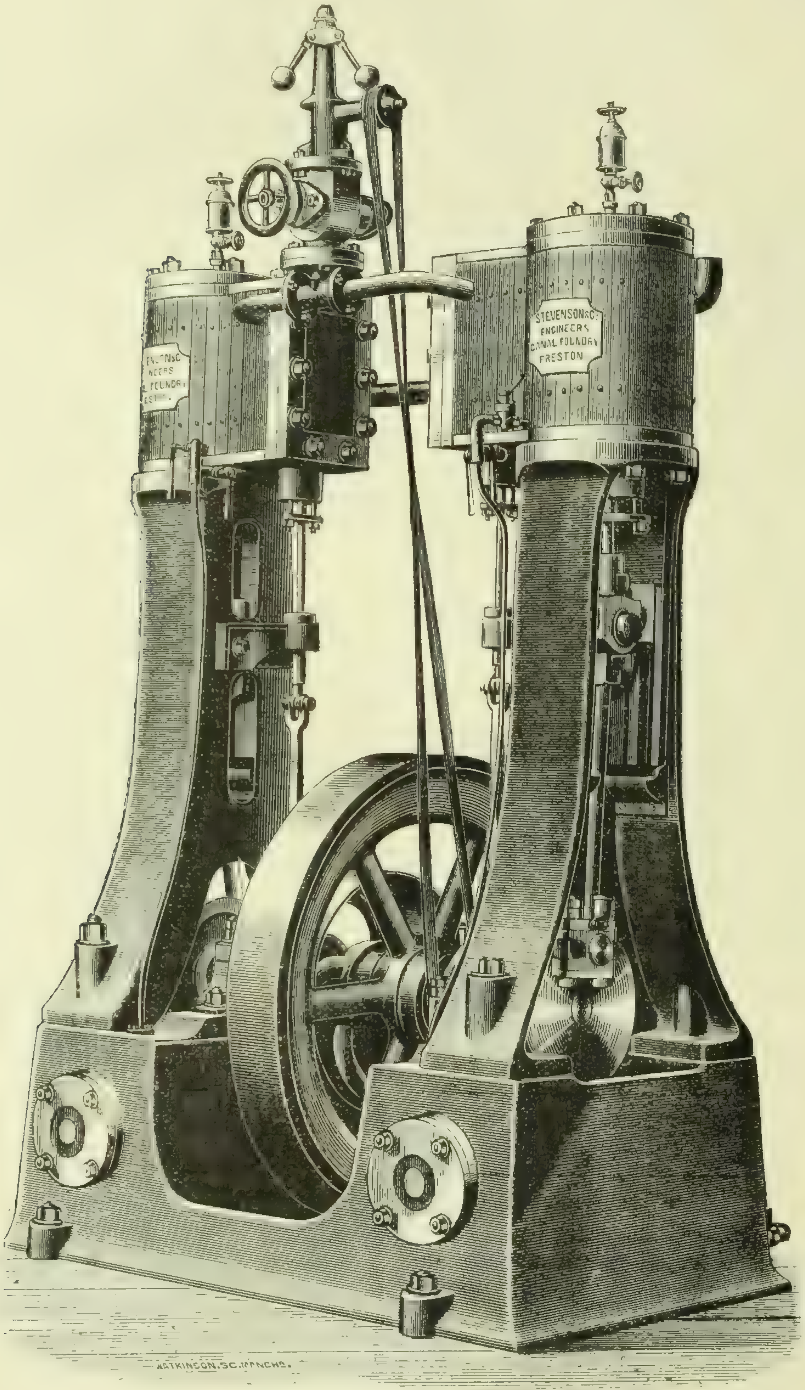
The pipe system connecting boilers, engines, heaters, pumps, &c., is worthy of careful study. The points to be borne in mind are: Abundance of area, as direct lines and as few bends as possible; suitable provision for expansion and contraction, and drains. By means of return traps all condensation in the live steam pipes can be returned to the boiler. These pipes should be well protected by non-conducting material.

Belting is also of great importance. Its slip must be a minimum. It must be well made and of good material, to be durable and reliable at speeds of a mile a minute or more. I have here a sample of a leather link belt which is proving popular. It is so heavy and pliable that its arc of contact on the pulley is much greater than with ordinary belting. It can, therefore, be run very slack, thus avoiding the great strain on engine and dynamo journals which is usually required to prevent belt slip. It also prevents air cushion. The driving and driven pulleys can be brought very close together. Transmission of power by ropes instead of belts is now being tried, and has some advantages. They are very cheap and easily replaced. The ropes run in V-shaped grooves, which render slip impossible. Sometimes a single rope is used, which encircles the pulleys a number of times, and is kept tight by passing over an idler, in the same manner as street railway cables. This arrangement is open to the serious objection that an accident to the rope means a shut-down. This could be obviated by dividing the rope into a number of parts, each independent of the other. The number should be sufficiently large that in case of accident to one the other ropes could carry the load until the engine could be shut down. As there is some elasticity in the rope, it is not certain that tightening devices would be required, but if they were they do not seem to be impracticable.

It will be seen that this discussion applies to the driving of dynamos of all kinds, without reference to the work being done. In arc lighting, the load is frequently nearly constant, but in incandescent plants, and for street railway work, the power required at different hours of the day and night varies greatly. The amount, and hours of loading seem, therefore, to be the factors upon which the selection and arrangement of the steam plant are most largely dependent.

INVERTED VERTICAL ENGINES.

CONSTRUCTED BY MESSRS. STEVENSON AND CO., ENGINEERS, CANAL FOUNDRY, PRESTON.



VERTICAL engines of the inverted type are now much used, and present great advantages where floor space is valuable and restricted. A very powerful engine can be erected on a very limited floor space. It is, however, very necessary to make such engines stiff and strong, otherwise they may give considerable trouble from undue oscillation. Messrs. Stevenson and Co., of the Canal Foundry, Preston, have made engines of this class, among others, for some years past, and as they have paid special attention to solidity of construction, and so designed the parts as to obtain easy adjustability even with the smallest sizes, we illustrate here a pair of their 6in. by 10in. engines.

From the illustration it will be seen that the engines are strong and well designed. The piston rods, crank pins, and keys are all of steel, as well as the valve spindles, while the pistons are of the Ramsbottom type. The belt may be driven from the flywheel, but where that is inconvenient a driving pulley is used, as shown. The bed plate is so arranged as to act as a feed-water heater when desired, and it is only necessary to remove the blank flanges, seen in our illustration, to make the steam connections. In small sizes, the high-speed belt-driven governor acts on an equilibrium valve. The engine is balanced so well that foundations are usually unnecessary, the mere spiking of the engine being sufficient to prevent creeping. The whole arrangements are of the most substantial and durable character.

THE QUILLFELDT PETROLEUM VAPOUR ENGINE.

This is one of the spirit launch engines exhibited at the Paris Exhibition, and is very similar in construction to the engine made by Messrs. Yarrow, of Poplar, which has created so much interest in this country. The Quillfeldt engine is intended, however, to use heavier oil than the English engine, and it is constructed by La Société Anonyme des Anciens Etablissements, Cail. In some points its details differ from Messrs. Yarrow's engine. We illustrate it in section at figs. 1, 2, 3, and 4. Fig. 1 is a longitudinal section through the motor and generator; fig. 2 is a cross section, and figs. 3 and 4 are sections of details on a larger scale.

The engine consists of three open-ended cylinders, in which work three single-acting pistons, driving by means of connecting rods three cranks, divided equally round the circle.

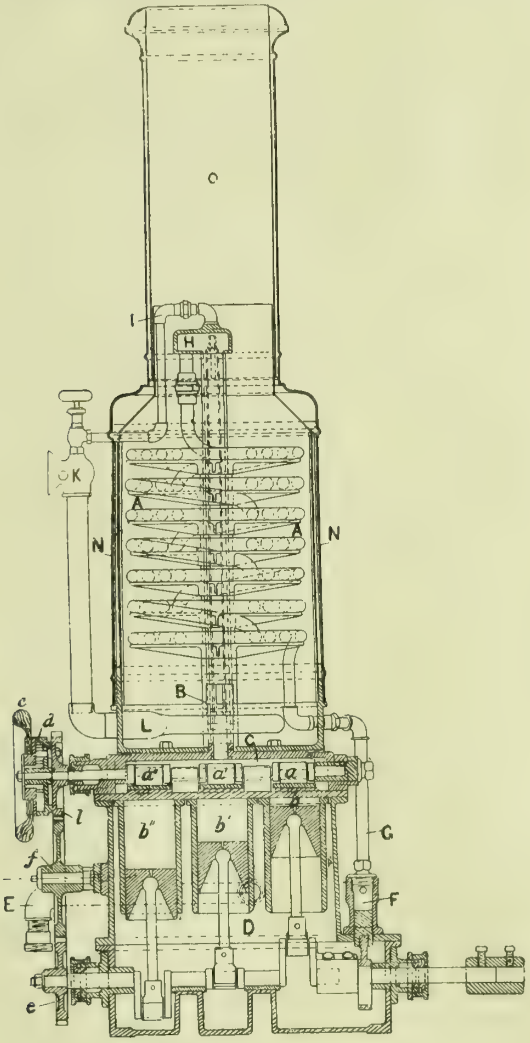


Fig. 1.

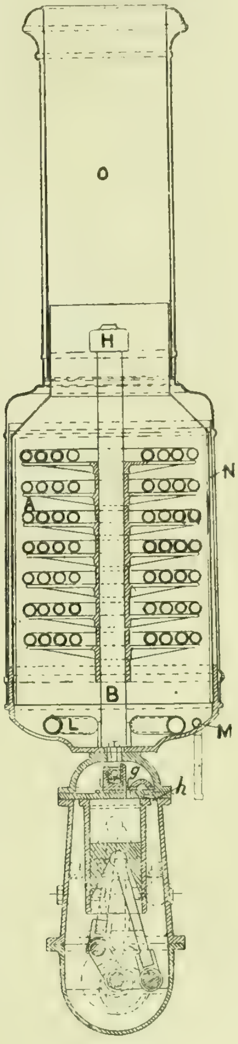


Fig. 2.

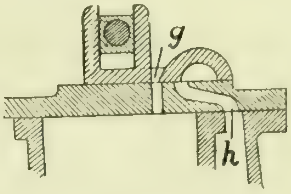


Fig. 3.

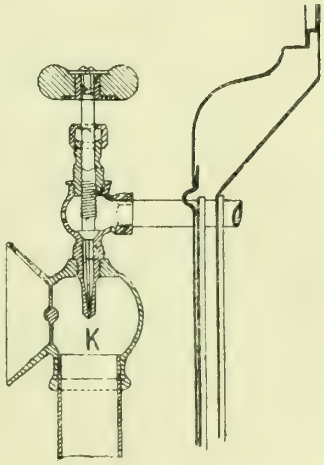


Fig. 4.

The generator consists of a copper coil A, communicating by a pipe B with the valve box C. The casing D contains the crank shaft and cylinders, and is closed from the outer atmosphere, the shaft being packed by the stuffing glands shown. The exhaust vapour from the engine passes into this casing, and is conducted to the condensing tubes placed under the bottom of the launch, and from thence to the oil reservoir. The petroleum feed pump F is driven from an eccentric on the crank shaft, and it pumps oil from the reservoir by the pipe G into the copper coil A. To start the engine, petroleum and air mixed are pumped by a little hand pump into the burner tube M (fig. 2), and the vapour issuing from the holes is lit by a torch. This flame heats up the copper coil A, and when petroleum is pumped into it the oil is volatilised, and part, as vapour, passes from the box H (fig. 1) by the pipe I to the injector K, shown in section at fig. 4. The vapour carries air along with it, and issues through holes in the main burner tube L, when it is ignited by the flame already burning from M.

When this occurs the engine may be started at once, and as the pump F forces oil into the coil at every revolution, the supply is kept up, and enough vapour is generated to supply both the engine and the flame. The hand pump is then stopped, and the starting flame burning from the burner tube M is allowed to be extinguished. When running, the engine requires no attention, as the oil remains in continual circulation from the reservoir through the coil and engine to the casing, and thence to the condenser.

When the vapour under pressure enters the valve box C, it is admitted at proper times by the three valves *a*, *a′*, *a″* to the cylinders *b*, *b′*, *b″*. These valves also serve to exhaust, as in an ordinary engine. Fig. 3 is a section through one of the valves, set in the position of admitting to the cylinder. When moved, the port *g* closes and the port *h* is opened to the cylinder by the usual exhaust cavity in the valve. The cylinders exhaust into the space between them and the exterior enclosing casing, from which the vapour passes to the condenser, as described. A valve shaft is driven from the main shaft by the toothed wheels *e* and *l*, connected by the intermediate wheel *f*, and the valves are driven to and fro by the cranks working in sliding blocks, as shown in fig. 3.

The reversing is accomplished, as in the Yarrow launch, by seizing the wheel *c*, which connects the driven valve shaft with the wheel *l*, when a friction clutch allows the connection to slip. This gives the valve cranks the required relationship to the engine cranks to admit pressure to reverse. When the engine is running reversed, in the same way, if this wheel be seized, it will go ahead. The connection is somewhat ingenious, and we shall shortly illustrate it separately.

The casing N is lined with non-conducting material in order to retain the heat, as is also the funnel O. Once the engine is started, the draught is sufficient to take in the supply of air required for combustion through openings made in the lower part of the casing, as seen in fig. 2.

These little engines are full of ingenious detail, and they are well worth careful study. Compared with steam engines of moderate dimensions, they are not economical in fuel, but compared with very small steam engines they give very good results. The great advantage, however, is not economy, but small bulk and weight for the power generated. The consumption of oil is stated to be one gallon per hour for a two horse power motor, which corresponds to about 4lb. fuel per indicated horse power per hour.

For a four-horse engine the average result is stated to be 2·9lb. of common petroleum per indicated horse power per hour. Some engineers expect great advantages from this type of engine when applied to large powers; but, as we have more than once pointed out in these columns, their advantages do not lie in great economy, but in great handiness and small bulk. We feel convinced that if it be attempted to apply the principle to large engines using expansion, failure will certainly result. There is an undoubted field for these motors on a small scale, where their peculiar qualities are valuable, and we are much indebted to the engineers who have developed the type in various parts of the world.

HARDENING AND TEMPERING OF STEEL.

On September 13th, Professor Chandler Roberts-Austen lectured in St. George's Hall, Newcastle, on "The Hardening and Tempering of Steel." There was a very large attendance. The chair was occupied by the President of the British Association (Prof. W. H. Flower); and, in addition to most of the members of the British Association in Newcastle, there were present the Mayor of Newcastle (Mr. Thomas Richardson), Lord Armstrong, Sir Charles Mark Palmer, Bart., M.P., &c.

The President said: Ladies and gentlemen, it seems quite superfluous on my part to introduce to you any one so well known as Professor Chandler Roberts-Austen. He is, as you probably know, professor of metallurgy at the Royal School of Mines, and is also chemist to Her Majesty's Mint. In that capacity he is responsible for the purity and the proper composition of the coins that we use in circulation; and probably there is no one so well acquainted with the properties of metals as he is. He is not going to talk to you about gold or silver, with which he is so familiar, but about another metal in many respects more useful. Without any further introduction I will ask Professor Chandler Roberts-Austen to give you the lecture for which he has prepared this extremely interesting and complete set of diagrams and apparatus.

Professor Roberts-Austen then delivered his lecture. After a tribute to the memory of the late Dr. Percy, who had almost created English literature of metallurgy, and a reference to the national value of Lord Armstrong's efforts in developing the use of steel, Prof. Austen proceeded to give a brief history of our knowledge of the art of hardening and tempering steel. Hardening, he said, is the result of rapidly cooling a highly heated mass of steel. "Tempering" or softening consists in heating this hardened steel to a temperature far short of that to which it was raised before hardening. He demonstrated these facts by hardening and tempering three sword blades of the same steel and of excellent quality, showing how greatly the efficiency of the weapons depended on the treatment they received. A sword blade which was over hard snapped under gentle pressure into many fragments, while one which was overtempered could readily be bent by the hands, and remained crooked. Professor Austen stated that such facts were of vital importance to the nation, Mr. Ruskin even having said that iron-working was the only art "of any consequence which we have at present in England," and that in armour plates our courage and endurance were written for ever with an iron pen nor iron parchment." Nothwithstanding the great importance of the art of hardening and tempering, the theory of the process was still far from clear, and such knowledge as we possessed had been but slowly gathered. It was shown that in early times great pains were taken to secure what was believed to be a suitable solution for quenching the hot steel, so as to abstract its heat. Othello's sword, Shakespeare said, had the "ice brook's temper," but cold water was far too simple a material for many a 16th century artificer to employ, as was shown by the quaint receipts for hardening steel which had been handed down to us, the operator being directed in a manual, published in 1531, to "take snayles and boil them in rain water taken in the two first months of harvest," in which solution, if hot steel were plunged, it would be very hard, the craftsman being prettily told so late as 1809 that he might "take the root of blue lilies, infuse it in wine, and quench the steel in it, and the steel will be very hard." The belief in such quaint nostrums survived into the present century, and it was pointed out that the early workers were right in attaching great importance to the nature of the fluid in which the steel was quenched, though their theories were wrong, the degree of rapidity with which heat was abstracted from the cooling steel being as important at the present day as ever it was. Professor Austen then traced the history of the theories relative to the internal condition of steel, pointing out that the work of Bergmann, of Upsala, showed, in 1781, that steel differs from iron only by containing 2-10 to 1½ per cent of carbon. The curious relation between the belief in the existence of phlogiston, and the fight made by the Phlogistic School with that of Lavoisier over the constitution of steel was dealt with at some length, and it was pointed out that the work of Bergmann, though himself a believer in phlogiston, had entirely changed the situation by showing that carbon was the steel-giving element. Clouet did much to prove (1798) that carbon in its diamond form could combine with iron and convert it into steel, a fact which had been confirmed by a working cutler, Mr. H. Pepys, in 1818, and finally by Professor Austen himself, who, for the purpose of the lecture, had heated diamond and carbon together in vacuo, because in all previous experiments a doubt as to the action of gases contained in the iron had existed. Professor Austen then proceeded to consider the mode of existence of carbon in the steel. He showed at great length that, although carbon in any of its forms, graphite, soot, or diamond, could enter into intimate association with iron, the relations of carbon and iron were really very complex. The researches of Karsten, Bertheir, and finally, of Sir E. Abel, had shown that in soft steel the carbon exists in the form of a true compound or "carbide" with iron, while in steel which has been hardened by rapid cooling the carbon is "dissolved," and not truly combined; in "tempering," or softening steel, another change in the relation of the carbon and iron being effected, the degree of hardness depending mainly on the relations subsisting between the carbon and the iron, although the state of the carbon did not explain all the facts of hardening and tempering. The next portion of the subject was one of great difficulty. Professor Austen gave full reasons for the belief that iron itself can exist in more than one state. For instance, carbon may be equally pure carbon, either in the diamond or sooty form; sulphur equally pure sulphur either in a form which is soft and pliable at ordinary temperatures or in the hard, yellow form with which we are all familiar with it; the soft passing instantaneously into the hard variety with evolution of heat. In the same way there is strong reason to believe that at a red heat the molecules of iron are really hard. If pure iron be cooled either quickly or slowly, it passes into the soft modification, but if carbon be present, and the metal be quickly cooled, it has no time to pass to the soft modification, the presence of the carbon hindering its passage, and hard steel being the result. Bearing in mind that evolution or absorption of heat is the surest indication of molecular change in the element, Professor Austen gave experimental evidence of the existence of molecular change in iron. One experiment was very curious. A red hot bar was taken from the furnace gripped only at one end, while a weight was attached to the other. The bar did not bend when being in its hottest state, it might have been expected to be soft, but it fell 6in. as soon as the point of molecular weakness came, the iron being comparatively cold. Prof. Austen showed how important the action of small quantities of matter on masses of metal really is, pointing out that this appeared to be a broad principle of nature, one recognised by the alchemists, and still employed by metallurgists, who marvel daily at the extraordinary effect which would be produced in iron by quite small doses of sulphur, phosphorus, chromium, or aluminium. Professor Austen said that he was not afraid of the taunt of Francis Bacon that "sottishly do the chymics appropriate the fancies of poets to the transformation of bodies to the experiments of their furnaces," for although metals could not be transmuted, they could be transformed, by very slight influences, so as to behave, from the point of view of special work demanded from them, either beneficially or prejudicially. He concluded by pointing to the importance of hardening and tempering in relation to all kinds of steel. In the early days when steel was substituted for iron, it was viewed with suspicion, mainly because the fact that iron could exist in two distinct molecular states was ignored. He showed that the material of which the Forth Bridge is made owes its substantiality to the fact that while being very strong, it is very soft and ductile, and will not harden energetically. The enormous importance of the substitution of steel for iron was shown by the figures supplied by Mr. Webb, of Crewe, who stated that on the entire system of the London and North-Western Railway eighteen tons of steel disappeared daily by oxidation and wear. With regard to highly carbonised steels it was shown that a properly tempered die would strike 40,000 coins, while one which had been over-hardened would probably fracture with the first coin it attempted to strike. In conclusion, Prof. Austen said it was strange that so few researches had been devoted to the relations of carbon and iron, and so many to organic chemistry. This arose, he thought, from the belief of chemists and physicists that operations which involved the use of high temperatures were necessarily inaccurate. It could not be that chemists feared to quote Macaulay, that "science would be degraded by being applied to any purpose of vulgar utility," for he trusted that he had shown that "the empire over matter," which was the object of all research, could be as surely gained in the field of metallurgy as in any other,

Sir Frederick Bramwell moved a vote of thanks to Professor Roberts-Austen for his lecture. They had had a lecture which was most appropriate in that city. The plans of hardening and tempering steel, which metal had within the last quarter of a century been gradually usurping the position that was formerly occupied by wrought iron, had been conducted to very good purpose. When they considered the difference of manufacture, and the difference of product there was between wrought iron made by the puddling process, and then united more or less perfectly by welding, and the steel made by some process involving fusion, and then forged in the ingot state, he thought they would all agree they had now to deal—and their successors would have to deal—with a material which, for almost all engineering purposes, was far and away superior to the wrought iron with which their forefathers had to be content. If this were true of the metal itself—as it certainly was—the question as to the treatment of this most valuable new metal—for new it was—in the wholesale manner in which it was produced and used—the manner in which this new metal should be treated as regarded its hardening and tempering was of the very highest importance, it was true that, except in certain particular manufactures, large masses of steel were not, as a rule, hardened and tempered, but there was one manufacture, and one which was the prominent manufacture of this city—that of artillery—wherein large masses of steel were dealt with to be oil-hardened, as it was called, and afterwards dealt with in the way of annealing, if not in the way of tempering. It was true they succeeded in them, but they succeeded by reason of the experience of the men who had been devoted to the manufacture all their lives, who knew what to do, and knew what would result, but could not tell why it would result; and it was to the labours of men like Professor Roberts-Austen, who endeavoured to investigate the cause of these effects obtained, that they looked forward to the certainty in manufacture which at present did not exist, our dependence at the present time being, as he had said, upon the experience, instead of being, as he hoped it would be, upon the application to the manufacture of well-known principles, as they applied scientific principles in other cases. But hitherto there was no doubt that the question of hardening and tempering steel had been truly a mystery, and he thought that no one more readily than the lecturer, who had interested and instructed them so much, would agree that it was still a mystery, and that those men who devoted themselves to solving those mysteries deserved well of their fellow countrymen and of the world at large. There was one use of steel of which they were told, where he expected it would be extremely difficult even for the most profound chemist to tell them how to temper it. Eighteen tons of steel used daily for pens! What chemist could tell them how to temper them? But he thought as regarded the steel to be used in the more innocent purpose of making weapons of destruction the researches which had been made, and which would yet be made, were and would be of the greatest importance.

Captain Noble seconded the vote of thanks. He said the lecturer had called the attention to the very great importance of steel. To few places, perhaps, was it of greater importance than to Newcastle, where so much of the prosperity of Tyneside was connected with industries dependent upon its use. Professor Roberts-Austen had said that a revolution had taken place during the last 26 years since the British Association was last in Newcastle. He could entirely confirm that statement. In the works with which he was connected, making a guess, he supposed that 26 years ago, of the iron they used not more than 10 per cent was used in the form of steel, and about 90 per cent in the form of iron. He did not suppose he was very far wrong in making a guess that those proportions were about reversed. But if they were to keep pre-eminence as ironworkers, which Mr. Ruskin was good enough to allow them, it could only be done by following researches in the spirit which Mr. Roberts-Austen has shown to them that night, and in the spirit in which that association, which was honouring them by being present, had done so much to encourage and to foster.

The vote of thanks having been passed, the proceedings ended.

HEAT ENGINES OTHER THAN STEAM.—II.

(*Continued from page 686.*)

Now, the plunger being at the bottom of its stroke, and the fire being lit, and this portion of the apparatus being made completely hot, the air below it is heated, expands, lifts the plunger; further air is driven in from the other cylinder by the descent of the displacer, through the regenerator and around the pendant liner in the cylinder; is also heated until the plunger is driven to the top of its stroke. At this time the compression plunger, or displacer, is at the half-stroke upwards, and as the engine moves on the power plunger comes down, and hot air from the power cylinder is driven through the regenerator, where, until it has time to cool in the compression cylinder, it acts to force the displacer upwards, assisting, therefore, the momentum of the flywheel to bring the power plunger downwards. By the time the power plunger is at the bottom of its stroke all the air has passed into the compression cylinder; has been cooled; and has thereby its volume reduced; then the momentum of the flywheel carries the crank shaft on; the displacer is brought downwards; the air—passing from the compression cylinder back to the power cylinder through the regenerator—picks up the heat which had been left behind in this; has fresh heat added to it from the hot sides of the power cylinder (against which it is forced by the pendant cylindrical liner in this cylinder); is by this heat again increased in pressure under the power plunger; forces this plunger upwards. This "cycle" of operations is continuously repeated as the engine works.

I have here also a working cardboard model of the "Bailey" hot-air engine. In this case we have only one vessel or cylinder, having within it the working piston and another longer piston called the displacer. At one end of this vessel the fire is placed, and at the other end there is a water jacket, through which a continuous current of cold water is kept circulating. The action, as you will see, is somewhat similar to that of the Rider engine, the two pistons, however, working in the one cylinder.

You will note that in neither of these engines—which are, as I have said, among the most successful and most largely used in England at the present day—is there any valve through which the air has to pass in order to go from that part of the apparatus where it is heated to that part of the apparatus where it is cooled; and, further, the only moving parts exposed to the hottest air are those in which there is no direct frictional contact between the surfaces. These engines, therefore, both of them, are free from the difficulties arising from valves subjected to the necessary high temperature, and are also, to a very large extent, free from the difficulties of lubrication of surfaces subjected to such high temperature.

An engine has recently been devised—and I believe experimental runs are now being conducted with it—differing from both of these, for in it the air is used under an initial pressure; a portion of it is passed directly through the fire, the remainder passes into the engine with this, and, mixing with the first air and with the products of combustion from the fire, together go to work the power plunger directly, being then exhausted from the engine, and a fresh charge of air drawn in at each stroke. A portion of this fresh charge of air is, as I have said, passed through the fire, but the remainder is delivered round the upper part of the power cylinder above the fire, and spreading itself round the power piston, which has—as the Rider engine has—a long pendant part below that which is in frictional contact with the side of the cylinder, sweeps downwards in the narrow space between the two, thereby (it is said) sweeping away the grit and ashes, thus preventing the excessive wear usually found to arise from these, and allowing of ample and sufficient lubrication of the surface in contact. In this engine, as I have told you, it is necessary (as the fire is burning in the air under pressure) that the fresh fuel shall be added without allowing escape of air. This is accomplished in an extremely ingenious manner by the engine itself, automatically, and at intervals (the fire having been once started) through what is technically known as an "air lock."

Time will not allow of any more lengthy description of the details of construction of the various other forms of hot-air engines. The one which I have last described appears to me to contain within it the elements of possible future success.

We will conclude this portion of our subject and our lecture for to-night by investigating, for some few minutes, the efficiency which has, up to the present, been obtained with hot-air engines, comparing this efficiency with that of the steam engine which we used last week.

We must do this by taking as the basis for our comparison the 11 per cent of efficiency of the steam engine, because that represents the percentage of effect obtained from the solid fuel which is put into the furnace of the steam boiler; that is to say, we must as far as the steam engine is concerned include, and not exclude, the boiler, and we must do this because in hot-air engines solid and not gaseous fuel is the fuel which is generally used; because it is burnt in a furnace, similar in its losses and its advantages.

So far as I can gather, the large engine of Ericsson—the one of which I have spoken as developing some 600 horse power—consumed as much as 6½lb. of coal per indicated horse power per hour; more than four times as much, therefore, as is consumed in a steam engine similar to that constructed by Messrs. Davey, Paxman, and Co., and tried by the judges in the Motor Trials of which I showed you the "balance sheet" this evening.

The lowest record that I find of consumption in a hot-air engine is that in connection with the celebrated engine of Stirling, which drove the machinery at the Dundee Foundry for upwards of three years. This had a working cylinder 16in. diameter and about 4ft. stroke, made about 25 to 29 revolutions per minute, and indicated some 40 horse power. Fairly careful trials were made with this engine, with the result that it was found to consume some 2½lb. of coal per indicated horse power per hour. This engine worked at the Dundee Foundry during the whole work of driving the factory for some three years; but it was then laid aside, because the heating vessels had by that time been entirely destroyed, owing to the high heat to which it was necessary to subject them in order to obtain the above power.

I think the hot-air engine—always using that term in its popular sense, and not in its truly scientific sense—is a striking example of how theory and practice are, at times, at variance. Theoretically, the mechanical efficiency of these engines should be very much higher than that of the steam engine, but owing to the many practical difficulties of which I have told you, their mechanical efficiency is, as we have seen, very much lower.

I think, as the result of what we have learnt this evening, you will agree with me that, although there may be special cases and special circumstances which will justify—in fact, compel, if I may so put it—

the use of a hot-air engine, yet it is not at all probable that such engines will supersede the steam engine for large powers; that it is only for small powers these engines will be at all largely used; and that for large powers they are practically, from an economical point of view, unusable.

It is not, in my opinion, therefore, the hot-air engine which is in the near future to supersede the steam engine.

LECTURE III.

That which we have to do to-night is to consider the gas engine; the most commonly used form (for power purposes) of "heat engine other than steam;" the one which has up to the present, in practice, given the most satisfactory results, and the one which is even now the thoroughly successful rival of the steam engine for small powers.

As most of you know, gas engines have received great consideration, both from scientific and from practical men. They have been subjected to experiment in almost every direction; and I suppose there is scarcely any apparatus used by the engineer which, as a fact, has been more elaborately investigated and discussed, and about which more has been written. There is no doubt that it is largely due to this, and to the increasing demand for an economical small-power engine, arising from the increasing needs of civilisation, that the gas engine owes its present advanced position. Further, there is no doubt it is in such engines, combining within them, as we shall find they do, the theoretical and the practical advantages necessary for a motive power heat engine, that the elements of future success are contained.

The gas engine is the product of many minds, and of the long-continued, assiduous labour of many men; it is one of the best practical examples of the successful attention of the engineer to minor details. It is true it owes some of its rapid advance to its rival, the steam engine. The steam engine has enabled many improvements in the mode of performing mechanical work to be attained, and this has, no doubt, helped the development of the gas engine.

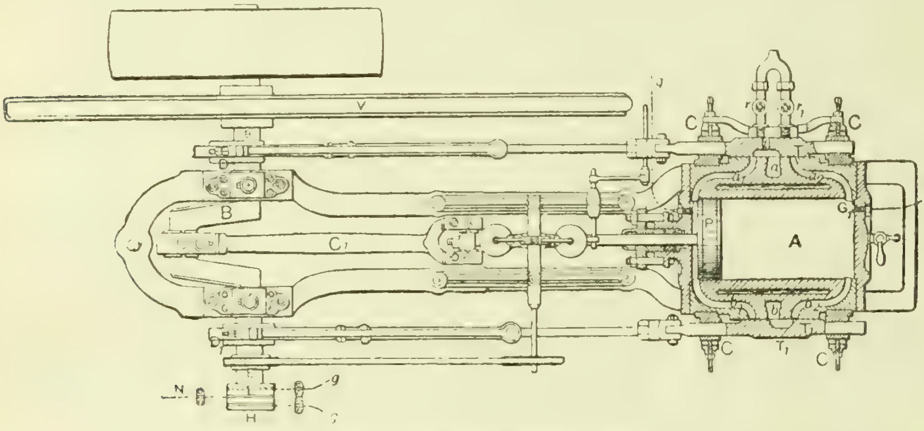


FIG. 11.—Lenoir's Gas Engine of 1860.

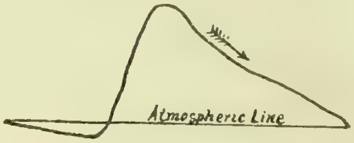


FIG. 12.

Although gas engines differ widely among themselves, yet they are alike in one respect, and that is they are all "internally-fired" engines. In them the working agent is air, which is heated by the combustion of coal or other combustible gas mixed with it in the power cylinder itself; *i.e.*, in all of them the heat is communicated to the working agent directly, and in the power cylinder itself, and the boiler, or its equivalent, is entirely absent.

Further than this, the true working agent—the air—is already a gas, and therefore none of the heat put into it by combustion of the fuel with which it is mixed is absorbed in the form of latent heat, as it is in the steam engine, where we have the fluid (water), which has to be turned into the gas (steam) before we can use it in the heat engine, requiring for this transformation a certain amount of "unutilisable" (if I may coin a word) heat. In the gas engine there is no absorption of heat due to this "latent heat of vaporisation." Theoretically, if we had materials of which we could construct the working cylinders of our gas engines which did not absorb any of the heat developed, and if we could overcome the consequent difficulty of premature ignition from the hot sides of the power cylinders, and other difficulties such as I pointed out to you when talking of the ideal heat engine of Carnot, it should be possible to obtain nearly the whole of the efficiency due to the difference between the temperature of combustion of the mixture of air and coal gas used in the cylinder—viz., some 3,500 deg. Fah. absolute, and the temperature of the exhaust, which should then be at least as low as that of the atmosphere, say 530 deg. Fah. absolute. It is needless for me to tell you such an efficiency as this is not likely to be attained.

Time will not allow of our considering the various theories which have been propounded as to the completeness of combustion of the gases in the engine cylinder, nor can we stop to consider the questions of dissociation of the gases due to the high temperatures of combustion. I shall only refer to these in so far as they are illustrated by the results which are obtained in practice.

It is true of engineering matters, as it is of almost all other things in this world, that you cannot get something for nothing; and we shall find that, while the economical advantage of eliminating the boiler from the gas engine is apparent, yet because we obtain this advantage, we are saddled with certain disadvantages, which to some extent counterbalance this. These disadvantages, which arise from eliminating the boiler, were of much greater importance in the earlier days of gas engines and of gas engine construction. I will not delay about these now, but will deal with them as we get further on with this most interesting portion of our subject. Further, I told you last week that air was one of the worst conductors of heat which we know. This, which was a disadvantage in the hot-air engine, we shall find is a practical advantage in the gas engine.

The earliest gas engine of which I have been able to get any record is one proposed by M. de Rivaz, who, in 1807,* described an engine which was to be used for driving a carriage on common roads. Hydrogen gas was the medium by which the heat was to be obtained, for at that time, as you are aware, illuminating gas was not known. From this time forward many patents were taken out, and many suggestions and investigations were made; but it was not until the years 1860-1861, when another Frenchman, M. Lenoir, patented and introduced his gas engine, that any noteworthy practical success was obtained. Lenoir was followed, in 1865, by Hugon, and many engines on both these systems were constructed and put into successful practical work, and some of them are at work even to this day.

The first of Lenoir's patents is dated 1860, No. 335. The engine consisted (as you will see from the sectional plan in fig. 11) of an engine similar to an ordinary horizontal steam engine, having the piston, piston rod, connecting rod, and crank shaft, which these engines usually have. On each side of the cylinder, however, there is a slide valve, each valve being worked by an eccentric, strap, and rod. These slide valves are not contained in cases or chests, as is the ordinary steam valve, but they are held against the faces on the cylinder by springs or adjustable screws. The mixed charge of gas and atmospheric air is brought to the cylinder by means of a pipe, which, in a certain position, of that one of these valves which is the inlet, communicates through an opening directly with the cylinder. The exhaust takes place through the second valve, and the firing of the explosive mixture was done by means of an electric spark.

The engine worked as follows: The piston moved forward for a certain portion of its stroke, drawing in the mixed charge of gas and air, and then this charge was fired by an electric spark due to the contact made at the right moment by the engine itself, and the expansion of the hot gases propelled the piston to the end of the stroke. Thereupon the exhaust valve opened; the fly wheel carried the engine on, and as the piston returned a mixed charge of gas and air was drawn in on the front side of the piston; this charge was fired; the piston was driven back to the back end of its stroke; the exhaust valve for the front end of the cylinder was opened; the inlet for gas and air to the back end of the cylinder was then opened, as the flywheel carried the piston on, the fresh charge for the back end was drawn in; this was fired, and so on.

You will see that this was a double-acting engine. I will ask you to look at the indicator diagram (fig. 12) taken from one end of the cylinder of one of these engines, and you will there see that the piston in moving forward, during the first quarter of its stroke, was drawing in the charge; that then the explosive mixture was ignited; the pressure rose; gradually fell as the hot gases expanded, till the piston reached the end of the stroke.

(To be continued.)

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* Since the above was written, I find in a paper by M. Edouard Delamare Deboulleville, read at the Paris meeting of the Institution of Mechanical Engineers in July of this year, that a reference to a gas engine was published by John Barber on the 31st October, 1791.

MELBOURNE TRAMWAY COMPANY.

A Remarkable Year.

The report and balance sheet read at the annual meeting of the above company on August 28th show that, notwithstanding the lack of financial success attending the Melbourne Centennial Exhibition, the tramways have had a most prosperous year. The following items are extracted from an account of the proceedings published in the *Melbourne Argus* of August 29th :—

Total profits, including £11,667 2s. 5d. carried forward from last year, and £7,296 9s. 3d. from sales of freehold properties, amounted to £197,389 16s. 9d. From this sum it was proposed to transfer the profit on properties sold to the reserve fund, to carry forward a sum of £10,093 7s. 6d., and to pay a dividend of 6s. per share, which, added to four quarterly dividends previously paid of 3 per cent each, is stated to make, for the original stockholders, a return of 72 per cent per annum upon the capital invested.

A further sum of £1,500 was presented to the directors as a bonus in recognition of their labours during the exhibition year. An exhibition bonus, amounting to £3,283 1s. 8d., was paid to the employés who were in the company's service prior to the 1st of April last, and a sum of £1,058 was paid to the Employés' Benefit Society.

The traffic returns showed that, including about 4,000,000 carried by the omnibus lines, the number of passengers carried during the year was 45,000,364. As the population of Melbourne and suburbs is about 436,000, the traffic was equal to 103 rides by every man, woman, and child during the year. The length of lines open would be, in the course of a few months, 45⅝ miles.

We believe the trams are worked from a central station on the wire-rope system.

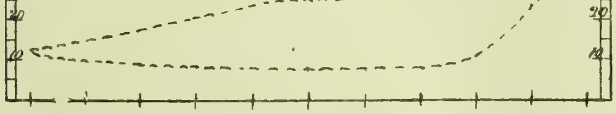
CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

INDICATOR DIAGRAM PRACTICE.

To the Editor of "The Practical Engineer."

Sir,—I was pleased to see in *The Practical Engineer* for August 2nd the commencement of a series of articles on this subject, and have been looking forward with interest to their continuance. Although, perhaps, most beginners are competent to calculate the horse power from the indicator diagrams, I have been surprised, in the course of an extensive practice during the past 20 years, to find how very few really understand all the points of a diagram. Beyond knowing when valves are too late or too early, or unequally set, the great bulk of engineers appear to have very hazy notions respecting the indication of serious defects, and unfortunately the works published on this important branch of practical engineering do not do much towards enlightening those who are anxious to extend their knowledge. Hence a series of practical articles such as you have begun will be likely to prove extremely useful to young engineers especially, and I trust will lead to discussion taking place from time to time, which may have the effect of causing many of your readers to send on diagrams which may have puzzled them, or which will be likely to prove interesting to others. Such a discussion cannot fail to prove mutually advantageous to all taking part in it, and will be calculated to elicit much valuable practical information concerning the actual working of steam engines.



By way of illustrating the kind of knowledge which exists in quarters where one would suppose those entrusted with the designing of engines or setting of valves would be better informed, I send you herewith copies of a pair of diagrams taken within the last month from a small non-condensing engine, which was put down only some five or six years ago by a well-known engineering firm not fifty miles from Manchester. The diagrams show the engine as it has been working for several years, and the valve setting as left by the makers when new. The cards are in many ways a curiosity, and it is quite evident from the figures that had the engine been driving anything but a very light load it could not have worked at all.

The boiler pressure at the time of indicating was 63lb. only, the safety valves being loaded only to 70lb., and yet it will be observed the compression at the back end is so excessive that at the end of the stroke the pressure in the cylinder is as high as 86lb., or 23lb. actually higher than the pressure in the boiler. When the valve opens for steam admission at the back end the pressure immediately falls to 60lb., or 3lb below the boiler pressure at this end. At the opposite end of cylinder, also the steam is compressed to a pressure higher by 7lb. than the actual initial pressure at the beginning of the forward stroke; but the most remarkable feature of these diagrams appears to be the fact that the actual forward pressure on the propelling side of the piston at the front end is less by some 2lb. or 3lb. during the first half of the stroke than the back pressure resisting the motion of the piston, and after half stroke the resistance, owing to the excessive compression, is enormously in excess of the propelling pressure. It seems surprising how the engine could work under these conditions, and in all probability it would not have done so had it not had an unusually heavy flywheel. The engine could only be started from the back end; and it will be borne in mind that during the first stroke there will only be the atmospheric resistance to contend with, so that a momentum would be got up at once, which would carry the engine round the other half revolution, and thus, with the momentum or energy stored up in the flywheel, cause it to work during the return stroke, with a resistance against the piston considerably greater than the steam pressure propelling it. An amusing feature of this case is that the engine is provided with cut-off valves on the back of the single slide valve.

The engine, as I have stated, has been working in this condition several years, but until quite recently the exhaust steam was conducted into the boiler chimney, and as it did its work, and was never indicated, no notice was taken of its condition. Recently, however, owing to some alterations, the engine has been removed to another part of the premises, some distance away from the boiler, and the exhaust has been carried up outside the building. It was owing to the noise caused by the exhausting of the steam into the atmosphere at over 30lb. pressure from one end of the cylinder, and the complaints of the nuisance made by those in the neighbourhood (a hospital being close by), that attention was called to the working of the engine, which resulted in diagrams being taken, of which the above are copies.

The engine, it may be mentioned, is of the ordinary non-condensing type; cylinder 9½in. diameter; 20in. stroke; and set to run at 120 revolutions per minute; but the actual speed at time of indication was 114 only, which could not be increased with governor valve wide open. It has a single locomotive slide valve with a port at each end, over which have been fitted cut-off plates, but these have now been dispensed with. The indicated H.P. is 7½. I have given the particulars of this case thus fully, because I should like the opinion of some of your practical readers on these diagrams, with any suggestions which they may have to offer as to improvement.—Yours, &c.,

Wrought Iron.

FIRE BRIDGES.

To the Editor of "The Practical Engineer."

Sir,—With respect to the above, the following is my opinion: With the exception of keeping the fire on the grate they serve no useful purpose, and where a skilled and careful stoker is at work the bridge need not be more than 3in. higher than the fire-bars. Make it as wide as you like, but keep it low, is invariably my advice when consulted on such matters. These conclusions have been arrived at by noticing that where good all-round results (both as regards economy and smoke) have been obtained, low bridges have been in use. Exceedingly good results have been got with Salmon's patent bridges, which are little more than level with the bars, but extend a considerable distance backward, gradually lowering until they eventually come level with bottom of flue. I do not think that any portion of the flue should be of less area than the total air space between fire-bars. That evil often results from high bridges is well known to many. If draught is sluggish, the high bridge makes it much worse; if the draught is powerful, the gases are partly extinguished by being forcibly drawn through a too limited area and thrown in contact with the much colder plates; while if the water is sedimentary, overheating is very likely to occur. The present success of several of the mechanical stokers is, in my opinion, partly due to the bridge being dispensed with. I was not aware that insurance companies requested bridges to be removed annually, except in cases where they are built on the seams, or for other special reasons. When the bridges are clear of seams and joints I do not consider it necessary to remove them oftener than say once in three or four years. Water bridges are certainly a failure, as previously explained in these pages.—Yours, &c.,

Chalkline.

To the Editor of "The Practical Engineer."

Sir,—In reply to your correspondent "Engineer," the fire bridge, besides preventing the fuel being thrown beyond the fire-grate, heats the cold air which enters the furnaces every time the doors are opened, and thus prevents the flues beyond being so suddenly cooled as would be the case if there was no bridge or other heated mass for it to impinge against. The usual rule for the height of bridges is two-thirds of the diameter of the flue. I cannot agree with "Engineer's" conclusion that the removal of fire bridges at every "thorough inspection" (as recommended by the insurance companies) is quite unnecessary; in fact, I do not see how an inspection can be "thorough" without removing the bridges. They are often found to conceal defects. Various and without number are the different forms and shapes in which fire bridges have been built, but we have not advanced much beyond the old form yet, and, like your correspondent, I think no harm would be done by an expression of opinion from some of our practical men.—Yours, &c., L.

October 7, 1889.

REPAIRS IN BOILER FIRED WITH WASTE HEAT.

To the Editor of "The Practical Engineer."

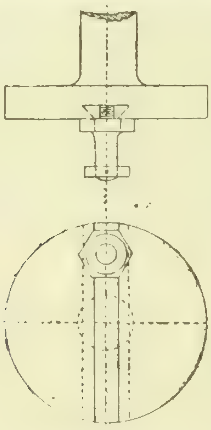
SIR,—I shall be much obliged for opinions from your practical readers on the following points. Is there any objection to the repair of the spherical ends of horizontal steam boilers with very mild steel plates?

The boilers are fired by the waste heat of mill and puddling furnaces. The heat at the ends is very intense, and soon destroys wrought-iron plates. They are also subjected to rapid heating up and cooling down each heat of the furnaces. I wish to reduce the excessive repair. Plates are sometimes so badly cracked in a month, that it is necessary to renew them. Shall be glad of any advice which can be given.—Yours, &c. R. T. C.

QUERIES AND REPLIES.

96. **STROKE OF HYDRAULIC ENGINE.**—What is the advantage derived from making the stroke of a hydraulic engine variable? How is it done? A sketch will oblige.—J. S.

Answer.—The stroke of the hydraulic engine is made variable for the purpose of altering the power of the engine, without affecting the speed. One method of altering the length of the stroke is shown by the two figures attached. A dove-tail groove is cut across the face of the crank disc, in which a wrought-iron die fits, not too loosely; the chased end of the crank pin screws into the die, and the pin can be secured in any position on the plate by means of a spanner fitting on the hexagon collar for tightening them up; the stroke can be quickly varied as required. The writer has used a plan of this kind for a similar purpose, which answered well. Messrs. Hastie have an ingenious method of varying the stroke of their water-power engines automatically, in proportion to the amount of the work to be done.—W. F.



99. **STRUT.**—I want to find what a round rod of wrought iron, say 3ft. long and 2in. diameter, will carry with safety when acting as a strut. Again, given the length of a rod (round), and the load it has to carry, to find what the diameter should be.—LUTON.

Answer.—The safe load will depend upon the purpose to which the strut is to be applied. Thus, if it is to carry a permanent load at rest, the safe load will be one-fourth breaking load; if a variable and vibratory load, one-sixth. If the strut is part of a moving machine the factor of safety will be one-eighth to one-tenth, according to the nature of the work. The formula for the breaking weight is—

$$W = \frac{16 \times S}{1 + \frac{l^2}{d^2} . b}$$

where W equals breaking weight in tons; S equals sectional area in square inches; l and d equals length and diameter in inches; and b equals a factor according with the conditions under which the strut acts. Its values are—

For a strut fixed (or firmly bedded) at both ends...... $b = \frac{1}{3000}$.
For a strut fixed at one end and jointed at the other.. $b = \frac{1}{1200}$
For a strut jointed at both ends .... $b = \frac{1}{750}$.

For your strut fixed at both ends—

$$W = \frac{16 \times 3\cdot141}{1 + \left(\frac{36}{2}\right)^2 \times \frac{1}{3000}} = 45\cdot35 \text{ tons.}$$

Working strength for steady load will be

$$\frac{45\cdot35}{4} = 11\cdot34 \text{ tons;}$$

or a vibratory load—

$$\frac{45\cdot35}{} = 7\cdot56 \text{ tons}$$

jointed at one end—

$$W = \frac{16 \times 3\cdot141}{1 + \left(\frac{36}{2}\right)^2 \times \frac{1}{1200}} = 39\cdot58 \text{ tons;}$$

jointed at both ends (as a steam-engine connecting rod, for instance)—

$$W = \frac{16 \times 3\cdot141}{1 + \left(\frac{36}{2}\right)^2 \times \frac{1}{750}} = 35\cdot09 \text{ tons.}$$

$$\text{Working stress} = \frac{35\cdot09}{10} = 3\cdot509 \text{ tons.}$$

By transposing the formula we get an expression for the diameter—

$$d = \sqrt{\frac{W}{25\cdot1328} + \sqrt{\frac{Wl^2b}{12\cdot5664} + \frac{W^2}{632}}}$$

Applying this to the first case to find the diameter for length, 36in. breaking load, 45·35 tons—

$$d = \sqrt{\frac{45\cdot35}{25\cdot1328} + \sqrt{\frac{45\cdot35 \times (36)^2 \times \frac{1}{3000}}{12\cdot5664} + \frac{45\cdot35}{632}}} = \sqrt{4} = 2\text{in.}$$

F. C.

Answer.—In answer to "Luton," I beg to inform him that Gordon's formula will give him the load his strut or pillar will support, and is as follows:—

$$P = \frac{F}{1 + \cdot0005 \left(\frac{L}{d}\right)^2}$$

Where P = crippling strain in tons per square inch of cross section;
F = ultimate crushing strain of material in tons per square inch equals 16 tons for wrought iron;
c = coefficient equals ·0005 for wrought iron;
d = diameter of strut or pillar;
L = length of strut.

In your example we have the following dimensions, viz.:—
L = 36in;
d = 2in.

Introducing these particulars in formula, we have—

$$P = \frac{16}{1 + \cdot0005 \times \left(\frac{36}{2}\right)^2} = 13\cdot76 \text{ tons crippling strain.}$$

Assuming a factor of safety at least 6, then

$$\frac{13\cdot76}{6} = 2\cdot29 \text{ tons—safe load for your strut.}$$

To find the diameter of strut necessary to carry a specified load we have only to transpose the above equation. First let

$$\left(\frac{L}{d}\right)^2 = H^2.$$

Then the formula stands—

$$P = \frac{F}{1 + (c \times H^2)}$$

Whence

$$H = \sqrt{2000\left(\frac{16}{P} - 1\right)}$$

Substituting value of P as found above—

$$H = \sqrt{2000\left(\frac{16}{13\cdot76} - 1\right)} = 18,$$

ratio between length and diameter as before.—J. R.

103. **POWER OF BEAM ENGINE.**—I am in charge of a beam engine. Its cylinder is 12½in. bore, length of stroke 3ft., making 60 revolutions a minute, the air pump 8in. bore, and worked at 50lb. pressure, and I should feel obliged if any of the readers of *The Practical Engineer* could inform me to what amount of I.H.P. it would drive.—SIMPLE.

Answer.—Allowing a drop of 5lb. between the boiler and engine, we have a pressure of 45 + 15 = 60lb. absolute. Assuming the clearance is 2in., and the cut-off to be at a quarter of the stroke, the rate of expansion will be $\frac{36 + 2}{9 + 2} = 3\cdot45$; and the terminal pressure in the cylinder will then be about that of the atmosphere, above which it would not be advisable to work. The theoretical mean pressure will be

$$60 \times \frac{1 + \text{hy. log. } 3\cdot45}{3\cdot45} = 60 \times \cdot648 \quad 38\cdot8\text{lb.},$$

and taking 75 per cent of this, so as to allow for back pressure, effect of compression, wire drawing, &c., we have 29lb. as the approximate mean effective pressure acting on the piston; the indicated horse power is therefore,

$$\frac{117\cdot8 \times 29 \times 3 \times 2 \times 60}{33000} = 37\cdot26,$$

and deducting 15 per cent for internal friction, the available power will become, say 31½ H.P.—ORION.

108. **FALLING WEIGHT.**—Will any reader kindly show me how to work out the following problem? If a weight of one ton falls from the height of 15ft., what would be the force it would have on the ground?—T. M. P.

Answer.—To solve this problem, let us first ascertain the velocity the weight would have attained at the moment it reaches the ground, which will be given by the formula $V = g\sqrt{\frac{2h}{g}}$ and taking 32·2 as our value of g, we have $V = 32\cdot2\sqrt{\frac{2h}{32\cdot2}} = \sqrt{64\cdot4\,h} = 8\cdot025h$, $\sqrt{h}$, h being the height in feet from which the body falls, which in "T. M. P.'s" query is 15ft., so that V the velocity acquired in feet per second in his case will be $8\cdot025\sqrt{15} = 31\cdot08$. Having obtained this, we can now proceed to calculate kinetic energy, or work accumulated in the weight at the instant it reaches the ground, from the formula

$$U = W\frac{V^2}{2g}$$

in which U = the accumulated work in foot pounds stored up in
W = the weight of the moving body in pounds, when moving at a velocity in feet per second represented by V.

Then taking the same value for g, we have for U, in the case under discussion,

$$U = 2240\,\frac{966}{64\cdot4} = 33600 \text{ foot pounds.}$$

Now, assuming the resistance of the ground to be such that this weight, falling from a height of 15ft., penetrates to a depth of 3in. before coming to rest, then this accumulated work, viz., 33,600 foot pounds, will be given out whilst the weight is descending through a distance of 3in. or ·25 of a foot; so that the mean statical pressure exerted upon the earth will be equal to $\frac{33600}{\cdot 25}$ = 134,400lb. = 60 tons.—Gravity.

100. Pulsometer.—What is the reason for giving the upper portions of the condensing chambers their peculiar tapered form?—Shiny Boots.

101. Differential Pulley-block.—In what way are the parts of these blocks arranged so as to get excessive friction, which must equal half the load, except in some cases where special retaining mechanism is applied? I should be obliged by sketch and description of the last-named arrangement. Shiny Boots.

104. Brass Furnace.—Will some experienced correspondent oblige querist with a rough dimensioned sketch of the most modern double-brass furnace suitable for say two 46lb. pots?—Mechanicus.

105. Foundry Cupola.—What are the most approved dimensions of a cupola capable of melting four tons per hour, blast pressure; size of wind belt, number of tuyeres and dimensions of same, also whether round or square, thickness of furnace lining, and approximate consumption of coke per ton of iron?—Resurgam.

106. Anti-Calcaire.—Will you kindly inform me as to what this is composed of, and what action it has on hard water? Would it be suitable for use with feed water?—Marine.

109. Balloon Motor.—Will some reader kindly give me particulars of the motor employed by the French officer who recently constructed a very large and elaborate balloon? Perhaps some reference to the description, if it has been published, can be given.—F. B.

110. Varnish for Drawings.—Will any reader kindly inform me what is the best varnish for varnishing mechanical drawings; also how it is made? C. A. B.

111. Paddle-wheels.—How is the curve of the float obtained, as in the wheels of recent cross-channel boats?—Shiny Boots.

112. Proportions of Connecting Rods.—Why is it usual to make the neck of the connecting rod larger at the crank pin end than at the crosshead end?—A. G.

113. Automatic Steam Damper.—Can any of your readers inform me who makes the automatic steam dampers so often seen at Lancashire cotton mills?—S. B. S.

114. Friction in Water Mains.—What methods are used for lessening any tendency to increase of surface friction in water mains?—F. J. J.

115. Hydraulic Brake.—What is the advantage of a hydraulic brake, as compared with one of rigid materials? A sketch of one by which a nearly constant arresting force may be obtained will greatly oblige.—F. J. J.

116. Seating Hydraulic Pump Valves.—I should be very glad to know what is the best method of seating valves in a hydraulic pump, the valve being 3in. or 4in. diameter and the pressure two tons per square inch. I am afraid, if seated in the ordinary way, they would leak and get loose. Pump Valves.

117. Driving Ropes for Engines.—Would some of your readers be good enough to inform me what size of ropes, and how many, would be required for an engine 500 horse power? also what would be about the price of such an engine.—Improver.

118. Moving Wheels out of Proper Gear.—Can any brother reader tell me how much I would lessen the life of a pair of wheels of about 3in. pitch, if I took them out of gearing about ⅜? Is there any rule for this, in plain figures?—One in a Fix.

119. Machine for Washing Mill and Furnace Ashes.—Can any reader refer me to makers and description of machinery for washing and cleaning the ashes from mill and puddling furnaces. Information will much oblige.—R. T. C.

120. Crank Pin.—I have a crank pin to put in; it is 10½in. diameter by 10⅞in. long in that part which fits the crank eye, and 9½in. diameter by 10in. long for the working part, with 1⅛in. of a collar outside, making it 22in. long. There is no taper on the pin, and it is held in position by a key. I want to know if there is any advantage in having a hollow pin; if so, what the advantage is, and what size of hole you would recommend. Also, if a steel forging can be got with a hole in it.—Crank Pin.

121. Boring Large Cylinders.—Will any of your readers kindly give the speed of cutter per minute allowed in boring machine for boring large cylinders? Also the traverse of cut usually allowed. I have a cylinder 60in. diameter and 4ft. 10in. length from end to end of cylinder. I am having it rebored, and want to know the rule for calculating time required to do same.—Percy.

PATENTS AND INVENTORS' QUERIES.

14. Placing Patents.—How are patents placed and worked upon royalty, and what is the usual percentage of the price of the patented article received by the patentee?—Patentee, Chatham.

Answer.—If the invention is a useful and novel one, there is no difficulty in arranging with a good firm to manufacture under license. A sole license is usually granted, and 10 per cent on the selling price is a very usual royalty, but this varies much with the nature of the invention, and the branch of trade to which it refers.

15. Time between Acceptances of Provisional and Final Specifications.—What is the usual time between an application with provisional specification and acceptance and the filing of complete specification and acceptance?—Patentee, Chatham.

Answer.—The time varies with the nature and complexity of the patent, but the acceptances generally arrive within one month of filing. Sometimes, however, longer time is taken. A patent must be accepted, if it is to be accepted at all, within twelve months of the application for provisional protection. We have answered two of your queries, and will deal with the third later, but we must ask you to forward your name and address as a guarantee of your good faith.

TO CORRESPONDENTS.

P. T., Saltney.—We are obliged for your suggestions. The articles to which you refer shall be continued. You must remember that we cannot devote our space too exclusively to any one branch of engineering. We shall deal with your query in our next issue.

J. H., Merthyr Tydvil.—Write to Science and Art Department, South Kensington, London, for "Science and Art Directory," enclosing 8d.

F. J. J., London.—We thank you for your very appreciative letter, and are glad to know that you find our paper of service to you. The articles on hydraulic engineering will be resumed shortly.

MISCELLANEA.

During the excavation for the Manchester Ship Canal some remains of the wild red deer, with malformed horns, were dug up near the bend of the river Irwell. They have been forwarded to Mr. Rowland Ward, F.Z.S., for mounting.

Mr. William Ripper, late Assistant Professor of Mechanical Engineering at the Sheffield Technical School, has been appointed in charge of the Engineering Department in the place of Professor W. H. Greenwood, who has resigned to take an appointment at the Birmingham Small Arms Factory.

As a measure of the strength of the Forth Bridge, Mr. Baker, the engineer, says that six of the largest ironclads yet built, weighing each from 12,000 to 14,000 tons, might be suspended from its six great cantilevers, while the size of its spans is so great that two Eiffel Towers laid horizontally and joined together at the centre would just span one of its openings.

At a meeting of masters and workmen engaged in the nut and bolt trade, held at the Queen's Hotel, Birmingham, last week, the employers decided to increase the wages of the operatives by 5 per cent on the list of 1881 from the 1st January next, on condition that the workmen's association enforced the advance at all the works in the district. The men, who had asked for an advance of 10 per cent, accepted the masters' offer.

Mr. Drummond, locomotive superintendent of the Caledonian Railway, is making a series of experiments on the coal consumption of locomotives with engines plying between Carlisle and Aberdeen. Six engines, identical in construction, and drawing the same number of vehicles, will steam at the following pressures: 150lb., the present ordinary working pressure, two engines; 175lb., two engines; and 200lb., two engines. A note will be taken of the conditions under which each journey takes place—the coal and oil used and the evaporation being accurately determined.

According to *Iron*, a letter-stamping machine is being tried in the post-offices of New York, and the results warrant the hope that a most difficult problem in the handling of masses of correspondence has been successfully solved. The hand-stamp operator, working with an ink pad, is able to stamp at the utmost sixty letters per minute, but the stamping machine, working at its maximum speed with evenly sorted letters, is capable of stamping 500 per minute, and performs nearly as good work when the envelopes and papers vary in size. The motive power comes from a small dynamo. An attendant feeds the letters into a hopper, and the machine does its own selection and rapidly passes the missives by a system of feed rollers to the printing die.

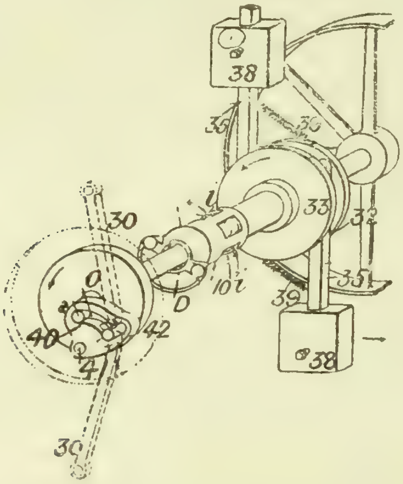
Russian Petroleum. — *Herapath's* states that the price of kerosene at Batoum has lately risen 25 per cent, and still has an upward tendency, while the price of crude petroleum at the wells near Baku has at the same time advanced 100 per cent. The cause for the advance is that the estimated demand for the present year is 3,225,816 tons, and the estimated yield from the Baku wells is only 1,612,903 tons. In other words, it is thought that the wonderful yield of the wells on the shore of the Caspian is exhausting the pool, and unless new sources of petroleum are discovered exports must cease. It is also rumoured that the Russian Government is on the point of imposing a duty on petroleum exported to foreign countries, with a view of keeping the supply equal to the domestic demand.

The New Pacific Liners.—The three new steamers which have been ordered to be built by the Naval Construction and Armaments Company at Barrow by the Canadian Pacific Railway Company are intended to be three of the fastest and smartest ocean going steamers afloat, and already the builders are making preparations for laying the keels. These steamers, which will run between Vancouver and Yokohama, will have twin screws, and be built with longitudinal bulkheads, the same as the City of Paris and the City of New York, and will be driven with two sets of triple-expansion engines, attaining a speed of 18 knots per hour. They are to be 450ft. long, 51ft. beam, and 36ft. depth of hold, and will have a gross tonnage of about 7,000 tons. One of the conditions of the order is that early delivery shall be made. It is understood that three other high-class steamers are to be built in this country in connection with the same scheme, to ply from England to Canada, thus affording an express route from this country by way of the Canadian Pacific Railway across the Pacific to the East.

ILLUSTRATED PATENTS.

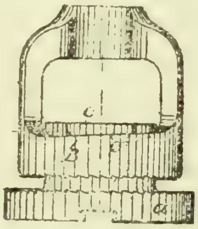
5310. Fluid-pressure Motors. W. P. Thompson, Liverpool.—*(E. B. Benham, Providence, U.S.A.)*

The invention relates to multiple cylinder motors of the class having a series of cylinders arranged in a fixed position in the same plane and radiating from a common centre, and consists of an improved distributing valve, and speed regulating devices whereby the distributing valve is caused to act by the irregular speed of the motor and induce a variation in the stroke of the pistons. In the arrangement described the radial cylinders are made in one piece, called the motor head, and are bolted to a pedestal which contains the inlet and exhaust passages. The motor head has provisions for carrying the shaft and flywheel. The distributing valve, which is mounted on the crank shaft, is shown on the drawing at 10, and the working fluid is admitted to radial passages leading to the outer ends of the cylinders through the sectorial opening D. The exhaust or discharge passes out to the exhaust passage in the pedestal through the openings *i*, *i*, *i*. For regulating the speed of the engine the distributing valve 10 may be turned on the crank shaft before or behind its normal position. This variation in its position is controlled by the governor balls 38, 38, which are connected by the rods 35, 35 and suitable links to the disc 33, fixed to the tubular extension of the distributing valve. The centrifugal force of the governor balls is balanced by springs 39, 39 connected at the inner ends to the disc 32 fixed on the crank shaft. If, for example, the speed of the engine increases, the sectorial opening D of the valve is advanced; the particular section of the radial cylinders acting for the moment through the rods 30, 30 on the crank pin 42 will also be advanced in front of the normal position, and the plate 40 on which the crank pin is fixed will turn on the pivot 41 till the pivot 41 and the crank pin 42 are in line with the resultant force from the acting pistons. The action of the governor through the distributing valve thus produces a varying stroke of the crank, and reduces or increases the speed as may be necessary.—April 10, 1888. [11½d.]



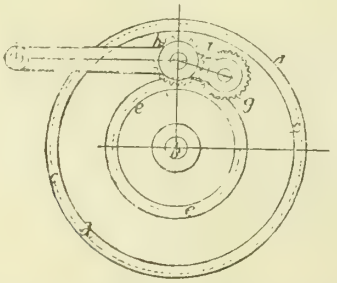
5849. Pump Buckets. W. Evans, Wolverhampton.

Relates to the mode of connecting the two parts of the bucket between which the cup leather is held. The follower *a* is provided with two wedging lugs *c*, which are inserted through cut-away portions in the cage B and then tightened on the inclined faces c^1 by turning. The gripping surfaces for the leather may be serrated, as shown, to assist in resisting the loosening of the parts, this being also applicable to buckets, the sections of which are screwed together.—April 19, 1888. [8½d.]



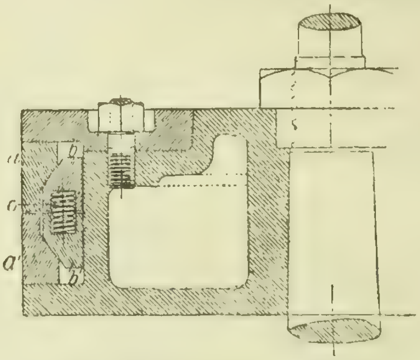
5960A. Reversing Mechanism for Machine Tools, Travelling Cranes, Mules, &c. T. C. Barraclough, Manchester.—*(N. de Landtsheer, Paris.)*

Friction Mechanism.—The disc *d* on the shaft to which motion is to be imparted has two flanges *c*, *e*, which are grooved to form friction surfaces. A friction roller is carried by the arm *i* and is connected to or is in one with a pinion *g* gearing with the constantly running pinion *k*. The arm *i* is centred on the spindle of the latter so that the friction roller can be brought against either of the grooves in *d*, while not interfering with the gearing of *k* and *g*.—April 21, 1888. [8½d.]



6022. Packing for Pistons, &c. J. Bickle, Cornwall.

Piston.—The packing rings *a*, a^1 are radially expanded and longitudinally pressed apart against the junk ring and piston flange respectively, by means of helical springs *c* conveniently disposed between the wedge-shaped expanding rings *b*, b^1. In a modification the springs *c* are mounted upon guiding pins. *Stuffing Boxes.*—With suitable and obvious alterations the above arrangement can be applied to stuffing boxes.—April 23, 1888. [11½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq. ***Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.***

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

September 13th.

14423	Speed Indicators, C. S. Snell and A. Thompson, Cornwall.
14424	Water Gas, H. Williams, Manchester.
14425	Carburetting Gas, H. Williams, Manchester.
14428	Recording Apparatus, J. Higginson, jun., Birmingham.
14430	Lubricants, A. Banks and A. Ness, Stockton-on-Tees.
14441	Marine Sounding Apparatus, W. C. Morison, Suffolk.
14469	Tube Stopper, S. A. Johnson, London.
14474	Reversing Gear, A. W. Robertson and J. Robertson, London.
14480	Wheels, E. Frankel, London.

September 14th.

14484	Pump, F. Lucich, Bristol.
14487	Diaphragm Cock, J. Zehren and A. Zehren, Paris.
14489	Overwinding in Coal Mines, W. E. Hobbs, London.
14507	Polishing Machines, R. Sudgen, Manchester.
14526	Punching Steel, W. Humphreys and I. Wyer, London.
14527	Rock Drills, J. W. Cann and R. E. Commans, London.
14532	Tubes, J. Wostenhofer, Germany.

September 16th.

14541	Tidal Motor, E. Barnard and G. Freeman, Bournemouth.
14546	Steam Boilers, W. Musgrave, Bolton.*
14555	Steam Generators, J. Jackson, London.
14558	Beating Engines, J. H. Annandale, Glasgow.
14564	Steam Boilers, J. Pregardien, Barmen.
14670	Water Gauges, L. Hugues, London.
14571	Electrical Switches, A. P. Lundberg, London.
14582	Purifying Water, R. Söderquist, London.
14588	Printing Presses, W. Heidenhain, H. Hoffmann, and W. Heidelmann, London.*

September 17th.

14607	Stoking Boilers, G. Little and J. J. Stevenson, Great St. Helens.
14612	Railway Rails, G. D. Moffat, London.*
14631	Ball Valve, C. T. Gann, Fulham.*
14647	Wheels, J. Rigby, London.*
14649	Covering for Steam Pipes, W. R. Lake, London. (C. T. Lee, United States.)*
14650	Friction Brake, C. Fairholme, London. (F. Dohlemann, Germany
14656	Glow Lamps, A. Bernstein, London.
14659	Pulleys, C. F. Batt, London.*
14662	Breech Mechanism of Guns, J. E. Compton-Bracebridge, London.
14665	Screw-threads, W. F. Lewis, London.*
14666	Conduits, J. W. Reno, London.*
14673	Combing Machines, T. Kennedy, London.*
14676	Hydraulic Compresses, A. L. Blackman, London.
14682	Water Gauges, D. Grangé, London.

September 18th.

14685	Metal Washers, D. Smith, Jun., Wolverhampton.
14686	Gas, H. Howell and L. Smith, London.
14689	Cutting Metal Rods, T. C. Barraclough, Manchester.
14708	Steam Generators, G. H. Taylor, London.
14712	Water-purifying Apparatus, G. E. Davis, Manchester.
14715	Oil-gas Apparatus, E. Mansfield, Manchester.
14717	Valves, G. W. Macalpine, London.
14729	Lubricators, G. H. Stuart, Liverpool.
14732	Chain-link, I. Brown, London.
14736	Centrifugal Machines, G. F. Redfern, London. (W. P. Abell, British Guiana.)
14748	Gas Lamps, E. C. Ribbard, London.

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THE

PRACTICAL ENGINEER,

OCTOBER 18TH, 1889.

NOVELTY IN PATENTED INVENTIONS.

In view of the enormous and ever-increasing activity of inventors at the present time in almost all civilised and even half-civilised countries, it is interesting to consider the question of the novelty of the very numerous successive inventions. It is very evident that few machines or inventions produced within recent years can be absolutely novel in every part, and the claims made by some inventors to entire and complete novelty of idea and carrying out can only be supported in rare cases. In other words, it is very rare indeed to find an invention which is entirely novel and has had no predecessors aiming at success on very much the same lines. Considering the similarity in the workings of the human mind under the pressure of the same necessities, this is by no means astonishing. On the contrary, it would be very amazing indeed if, among the more than ten thousand patents applied for yearly in this country, a goodly number did not attempt to solve the same problems, and often by very similar means. An examination of a few leading inventions now at work, with the most beneficial results to society at large, will amply repay us in illustrating this question, and will prove that a very small advance in overcoming some mechanical or other difficulty has made all the difference between a machine or apparatus which was almost commercially successful, and one which was completely and triumphantly so. Almost right, as applied to mechanism, means commercial failure, while the small difference between almost and quite right may, and often does, mean a great and widespread good to the public in general, and a grateful pecuniary success to the inventor in particular. Within our own experience we can recall many examples of very similar inventions, with apparently but minute differences between them, which minute differences, however, were quite sufficient to ensure success, while their absence was enough to cause disastrous failure. The well-known "Weston" pulley block is a good example, as greatly by its means the Messrs. Tangye succeeded in building up the huge engineering concern in Soho, so well known throughout the world.

In an action brought by the Messrs. Tangye, many years ago, against infringers of the "Weston" patent owned by them, the defendants, in their particulars of objections, among other things, alleged want of novelty, and brought into court an inventor named Moore, who had previously constructed a similar block. The block was produced, and it differed from the "Weston" mainly in the use of pegs instead of recesses in the periphery of the wheels. The "Weston" block, as most of our readers are aware, depends for its power on a small difference in diameter of two pulleys, cast or fastened together, and having recesses into which fit the links of an endless chain. This chain is passed over the two parts of the differential pulley in opposite directions, and forms two loops: on one loop hangs the hook block to which the load to be raised is attached, and the other loop is the part of the endless chain which is moved by hand in order to hoist or lower. It is evident that if the chain be moved to rotate the differential pulley in one direction, as the two portions are different in diameter, one pulley must take on more chain than the other pays out, and consequently the loop carrying the hook block gets shorter and shorter, and therefore the load is raised; while, if rotated in the opposite direction, more is paid off than goes on, and that loop is lengthened and the weight is lowered.

In this manner, by proportioning the relative diameters of the two parts of the differential block, any desired leverage may be got over the weight to be raised. At the same time the friction of the chain links, in moving in and out of the recesses formed to receive them, is sufficient to prevent the load from running down when the hand-chain is let go. This "Weston" block is a most convenient hoisting apparatus—simple, effective, and handy; accordingly it is almost universally used now, and in various modifications it is constructed and sold by many makers.

The block produced in court in the case to which we have referred differed from the "Weston" block mainly in the fact that pegs were used in the periphery of the differential pulley, into which a flat link pitch chain geared, instead of recesses shaped to receive the links of an ordinary chain. Mr. Moore's block had not been patented, but had been repeatedly described and illustrated in scientific publications, and one had also been exhibited at a public mechanical museum; so that there could be no doubt whatever that if his invention really anticipated Mr. Weston's, the idea had been widely published and made public property. In that case Mr. Weston had made no invention. Mr. Moore was examined as to whether his block had been manufactured or largely used, and it transpired that only one had been made, and that it was but once used, with difficulty. It was held by the court that the difference between pins and a flat link pitch chain and recesses arranged to take ordinary link chain was a great advance, and its extensive public use proved it to be a most valuable invention. The Weston patent was therefore held to be perfectly valid, and the block was decided not to be anticipated by Moore's. In this case the change from pins to recesses, and pitch chain to ordinary chain, made all the difference between engineering and commercial failure and success.

Take another example. The first really successful and economical gas engine ever constructed and largely sold was the well-known Otto and Langen engine. Its appearance is doubtless familiar to many of our readers. It was called by the British makers the atmospheric engine, because in it the explosion was not utilised directly to propel a piston connected to a crank, but the explosion shot out the piston in an open-ended upright cylinder against atmospheric pressure, and the vacuum so formed under it was utilised to drive the engine shaft round upon the down stroke. This engine appeared very novel to the world at large, and the patent was sufficiently good to yield a substantial pecuniary reward to the inventor; but notwithstanding that fact, a search of the British patents upon the subject reveals that two Italian inventors—Barsanti and Matteucci—many years previously constructed an engine on precisely similar lines. The piston was launched against the atmosphere by the explosion, and the descending stroke did the work, the piston being driven down by the pressure of the atmosphere above it. Nevertheless, the first engine failed, while the latter succeeded. The success was entirely due to superiority in small details which were not indicated by the general principle of the machine at all. In the latter case, the clutch allowing the piston to move up freely and engage on the down stroke was of the roller and wedge kind, and very perfect in its action; while in the former case only pawl and ratchet wheels were used, which failed under the shock. The Otto and Langen engine also used a very superior new flame-igniting valve, while the Barsanti and Matteucci only fired by the imperfect method of the electric spark.

We could instance many successful inventions which differ from unsuccessful ones only in small details, but the two already referred to are very prominent and striking. So long as the point of novelty in a new invention, however small it may appear to the uninitiated to be, makes the difference between a successful machine and a failure, that point is quite sufficient to make a strong and unassailable patent. Accordingly we would advise our engineering and mechanical readers who are inventors to persevere in their endeavours to overcome difficulties in practically applying new combinations of parts to useful industrial purposes, and to have little fear of interference from previous patents of machines, however similar, which have never proved useful in public. So many crude ideas have been patented, that it is very usual to find previous unsuccessful patents very similar indeed to new and successful machines, but these seem the necessary stages in the perfect development of practicable machines and processes, and should rather encourage the inventor by instructing him as to the rocks and shoals which have proved fatal to his predecessors.

In any case, inventors may feel tolerably safe that if they, by labour and thought, produce industrially useful results, the law will not allow previous failures, in the shape of patent specifications, to step in and prevent them from reaping their hard-earned reward. If there is any crucial point of novelty, however apparently small, if it be the turning point, it is quite sufficient. This is the view taken by English judges in the great mass of patent cases tried before them.

EARLY COMPLETION OF THE FORTH BRIDGE.

THE completion of the Forth Bridge is now a matter of a few weeks only. The connection between the south and the central cantilever is just being finished, and already many persons have passed from the south shore of the Forth to the island of Inchgarvie by bridge. At the end of September the gap was reduced to six feet between the ends of the girders. On the afternoon of September 26 a workman named Fitch placed a ladder between the jibs of two cranes on opposite sides, and first crossed the gap by this adventurous gangway. The connecting girder bridge has not been quite completed, but a substantial temporary gangway is now laid down while the final riveting up is proceeding.

The bridge between the central and northern cantilever is not so far advanced, as about 100 feet still remain to be built up, but it is confidently expected that continuous communication will be made by the end of the present month. In that case the bridge bids fair to be practically completed within five and a half years from the date of its commencement.

When railway connections are completed, the fast run from Edinburgh to Perth will be made in one hour, instead of requiring two hours and seven minutes, as at present, and the journey from Edinburgh to Aberdeen will take three and a half hours instead of five, and to Inverness six and a half hours instead of eight.

So far as concerns London traffic, the position of the East Coast companies will be enormously improved, and we may expect to see a very general acceleration over the country, in order that the West Coast companies may compete with them.

DR. JAMES PRESCOTT JOULE.

OUR readers, in common with the whole engineering and scientific world, will hear with deep regret of the death of Dr. Joule, whose honoured name ranks with that of Newton as the discoverer of a fundamental law quite as far-reaching in its application as the great law of gravitation. Dr. Joule died at his residence near Manchester, on Friday last, at the ripe age of seventy-one years. As the discoverer of the great law connecting the evolution of heat with the absorption of mechanical work, known as the law of the mechanical equivalent of heat, the name of Joule will be known throughout all time. When the nineteenth century has sunk in the distant past but few of the names which are at present familiar to all will then be known, but among those very few the name of Joule will occupy a foremost place. He is indeed one of the men of this century.

The fact that when work is performed a fixed and invariable proportion exists between the heat evolved and the mechanical work which disappears was first announced by Joule, in 1847, as the result of many careful experiments, and the announcement was received with comparative coldness. It was not till years after, that the importance of the discovery became manifest and its wide-reaching consequences became evident. As the fundamental law of thermo-dynamics, it is as applicable to the problem of the collision of worlds as it is to the case of the heat engines. It is now part of the stock knowledge of every inventor who attempts to improve the economy of steam or other heat engines, and enables engineers to understand fully how far to go, and where their improvements may be expected to lead them.

The practical engineer is as much indebted to Dr. Joule as the speculative physicist, and to both he has handed a key to much which would otherwise be dark and mysterious. He himself attempted to apply his ideas to air engines, which he conceived would in future supersede steam in some form; but the time was not ripe, and practical experience in detail had to be laboriously accumulated; but now the air engine, in the form of the gas engine, is rapidly proving the essential truth of the position taken up by Dr. Joule so many years ago. Our readers will find an account of the leading incidents in the life of Dr. Joule in another part of this issue, and in a future number we shall discuss the effect of the idea of the mechanical equivalent of heat upon the motive power engineering of to-day.

THE EDINBURGH ELECTRICAL EXHIBITION.

THE executive committee of the Edinburgh Electrical Exhibition have just completed their arrangements for this exhibition, which we observe is to be held in 1890, partly in celebration of the opening of the Forth Bridge. The bridge is expected to be opened for passenger traffic in the spring of next year. A special feature of the exhibition will be the provision of a lecture hall for meetings of the Institution of Electrical Engineers and other scientific bodies whom it is hoped will be induced to visit Edinburgh. We wish the scheme every success.

BOILER EXPLOSIONS.

Board of Trade Reports.

Report No. 320 refers to the explosion of a crane boiler at Dartford, Kent, which occurred on the 19th January last, at the Joyce Green Estate Company's wharf.

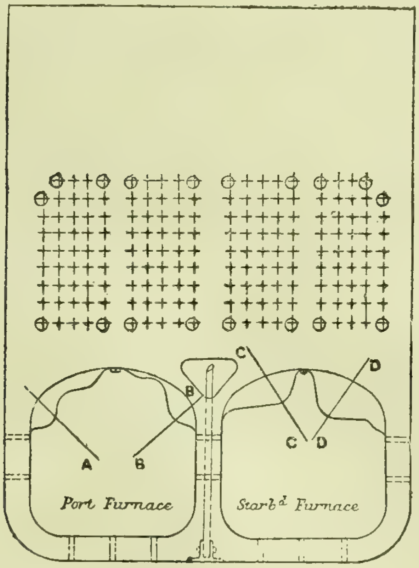
The boiler was made of wrought iron, and was of the ordinary cylindrical vertical type, with internal fire-box and central uptake. Two cross tubes were originally fitted in the fire-box, but these, having become worn out and leaky, were removed in September, 1888.

The explosion was extremely violent, and the boiler was propelled by the reacting force of the escaping water and steam to a great height, and landed in a field about 90ft. from the crane. The fire-box was completely destroyed, and the fracture appears to have commenced at a rivet hole in the seam, about 18in. from the top. The explosion was caused by the wasting away of the fire-box by corrosion, until it was no longer able to withstand the pressure to which it was subjected. Probably originally $\frac{5}{16}$in. thick, it had become thinned pretty uniformly to a thickness of from $\frac{5}{32}$in. to $\frac{3}{16}$in.

One person was killed and three others were injured by the occurrence. The boiler was repaired in 1888, but was not insured, nor was it inspected by any competent person while in the hands of the present owners. It was said to be about 20 years old.

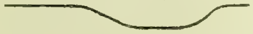
Report No. 321 deals with the bursting of a tube in a tramway locomotive, and it can hardly be seriously classed as an explosion. One of the tubes split, commencing close to the fire box tube plate, and the split extended to about 1½in., the widest opening being $\frac{3}{16}$in. The explosion occurred at Kingsbridge, Dublin, while the engine was waiting to start. Two men were slightly injured by scalding, but recovered rapidly.

Report No. 322 gives details of an explosion due to collapse of a flue on board the steamship Sussex, of Newhaven, while she was steaming past the Breaksea Light-vessel in the Bristol Channel. The boiler is of the rectangular multitubular type, having return tubes above the furnaces. It is constructed of iron, and has two furnaces, with a common combustion chamber.

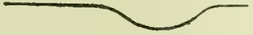


Front Elevation shewing Collapse of Furnace Crowns.

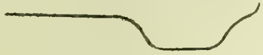
Section of Port Furnace Crown at A A



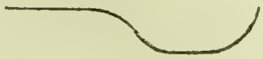
Section of Port Furnace Crown at B B.



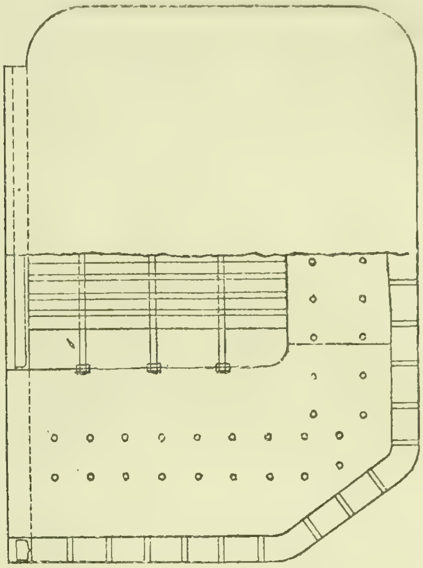
Section of Starboard Furnace Crown at C.C.



Section of Starboard Furnace Crown at D.D.



The explosion was caused by the collapse of the starboard furnace. Two small cracks, ¾in. and ⅜in. long respectively, appeared in the bulged crown of the furnace. Through these part of the water in the boiler was blown out, the fire being nearly extinguished by it. The collapse was due to excessive incrustation on the plates, which prevented the transmission of heat from them, thus causing them to be overheated, and consequently incapable of withstanding the ordinary working pressure. The accompanying illustrations clearly show the nature of the boiler and the collapse. No person was killed or injured. The boiler was last inspected by one of Lloyd's engineer surveyors in November, 1888, at Newport, Monmouthshire.



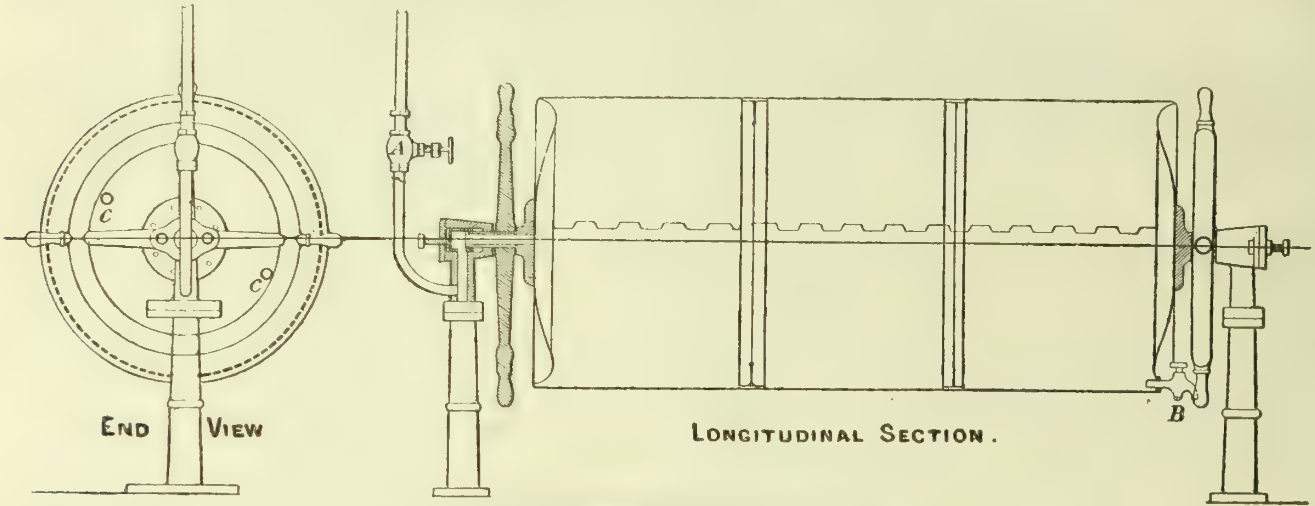
Side View and Section.

Report No. 323. This report deals with the explosion of a Cornish boiler, by which, however, no person was killed or injured. It occurred at Preston, on the 15th of February last. The boiler was made of wrought iron, was 10ft. 6in. long and 4ft in diameter, with one internal flue 2ft. 3in. in diameter. The bottom plate of the back ring of plating gave way about the middle of the plate, and ripped along the seam of the second course and the inside edge of the angle at the back end. Before breaking off at the circumferential seam it fractured through four rivet holes, leaving a hole about 21in. by 18in. in the boiler, through which the contents of the boiler rushed with such force as to turn the boiler bottom up, and project it, back end first, to a distance of 28ft. from the former position of the back end. The brickwork seating and flues were also demolished, as well as a wall about 9ft. square, and a portion of another wall, which divides the boiler from the workshop. The boiler was arrested by the wall of an adjoining stable, in which a hole 3ft. square was made. The explosion was caused by the bottom plate in the back ring of the shell having become so thin, owing to corrosion, as to be unable to withstand the steam pressure within the boiler. The plate, at the point of fracture, was only about $\frac{1}{32}$in. thick.

The boiler was worn out with age and use, and it appears that the insurance company cancelled the policy some years ago on account of want of facility for inspection. Had the boiler been properly examined, it would have been condemned and the explosion avoided.

Report No. 324 describes the details of the bursting of a cast-iron steam pipe at a paper mill near Blackburn, but fortunately no one was killed or injured. The pipe was 6ft. 9in. long, and 10in. diameter inside and 11⅝in. diameter outside. It contained a branch cast at right angles to its length, and a bend at one end. The core had shifted, and the casting was uneven in thickness. The explosion seems to have been caused by allowing water to accumulate in the pipes, and then suddenly opening the drain cock and causing a water-hammer action by the rush of steam impelling the water. The blow given by this movement was sufficient to fracture the pipe.

Report No. 325. This explosion took place at the Campbell Dyeworks, Perth, and no person was injured. It was due to the blowing out of the end of a copper steam drying cylinder. It was 5ft. 9in. in length and 2ft. 6in. in diameter. The shell was formed of one sheet of copper, and the longitudinal joint was brazed. The ends were of charcoal tinned iron ·08in. thick, and were dished for strength and flanged to attach to the shell, to which they were fastened by soft soldering. Cast-iron trunnions were attached to the ends; these revolved in suitable pedestals, the cylinder being turned by a handwheel attached to each trunnion. Steam was admitted through one of these trunnions, the pipe being fitted with a stop valve A (see illustration); at the opposite end there was a common plumber's tap B for discharging the steam and condensed water. Three atmospheric valves, to prevent collapse, were fitted, two C, C at one end, and the third at the opposite end. The explosion occurred through the absence of arrangements to prevent over-pressure. The tap did not allow the pressure to escape, because it was found to be plugged up with brown paper. This would almost entirely prevent the escape of steam. The boiler pressure was almost 40lb., and as the discharge tap choked, a pressure sufficient to destroy the cylinder rapidly accumulated.



The Dotted Lines in End View Show Rupture.

The explosion was caused by working the cylinder at a pressure for which it was unfit, and the soft solder failed all round, allowing the end to be blown clean out.

It would be well that owners of steam heated vessels of this and other classes, such as are used in confectionery trades, should use reducing valves between the boilers and their vessels, and also safety blow-off valves as well as vacuum valves, so as to guard against excessive internal as well as external pressure. In this case, the owners of the drying cylinder fitted their whole works with these safety appliances upon recognising their danger.

SMOKELESS POWDER.

Much has been written lately on the smokeless powder used by the French and German military authorities; and it has been assumed that England is behind-hand in this matter. Some statements communicated to the *Pall Mall Gazette* contradict this view. The authority cited is Mr. J. D. Dougall, jun., of the Smokeless Powder Company. He says that this country is really "very much in advance, for we possess what no other country in Europe has—that is, a factory on a very large scale established to make nothing else but these new powders." Our troops have no smokeless powder, but experiments are going on at Woolwich. As to the powder used by the German troops, Mr. Dougall is not certain as to the quality. "The only country which has its army prepared to enter into war with smokeless powder is France; no other nation has advanced so far as they have. The German troops have been using in the manœuvres so-called smokeless powder, undoubtedly with the object of showing themselves equally prepared as they are in France; but the use of such powders in sham-fights is no proof of their suitability when the cartridges are loaded." Smokeless powders are not absolutely smokeless; "but the smoke is reduced to a minimum, and is invisible at a hundred yards."

Of the different kinds of smokeless powders the following information is given: "There are two kinds of smokeless powders—one for the rifles already existing in European armies, such as the Martini-Henry, and the other for the new small-bore, or what is called eight-millimetre calibre. For example, there is a French Lebel cartridge and bullet of eight millimetres. It is a lead bullet with a jacket of steel. There is the proposed English cartridge and bullet of 7·6 millimetres. It is slightly smaller than the French, and it is a matter of discussion between experts which of these two is the better. The majority prefer the eight, and with them I agree. There is the Portuguese cartridge, which is also an eight millimetre. They have possessed a rifle of this bore longer than any other continental government. Their bullet, however, is not covered with steel, but with what may be called a lining of copper." The new cartridges are very small as compared with the Martini-Henry, and the bullet is not the size of the barrel of a medium-sized penholder. The existing Martini-Henry cartridge has a bullet of 480 grains weight, whereas the new 7·6-millimetre bullet weighs only about 213 grains. Two different powders are required for these two calibres; the smaller calibre must have a powder which burns much slower than is required for the larger or 11-millimetre bore. The advantage which black gunpowder has possessed for centuries is the facility for changing its rate of combustion by a difference in the size of the grain. It is necessary in order to take the place of black gunpowder that the new powders should also contain within themselves the means of altering their rates of combustion, and this they have in a high degree. There is a great gap between the smokeless rifle and smokeless sporting powders. The former burns far too slow to be of any use in the ordinary sportsman's gun. Quicker burning is required for the shot-gun. Black powder can hardly be used at all in small-bore rifles, because the fouling immediately detracts from the accuracy of the shooting, and the combustion is too quick for the resistance which the narrow long bullet offers in passing through the barrel, where it has to turn three times before it leaves the muzzle. A slow combustion is also necessary to prevent a dangerous strain either upon the sides of the barrel or upon the bolt of the magazine which is behind the cartridge."

A CENSUS OF STEAM ENGINES IN BIRMINGHAM.

In the year 1836, the Birmingham Philosophical Society made a record of the steam engines then at work in Birmingham, from which it appeared that 169 steam engines were then at work in the borough, of an aggregate power of 2,700 horse. In continuation of this work, the present Philosophical Society has recently appointed a committee to arrive at the power of the engines presently at work, and they have issued a circular to Birmingham manufacturers for the purpose of the inquiry. The forms invite manufacturers to send in two kinds of returns—(1) the number of engines and nominal horse power, whether steam, gas, or other prime movers, with the dates of their erection; and (2) engines removed, with the same particulars under this division. The object of the inquiry is to ascertain, as far as may be, the actual number and power of engines employed in Birmingham, distinguishing the branches of manufacture in which they are used; and also to show the development of the adoption and use of such power. A return of this kind would obviously be extremely interesting, as illustrating the growth and present position of our manufacturing industries; and as a means of comparison with the return obtained by the Philosophical Institution more than half a century ago. The preparation of the general figures from the returns which may be sent in—and for which, we understand, about 2,000 forms have been issued—will be a matter of great labour; but the gentlemen who have been requested by the Statistical Section to undertake the inquiry are willing to give the requisite time and work to it, and they hope that manufacturers generally will be disposed to put the necessary materials at their disposal. At the same time, the committee desire to trace the development of the use of gas engines, and desire information upon these motors also. The previous return is published in the report of the Birmingham Philosophical Institution of 1836, and a table is given which extends year by year, from 1780 to 1835, the additional engines erected in each year being recorded under the heads of the respective trades in which they were used. The record for 1780 is the removal of engines of fourteen horse power; in 1783 there was at work only one engine of twenty-five horse power, used in grinding flour. From 1787 to 1791, inclusive, no engines were erected, but fifty horse power was sold or removed in the three years. In 1798 there was another blank; no new engine was put up. The year 1803 showed a marked advance; four engines were erected, of 184 aggregate horse power, of which 160 horse power was employed in working metals. There was another advance in this direction in 1807, an addition of 105 horse power being made to engines used in metal working; in 1816 as many as nine engines were put up in the year—small ones, the total horse power being only ninety-eight; and in 1826 and following years there was still greater progress, as will be seen from the subjoined table:—

Year.	Engines.	Total H.P.	Used in Metal Trades.
1826	12	159	102
1827	6	187	153
1832	10	300	29
1834	17	157	113
1835	22	208	159

The total figures for 1835 were given as follows: Engines now at work, 169; total horse power, 2,700—employed in grinding flour, 275; working metals, 1,770; pumping water, 279; glass-grinding, 87; working wood, 97; paper making and glazing, 44; grinding clay, 37; grinding colours and chemicals, 61; sundries, 50.

COMPOUND MARINE BOILERS.*

For many years it had been evident that something more should be done to utilise the waste gases in marine practice than had been the custom of the trade. In land practice a good deal more had been done, and for many years fairly good applications of feed heating had been in use, such as the well-known "Green's" economiser, and similar appliances.

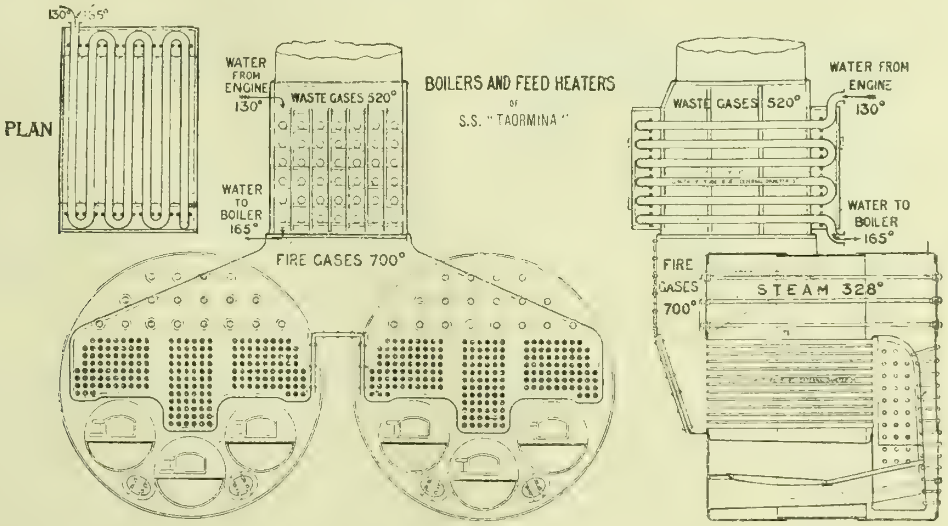


Fig. 1.

In compound engines, with double, triple, or quadruple cylinders, high-pressure steam in graduated stages of temperature was used, and better results were got than if it were used in a single stage. In the same way, if fire gases were utilised in stages of temperature, better results were got than if used in one stage.

The object of the paper was to put before the institute the results of the writer's experience in various forms of feed heaters and compound boilers.

In the year 1879, the steamship Plantyn, a Belgian steamer trading between Antwerp and New York, was fitted with a feed heater of the style shown in fig. 1, but with a smaller surface than the one shown. Its heating surface was equal to about 3½ per cent of the main boiler surface, and in regular working conditions at sea it gave an increase of temperature to the feed water of about 15 deg.

The arrangement was as follows: The water from the feed pump was delivered into the first tube of the top row, and travelled backwards and forwards until it got to the last tube of the bottom row, when it went into the main boiler. A saving of coal of about 4 per cent had resulted from a test from New York to Antwerp and back again, with the feed heater in use on the return voyage.

The tubes were all alike, so that spare ones would fit any part of the heater. There were also loose cast-iron doors laid on near the end of each tube, which can be lifted off when the boiler is at work, for the purpose of cleaning the soot off the tubes by a hand scraper. This was found to be useful in keeping the heater efficient. The doors also enabled a spare tube to be put in at sea, by shutting off the heater and feeding direct, without interfering with the regular working of the boilers. The inside of the tubes could also be cleaned by taking off the knee pipes, which join the ends of the tubes.

Feed heaters had been fitted to several steamers trading between Glasgow and Indian ports with a proportion of heating surface of about 5 per cent of that of the boilers, and in regular work at sea 20 deg. increase of temperature to the feed water had been obtained.

The particulars of heating surface, temperature, &c., of the foregoing were given in Table I. These heaters were still all in good order, with the exception of those of the two last-named vessels, which had been lost at sea. At this stage of his experience the author was disappointed with the results so far obtained.

In the Taormina the heaters' surface was fully 10 per cent of that of the boiler surface, and the increase of temperature only 35 deg., with the fire gases above the heater still about 520 deg., and below the heater about 700 deg.

In 1888, therefore, a boiler was made for the steamship Bleville, consisting of two ordinary return tubular boilers, with four stacks of water tubes placed at the front of each boiler, the bottom stack being just above the top row of boiler tubes, the feed water from the engines entering at one end of the top stack, where the fire gases were coolest, and travelling backwards and forwards through the various rows of tubes, and from one stack to another, until it reached the bottom stack, where the fire gases were hottest, from which place it was discharged into the main boilers. The heaters in this case were larger than the main boilers, and had about twice the heating surface of the latter. This being so, and the heat of the fire gases being utilised in stages of temperature in the same way as the steam is used in stages of temperature in the compound engine, the author thought it would be right to call the combination a compound high and low temperature boiler.

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* Abstract of Paper read by Ebenezer Mr. Kemp before the Institution of Engineers and Shipbuilders, Glasgow.

The boilers were made to work either with or without a forced draught. With the fire gases leaving the tubes of the high-temperature boiler at 750 deg., and escaping just above the tubes of the low-temperature boiler at about 350 deg., the feed water going into the first or top stack at about 130 deg., and leaving the bottom stack at about 280 deg., the steamer could do her work very well.

There were several constructional drawbacks, however, and much trouble had been experienced at sea with the tube fastenings, but the economical results obtained proved that the principle was good.

The boiler shown in fig. 2 was then constructed for the Caloric. In this arrangement the feed water from the engine entered one of the top boilers at the end where the fire gases were escaping to the chimney, and left it at the opposite end. It entered the first at about 130 deg. of temperature, and left the last one at about 270 deg., thus gaining about 35 deg. in each boiler. The fire gases, after leaving the high-temperature boiler at about 675 deg., entered the tubes of the bottom pair of low-temperature boilers, and returned through the tubes of the top pair, on emerging from which the gases were reduced to about 225 deg., thus utilising about 450 deg. of the waste gases.

With the object of making the high-temperature boiler as efficient as possible, and seeing what heat was left to be utilised by the low-temperature boiler, the author made the former about 44ft. of heating surface to 1ft. of grate area. The tubes were 3in. in diameter and 8ft. 4in. long, the low-temperature boiler tubes being exactly similar. Both the boilers were fitted with Mr. W. S. von Essen's patent steam tube cleaners.

The Caloric had steamed over 44,500 miles, and had been running for about 14 months. The only unsatisfactory thing that had occurred was that the tubes of the low-temperature boiler had been pitting. They were made of iron, and the pitting was no doubt due to the too plentiful use of tallow. Since then, however, care has been taken to use as little oil in the cylinder as possible, and the piston rods were now swabbed with cylinder oil. The economic results of the Bleville and Caloric were practically the same, and the coal consumption (1¼lb. per I.H.P. per hour in the case of the Caloric) was taken from trials made at sea in the Mediterranean, Atlantic, and on the voyage to the River Plate. In addition to these trials, the author had had another means of judging of the economy by comparison with three other steamers, viz., the Vascongada, Victoria, and Domira; the first-named being rather smaller, but the two latter exactly the same model and dimensions as the Caloric.

The engines of all four had cylinders 18in., 29in., and 46in. diameter, by 39in. stroke, with a boiler pressure of 160lb., and were in every respect the same. The boilers, however, were all different. The Vascongada's was single ended, 14ft. diameter by 11ft. 9in. long, having three furnaces 3ft. 3in. in diameter, and a total heating surface of 2,375ft; the fire-grate surface over full length of bars by mean breadth was 49½ft. The Victoria's was double-ended, 11ft. 6in. diameter by 17ft. long, having four furnaces 3ft. 4in. in diameter, and a total heating surface of 2,444ft.; the fire-grate surface over full length of bars by mean breadth was 62ft. The Domira's was single-ended, 14ft. 6in. diameter by 11ft. 9in. long, having three furnaces 3ft. 6in. diameter, and a total heating surface of 2,488ft.; the fire-grate surface over full length of bars by mean breath was 53½ft.

The Caloric's high-temperature boiler was single-ended, 12ft. diameter by 11ft. 6in. long, having two furnaces 3ft. 9in. diameter,

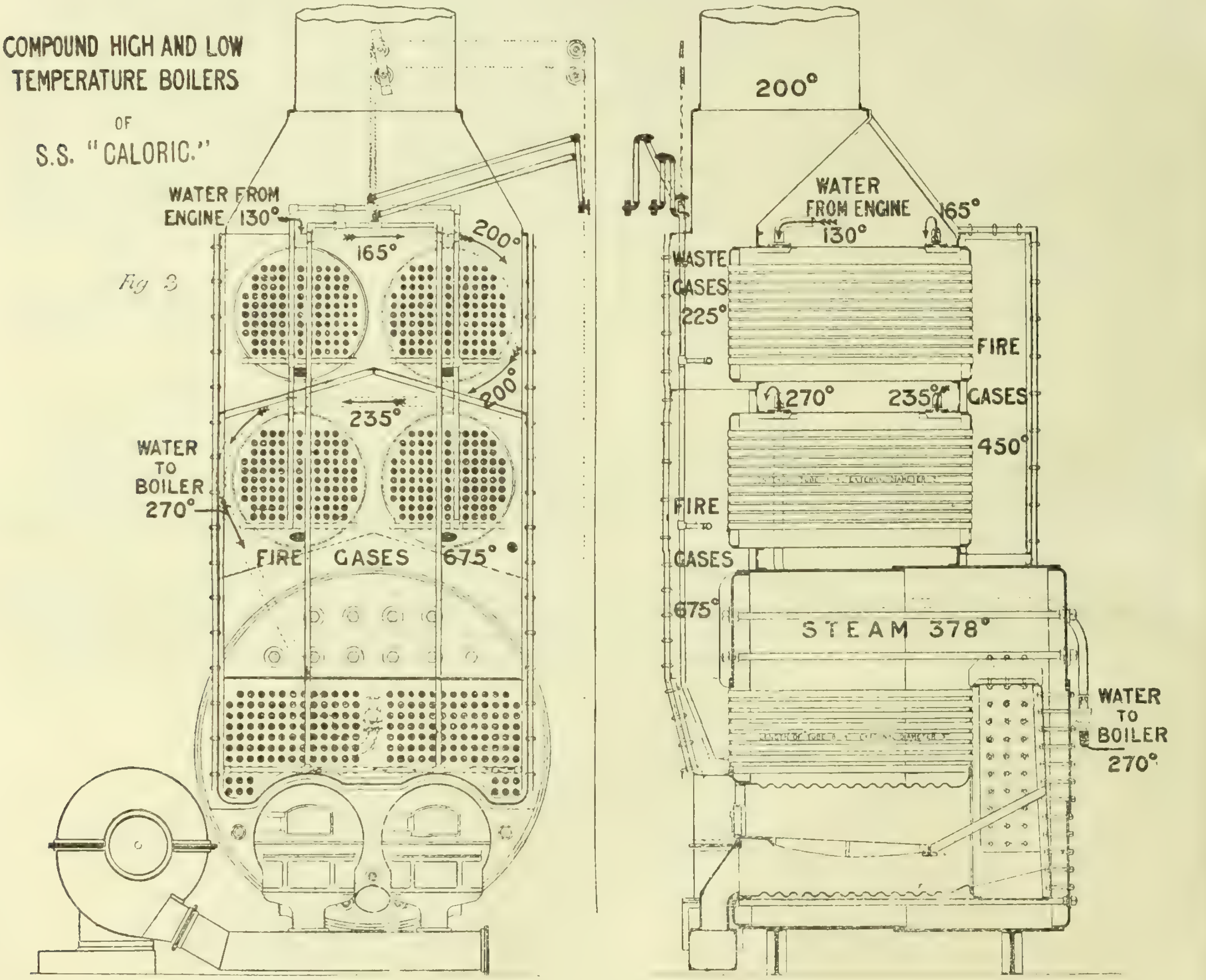


Fig. 2.

and a total heating surface of 1,613ft. There were four low-temperature boilers, 4ft. 6in. diameter by 8ft. 4in. long, with a total heating surface of 3,505ft. The combined heating surface of high and low temperature boilers was thus 5,118ft. The fire-grate surface over full length of bars by mean breadth was 38½ft.

The Vascongada's dimensions were 250ft. by 35ft. by 18ft. 3in., and she could load about 2,400 tons dead weight. The Victoria, Domira, and Caloric were 260ft. by 36ft. 9in. by 18ft., and they could all load about 2,500 tons dead weight. All four vessels could steam 9½ knots on trial fully loaded, and 9 knots at sea in good weather, and they had an all-round speed at sea of about 8½ knots. The three former burned about 11 tons of coal per day for all purposes, getting up steam, steam winches, stearing gear, galley, &c., and similarly for all purposes the Caloric burned about 9¼ tons, and if allowance was made for getting up steam, &c., the consumption for the engine only would be about 8¼ tons per day.

The vessels were built by Messrs. Alex. Stephen and Sons in the following order, viz., Vascongada, Victoria, Caloric, and Domira. They were all new vessels, and all engaged in the same kind of trade, and as nearly as could be got at they have all been steaming about the same average speed, and the saving in coal in the Caloric over the others was fully 15 per cent.

The boiler lost very little pressure of steam when the fires were being cleaned, owing to the heat stored up in the low-temperature boiler acting like an accumulator, and through the forced draught being shut off the fire that was to be cleaned, the remaining fire was forced with more vigour than when they were both working.

In testing the temperature of the gases in the smoke boxes, the pyrometers used were at first one of Krausse's, of Paris, and afterwards two of Murrie's, of Glasgow. The thermometer used for testing the heat of the water in the low-temperature boilers for the first nine months was made by Mr. James Gardner, Glasgow, and was fixed in a bath of mercury. Those in use since that time were made by Messrs. Baird and Tatlock, Glasgow, and were fixed in a bath of oil, and both systems gave nearly the same indications.

To meet the growing demand for increased pressure in modern marine practice, the compound construction of boilers was well adapted, owing to its having so large a proportion of the heating surface contained in comparatively small diameter shells of the most simple construction, and by obviating the difficulty of having great differences of temperature in any one shell, the system was calculated to add to the durability of the boilers.

THE CYCLOIDAL TOOTH FOR SKEW-BEVEL GEARS.

By George B. Grant.

There is certainly no branch of the theory of the teeth of gears that can compare for intricacy and difficulty with that relating to the teeth of the skew-bevel or hyperboloidal gear. The various expert writers evolve complicated diagrams and interminable formulæ, and contradict each other in a manner that is bewildering to the novice in search of information, and leaves the impression that this item of knowledge may perhaps be too difficult for the human mind to thoroughly understand.

Olivier, who studied the matter as long ago as 1816, and was probably the first to scientifically attack the skew-bevel gear, contrived a peculiar "spiraloidal" tooth, and has left us a formidable treatise, bristling with the toughest possible mathematics.

Willis, some time afterwards, 1840, proposed the cycloidal tooth, commonly and ignorantly adopted at the present day. He apparently relied on the strength of its resemblance to the same tooth for spur and bevel gears, for that keen observer and skilled mathematician would not have failed to have seen its true action if he had carefully studied it.

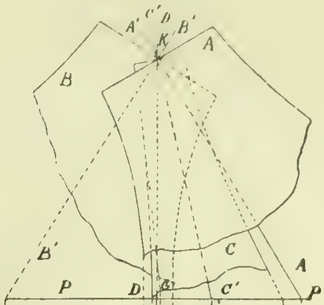
Rankine—and few rank higher in theoretical mechanics—adopted the cycloidal tooth without suspicion, so plausible is the fraud.

Herrmann appears to be the first to clearly show the inaccuracy of this tooth. He gives a universal law for the formation of all teeth, that clearly throws it out, but he does not seem to have as clearly seen its real action. He describes it as approximately accurate, as if it was serviceable, though not theoretically correct.

MacCord gives a demonstration to the same effect as Herrmann's law, showing that the supposed line of tangency is in reality a line of intersection. And yet he thinks enough of that form of tooth to elaborately describe it, and gives methods for its practical application. This writer supposed himself to be the first to demonstrate the true action of this tooth, for in his preface he claimed that discovery. It was, no doubt, original with him, but, in points of novelty and scientific thoroughness, the universal law of Herrmann takes precedence.

Most practical writers who touch this subject adopt the cycloidal tooth, and give rules for its construction; but there should be a thorough change in this respect, for that form of tooth will not work at all. It is wrong to even propose it as a makeshift or approximately correct tooth, for it will not work approximately unless the axes are very nearly parallel, or nearly intersect. This fact is shown by the work of the writers named, but not so definitely as to determine the actual amount of the error. They show the fact of inaccuracy, but do not measure it.

Fig. 1.



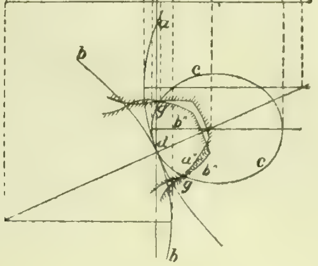


Fig. 2.

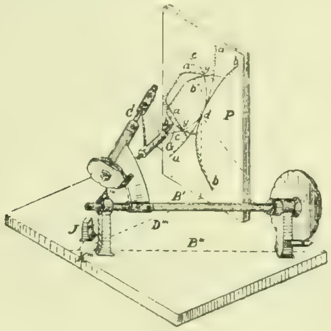


Fig. 3.

I have always found the skew-bevel gear to be a thing to be dreaded and approached with respect. No matter how much study is put into it, a satisfactory result is to be reached only by the skilful and persistent application of that good old rule, "Try, try again." The usually published method may serve as a starter to prepare the way for a second trial, but is not otherwise serviceable.

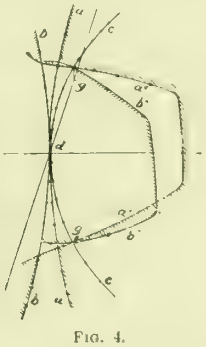


Fig. 4.

To determine whether the cycloidal tooth is really serviceable or not, I found it necessary to construct or draft the actual tooth, for the theoretical treatment and general reasoning are insufficient

BISCUIT-MAKING MACHINE AT THE PARIS EXHIBITION.

CONSTRUCTED BY MESSRS. J. BAKER AND SONS, ENGINEERS, LONDON.

(For description see page 715.)

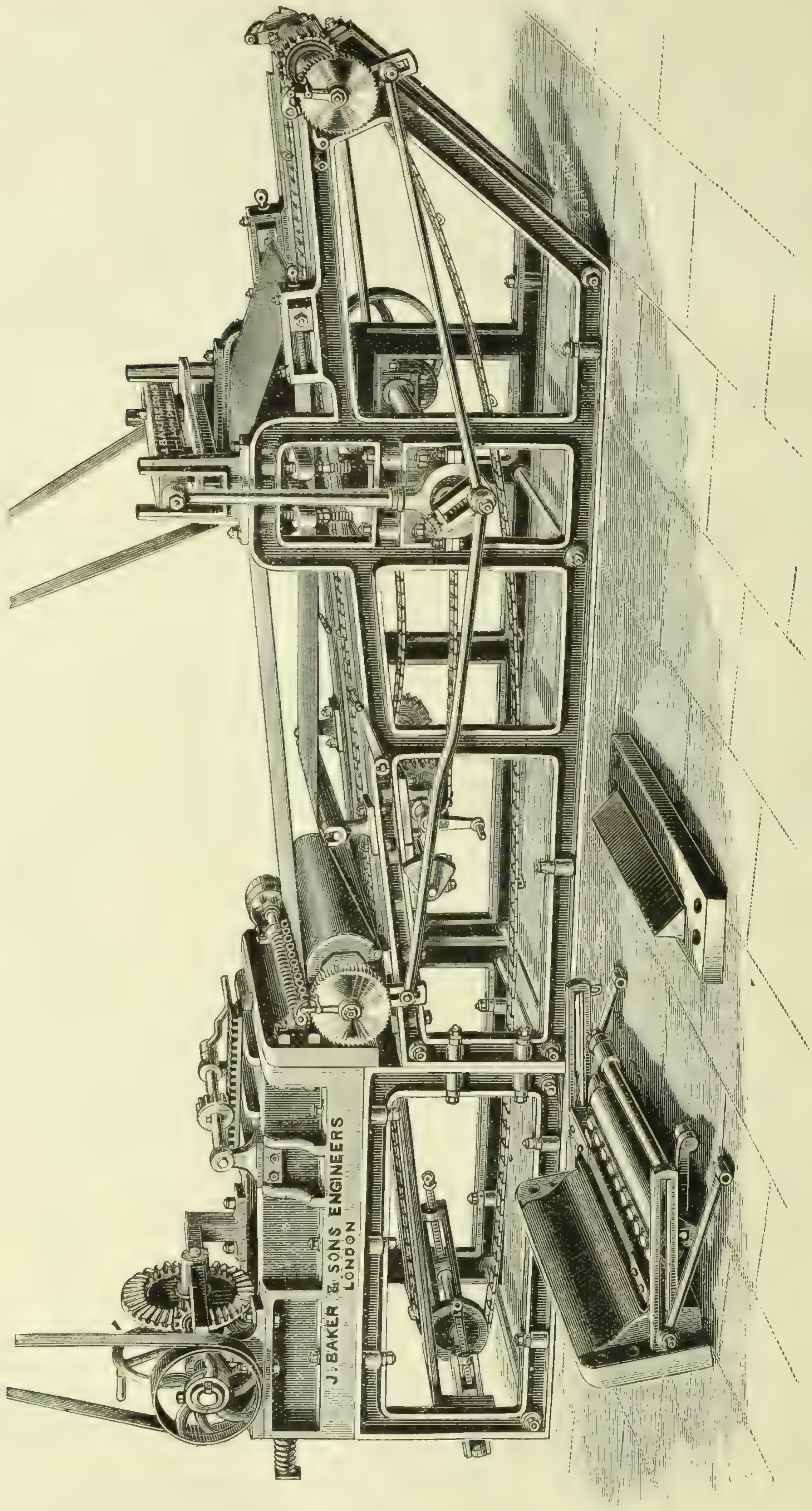


Fig. 1.

for that purpose. As the construction of the actual surfaces would be exceedingly expensive, I adopted the method of drafting the curves alone by means of the mechanism to be described.

To clearly present the matter at hand, and the instrument for drafting the tooth curves, it will be necessary to describe the cycloidal tooth in a general way. Fig. 1 shows the pitch hyperboloids A and B, and the auxiliary hyperboloid C, rolling together on their fixed axes A′, B′, and C′, and having the element or instantaneous axis D in common. An element G of the hyperboloid C, called the generatrix, will sweep up cycloidal surfaces on A and B. Fig. 2 shows a section of fig. 1 by the vertical plane P; a, b, and c are the sections of the hyperboloids A, B, and C, while a'' and b'' are sections of the supposed tooth surfaces. As shown, these tooth sections always intersect on the section c as a line of action, and, as the solid parts of two teeth would interfere, they cannot act as gear teeth, or even be practically useful for that purpose, unless the interference is very little indeed.

Herrmann shows that these teeth are inoperative because their construction is not in accordance with a universal law, which requires the generatrix to so move as to be always parallel with the instantaneous axis. MacCord adopts the more direct but limited method of a demonstration that the surfaces intersect. Neither one of these methods was clear enough to show their inventors the true condition of the tooth. My method is to actually draft the intersecting curves of the section made by the plane P for some particular case, and it has the advantages that it is readily comprehensible without resort to complicated mathematical processes, and that it not only demonstrates the fact of interference, but measures its amount.

To do this I constructed the simple instrument shown by fig. 3, in which the parts are lettered to correspond with the other figures. The axis shaft B' carries an index by which it can be rotated and fixed in the required positions. The auxiliary shaft C' carries another setting index, and is firmly fastened to the shaft B'. The pointed generatrix rod G slides in a sleeve attached to the shaft C'. The vertical board P represents the section plane, and, as the two shafts are properly rotated, the rod G will prick points upon it in the required sections of the hyperboloids and tooth surfaces. The figure shows the instrument set to draft the faces b''; and to draft the flanks a'' it is reset to the axis A, of which A''' K''' is the projection.

The action of the instruments is strictly correct, and the resulting drawing is far more satisfactory than actual surfaces would be—for the latter could not be made to fully interfere.

Fig. 4 is a reduced copy of the work of this instrument. The dots show the points found by the instrument, and the lines are filled in to show the true shape of the whole tooth. It is seen that they interfere very badly, and that it would be useless to try to make them serve the required purpose with approximate accuracy. They are not gear teeth at all, and all the writers who have adopted them at all have been clearly wrong.

The figure shows a section at a considerable distance from the gorge line K, and a nearer section would show an increased interference. If the axes were nearly parallel, or nearly intersected, the interference would be less, but the axes are generally at right angles, and the case selected is fairly an average one.—*American Machinist.*

THE PARIS EXHIBITION—BISCUIT-MAKING MACHINERY.

The English working bakery of Messrs. J. Baker and Sons, City Road, London, at the Paris Exhibition, has been already referred to by our Paris correspondent in his notes on the Exhibition. It is most elaborately and completely fitted up, and the whole process of biscuit making by machinery is shown in full operation. Among the most interesting machines, we observed one for the manufacture of café and rout biscuits, and an improved whisking machine, which we illustrate at figs. 1 and 2. The café and rout biscuit machine (fig. 1), we are informed, produces every variety of press goods with great economy and perfection, and makes as well a number of new forms in this class of biscuit, which are in rapidly-increasing demand. It is strong and powerful, so as to deal with large quantities of rout biscuit doughs, one machine being capable of keeping the largest sized travelling oven fully employed.

For ordinary forms of dough the machine is shown as fitted in fig. 1, with travelling web to carry dough from the dies to the cutters. When cut it is automatically placed upon the baking pans, and these, when filled, are moved forward by the "skip" motion, which prevents any of the dough falling on the edges or between the pans. The variable speed required for the different kinds of biscuits is given by means of the cone driving gear, which can at once cause change of speed as required. Fig. 2 illustrates Messrs. Baker and Sons' "Baker-Cadisch" patent whisking machine, which contains all the latest improvements applicable to such machines. The cone driving gear allows the speed to be increased as the whisking proceeds, and the improved shape of copper pan is held securely by arms of a new design, which allow the pan to be lifted and replaced in an instant.

There are many other machines at Messrs. Baker's installation, some of which we propose to notice in a future issue. The English Bakery is exceedingly creditable to the engineers, and is continually thronged by interested visitors. If English steam engineering were as well represented at Paris as baking engineering, it would have been most gratifying.

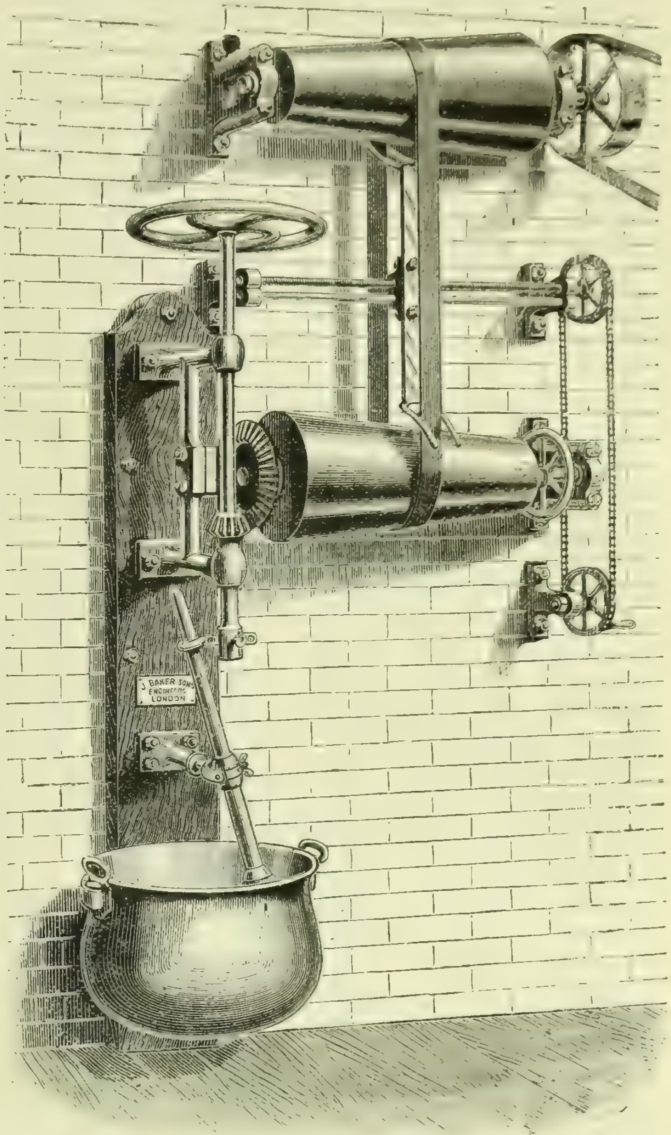


Fig. 2.

DEATH OF DR. JOULE, THE DISCOVERER OF THE MECHANICAL EQUIVALENT OF HEAT.

Probably no man's name is better known in the scientific world of the present century, as certainly none is more profoundly respected, than that of James Prescott Joule, and the news of his death, which took place at his residence, near Manchester, at half-past 10 o'clock last Friday night, will be received with the deepest regret by a very wide circle indeed. His health had been deteriorating for several years past; he had been more or less confined to his house for about two years, and of late had been gradually sinking.

Dr. Joule was born in New Bailey Street, Salford, on Christmas Eve, 1818. His grandfather and his father were brewers, and carried on that calling with success in the borough of Salford until 1854, when the business was disposed of owing to the failing health of the father of Dr. Joule.

In his early years James Prescott Joule was a delicate child, and, as a consequence of his feeble physical condition, was not sent to school. The rudiments of learning were imparted to him by his mother's half-sister, and his education was subsequently carried on at his father's house at Broomhill, Pendlebury, by tutors, until he reached the age of 16. His first instruction in physical science was received from Dr. Dalton, who has been deservedly described as one of the most distinguished chemists of any age or country. The doctor had arrived in Manchester, when in his 23rd year, to become professor of mathematics and natural philosophy at the New College in Mosley Street, and on the removal of that institution to York he became a private teacher of the same subjects, occupying for the same purpose the lower rooms of the Literary and Philosophical Society in George Street. In 1835, when the father of Dr. Joule sent his son James with his brother Benjamin to Dr. Dalton, to be instructed in chemistry, the doctor was president of the Literary and Philosophical Society, and had travelled far above the bottom rung of the ladder of fame on which he subsequently attained so high a position. Very early in his studies Joule was found at work on the molecular constitution of gases, following in the footsteps of his talented master, whose investigations into the constitution of mixed gases and on the behaviour of vapours and gases under heat were among the most important of his age.

Dalton imparted to young Joule his first acquaintance with physical apparatus, and as the acquaintance ripened the fruit was seen in the anxiety of the pupil to commence researches and to make experiments on his own account. His father allotted him a room as a laboratory, and his first effort seems to have been the construction of a cylinder electric machine of a very primitive form.

The future Dr. Joule gradually increased the apparatus at his command, and soon entered the ranks as an investigator. His first original paper appears to have been published in 1838, when the writer was only nineteen years of age, in Sturgeon's "Annals of Electricity" for January of that year. He had constructed an electro-magnetic engine, described in his paper, and following up his first experiment in this subject he constructed other machines and electro-magnets of novel forms, with which he obtained results of great importance. These results showed the impossibility of realising the expectation which appears to have been then entertained that electro-magnetism would eventually supersede steam as an economical source of motive power. In 1840 he discovered the existence and value of the limit to the quantity of magnetisation in soft iron, and applying this principle he succeeded in constructing electro-magnets of a much greater lifting power than any which had been previously obtained, while he studied also the methods of modifying the distribution of force in the magnetic field.

In commencing his investigations into the subject of the distribution of force in the magnetic field, Dr. Joule was met, to use his own words, with "the difficulty, if not impossibility, of understanding experiments and comparing them with one another which arises in general from incomplete descriptions of apparatus, and from the arbitrary and vague numbers which are used to characterise electric currents. Such a practice might be tolerated in the infancy of science, but in its present state of advancement greater precision and propriety are imperatively demanded." He therefore determined to abandon the quantity numbers which he had previously used, and to express his results on the basis of a unit which should be at once scientific and convenient; and realising the importance of having a system of electric measurement which would make experimental results obtained at different times and under various circumstances comparable among themselves, and also perceiving the advantage of such a system dependent on, or at anyrate comparable with, the chemical action producing the electric current, he adopted as the unit quantity of electricity the quantity required to decompose nine grains of water, nine being the atomic weight of water according to the chemical nomenclature then in use. He had previously made important improvements in the construction of galvanometers, the results of which he had made public, and he graduated his tangent galvanometer to correspond with the new system of electric measurement. Working on this basis, the numbers used in all his subsequent papers are easily reducible to the modern absolute system of electric measurements, in the construction and general introduction of which he himself played so prominent a part.

In 1840, after experimenting on improvements in voltaic apparatus, he turned his attention to the heat evolved by metallic conductors of electricity, and in the cells of a battery during electrolysis, and by papers which he published in that and the two following years laid the foundation of a new province in physical science, then totally unknown, but now familiar to all practical electricians—that of electric and chemical thermo-dynamics. With regard to the heat evolved by a metallic conductor carrying an electric current, he established what had previously only been supposed to be the law, namely, that "the quantity of heat evolved by it (in a given time) is always proportional to the resistance which it presents, whatever may be the length, thickness, shape, or kind of the metallic conductor."

Having proved the impossibility of applying magnetism to the generation of motive power economically, he turned his attention more especially to the transformation of chemical energy into heat, and in a communication made in 1840 to the Proceedings of the Royal Society he established relations between heat and chemical affinity, which high scientific authorities have since acknowledged contained the germs of the subsequent vast development of dynamical science as applied to chemical action. In 1841 and 1842 he continued his investigations into this branch of study, and in January, 1843, was able to announce with certainty that the magneto-electric machine causes the conversion of mechanical power into heat.

At the meeting of the British Association in Manchester in 1842—the last meeting, it may be remarked by the way, at which his teacher Dalton appeared—Dr. Joule read a paper on the "Electric Origin of Heat," which evoked considerable attention from the savants present; and in the following year, when the association met at Cork, he read a second paper on "The Calorific Effects of Magneto-electricity and the Mechanical Value of Heat," in which he described a series of experiments in magnetic electricity, made with a view to determine the mechanical value of heat, and which had the effect of attracting still deeper attention to the subject.

In a postscript to this paper Dr. Joule said: "I shall lose no time in repeating and extending these experiments, being satisfied that the grand agents of nature are, by the Creator's fiat, indestructible, and that wherever mechanical force is expended, an exact equivalent of heat is always obtained." He did continue the experiments, and being met with the pressing need of accurate thermometers, he produced, with the assistance of Mr. Dancer, instrument maker, of Manchester, the first really accurate English thermometers. In 1844 he communicated to the association a paper on his continued experiments, and again in 1845, in an important paper on "The Mechanical Equivalent of Heat," he detailed the results gained from water agitated by a paddle-wheel.

In 1847 (the year in which Mr. Joule married Amelia, daughter of Mr. John Grimes, Comptroller of Customs at Liverpool) the British Association met at Oxford, and in one of the sections Mr. Joule read a fresh paper on "The Mechanical Equivalent of Heat," and the following extract from a letter written by Sir W. Thomson to Mr. J. T. Bottomley describes the meeting of the celebrated physicist with the subject of our sketch at this gathering of scientific men: "I made Joule's acquaintance at the Oxford meeting, and it quickly ripened into a life-long friendship. I heard his paper read in the section, and felt strongly impelled at first to rise and say that it must be wrong, because the true mechanical value of heat given, suppose in warm water, must, for small differences of temperature, be proportional to the square of its quantity. I knew from Carnot that this must be true (and it is true; only now I call it 'motivity,' to avoid clashing with Joule's 'mechanical value'). But as I listened on and on, I saw that (though Carnot had vitally important truth, not to be abandoned) Joule had certainly a great truth and a great discovery, and a most important measurement to bring forward. So instead of rising with my objection to the meeting I waited till it was over, and said my say to Joule himself, at the end of the meeting. This made my first introduction to him. After that I had a long talk over the whole matter at one of the conversaziones of the association, and we became fast friends from thenceforward. However, he did not tell me he was to be married in a week or so; but about a fortnight later I was walking down from Chamounix to commence the tour of Mont Blanc, and whom should I meet walking up but Joule, with a long thermometer in his hand, and a carriage with a lady in it not far off. He told me he had been married since we had parted at Oxford, and he was going to try for elevation of temperature in waterfalls. We trysted to meet a few days later at Martigny, and look at the Cascade de Sallanches, to see if it might answer. We found it too much broken into spray. His young wife, as long as she lived, took complete interest in his scientific work, and both she and he showed me the greatest kindness during my visits to them in Manchester, for our experiments on the thermal effects of fluid in motion, which we commenced a few years later." Mr. Joule still further continued his experiments, until he had secured that at which he aimed, and the truth of his theory was assured.

(To be continued.)

The theoretical composition of pure water gas is $CO + H_2$, or two volumes carbonic oxide and two volumes of hydrogen. In practice, however, nitrogen is always present.

STEAM AND VACUUM GAUGE TESTER.

We here illustrate a very neat and handy arrangement for comparing pressure and vacuum gauges, in which external tube connections to the different gauges are successfully avoided. The apparatus consists, as will be seen from figs. 1 and 2, of an internal cylinder slipped within an external one A, which carries two branches, B and C, to which to attach the gauges to be compared. A piston K is moved in the internal cylinder by the screw L, actuated by the handwheel shown. The internal cylinder F is screwed into the cylinder A by the screw G at the point H. The action in testing is as follows: A small india-rubber tube is slipped on the tube I, while the other end is dipped in a tumbler of water, and the passages to the branches are shut by the cocks D and E. E is a three-way cock, arranged to open to the tube I and the cylinder F, while it shuts to the branch aperture B. The piston K is first screwed back to the bottom of the cylinder, and is then screwed out so as to fill the cylinder with water. The air lodged between the two cylinders is next allowed to escape by the cocks D and E, and the further movement of the piston causes the whole space to be filled with water. To compare the gauges it is then only necessary to screw in the piston to put pressure upon them, if they are pressure gauges, and to screw it out after filling the annular space with water, if they are vacuum gauges. In this way high pressure or good vacuum may be easily attained. The arrangement is very simple and reliable. It is constructed by Messrs. Wm. Reid and Co., of London and Newcastle-on-Tyne.

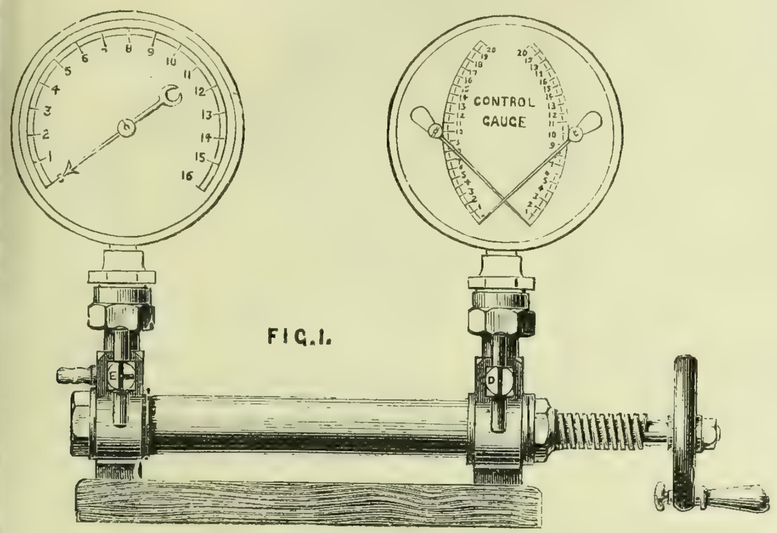


FIG. 1.

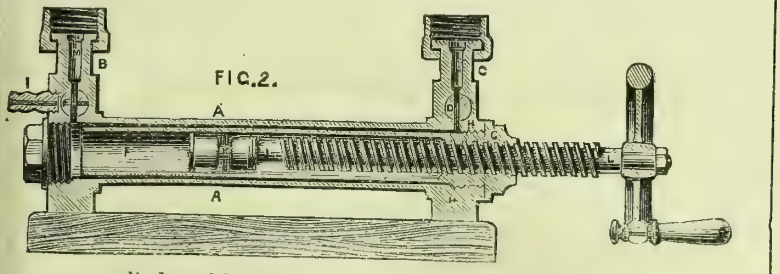


FIG. 2.

HEAT ENGINES OTHER THAN STEAM.—III.

(*Continued from page 702.*)

The Lenoir engine was practically similar to an ordinary high-pressure double-acting steam engine, with a valve arranged for the admission of an explosive mixture of gas and air at the ordinary atmospheric pressure at each end of the cylinder, and with means provided for igniting this explosive mixture electrically at the proper moment, and with another valve arranged to allow of the exhaust of the exploded gases; the great difference between the steam engine and the Lenoir engine being that in the latter about one-fourth of each stroke was inoperative for power purposes, the movement of the piston during this portion of the stroke being utilised to draw in to the cylinder the charge of explosive mixture.

There was provided around the cylinder of the engine a water jacket, through which cooling water was allowed to circulate, so that the surplus heat generated by the explosion might be carried off from the cylinder, and that thus the surface of the cylinder might be kept cool enough to allow of efficient lubrication.

As I have told you, in this engine of Lenoir's the explosion was caused—or, to use the commonly accepted term, the "firing" was done—by an electric spark. Great difficulties were experienced with this in practice, as it required careful manipulation and adjustment, and frequently failed to cause explosion, or "missed fire."

The next engine of importance, that of Hugon, was, as I have said, patented in 1865, the patent being No. 986. The patentee states that the explosion or combustion of the mixture has hitherto been effected by an electric spark; and he says that the object of his improvements is to produce the explosion or combustion in another way with certainty and at regular intervals. He proposed to do this by a modification of the lightning arrangement patented by Barnett in 1838, some 27 years earlier.

This arrangement of Barnett's is extremely simple to understand, and I will ask you to look at the diagram (No. 13) which shows it.

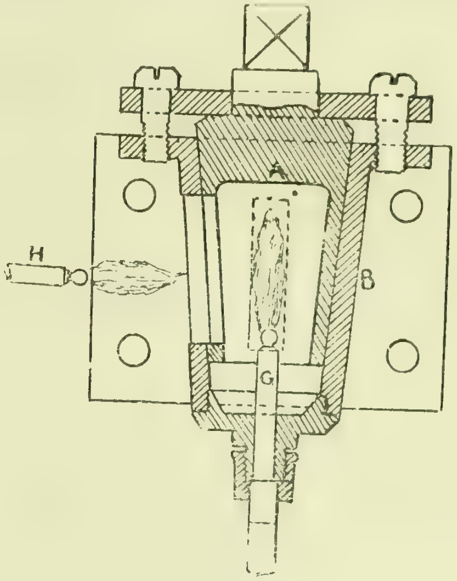


Fig. 13.—Barnett's Igniter of 1838.

You will see that in an ordinary tap there is a hollow plug A, shown in its normal position, and that in this plug a gas flame G is burning; this gas flame being lit by the outside flame H. Now, the plug can be turned through a quarter of a revolution, and will thereby close the opening to the outside flame, and connect the inside flame through the opening shown in the dotted lines with the working cylinder in which the explosive mixture is contained thus firing that mixture; and, although the explosion may, probably put out the flame which has been burning in the hollow plug, yet, when this plug is turned again to its normal position, the flame will be relit by the outside flame.

I remember, when I was in the "shops," as a precaution against fire, we were forbidden to bring matches into the works, and it was very often some little trouble to get a light, either in the early morning or in the evening, when gas was required. But if one burner in the shop was alight, we found no difficulty; for, taking a stop-ended handle off the slide-rest from a lathe, all that was required was to hold this well down over the gas burner which was alight. The handle became filled with gas, burning very slowly, because the air necessary for combustion could not rapidly get at it, and it was possible, in fact common, to carry a light thus obtained the whole length of the shop, say some 30 or 40 yards, and light another burner there.

I have here a stop-ended tube, and will hold it over this burner, and will try if I can light the one on the other side of the lecture table. The principle thus illustrated, which, as you will see, is the one used by Barnett, is the principle by which the "firing" has been done till recently in almost all gas engines. I shall have to tell you of another mode, which is now being adopted, when we come to speak of the Crossley and of the Atkinson engines.

Another point of improvement of Hugon over Lenoir was connected with lubrication. When you remember that the temperature of combustion of the explosive mixture in the cylinder of a gas engine is generally assumed to be something like 3,000 deg. Fah., while the melting point of cast iron (the metal of which the cylinders are composed) is only about 2,000 deg. Fah., you will see that this question of lubrication is one likely to give trouble. I daresay you will wonder, if these temperatures are correct, why the gas-engine cylinder is not melted. I will explain this to you presently, but for the moment must ask you to leave it; simply to take it for a fact that these temperatures do exist, and try to realise what must have been the lubrication difficulties. Hugon had realised these, and he suggested modes of solving them. The second claim of his patent is for "The employment in gas engines of arrangements for injecting water or other fluid capable of vaporising in the manner and for the purposes described." One effect of this would of course be to cool and lubricate the cylinder and piston.

Although these engines of Lenoir and of Hugon were to a large extent, as I have said, successful, yet the quantity of gas consumed in them was very much in excess of that which theory tells us is necessary, and was five or six times as much as that which is used to obtain an equivalent power in gas engines of the present day. The records of trials of these engines give the consumption as about 136 cubic feet per indicated horse power per hour, instead of the 20 to 22 cubic feet, which we shall find is all that is required by present gas engines.

I will not occupy any more time in describing early engines (the description of these two is sufficient for our particular purpose), but I will come at once to the Otto and Langen free-piston engine, the engine which practically revolutionised the manufacture of this form of heat engine, and did so because it reduced the gas consumption from the 106 cubic feet, of which I have just told you, down to some 25 to 30 cubic feet

I shall purposely neglect the Bischoff engine, as our time is so limited, and I shall do so although this engine attained a large measure of success; although it was fairly economical; and although it is even now successfully in use where very small powers are required. It is not, however, necessary to describe it, for if you fully understand the Lenoir and the Hugon and the various other gas engines which I must explain to you, you will thoroughly realise the principle on which the Bischoff engine works, and what it can do.

To revert to the Otto and Langen free-piston engine, shown in sectional elevation at fig. 14. The idea upon which this engine is based is this:—

The cylinder is vertical, and the piston is not directly attached to the shaft, but can move from the bottom to the top of its stroke freely—*i.e.*, without exerting any power to turn the shaft. This piston was made heavy, and the explosion of the gaseous mixture blew it upwards in the cylinder, as a shot is blown along the bore of a gun, and it was only as the piston fell that any work was done in turning the shaft.

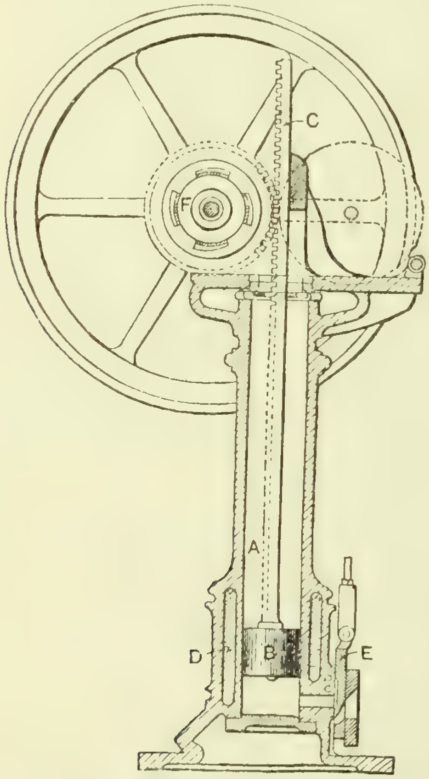


Fig. 14.—Loose Piston Gas Engine.

The means by which this free piston in its descent caused the shaft to revolve are shown upon the diagram of the clutch, fig. 15.

The piston rod of the engine had upon it a rack, and the outer portion of the clutch consisted of a toothed wheel D, the teeth engaging with those of the rack. This toothed wheel D is free to rotate in one direction, but if you attempt to move it in the other the small rollers, marked E, roll up the inclined planes on that portion B of the clutch which is keyed to the shaft, and are jammed between the outside of this and the inside rim of the toothed wheel, the result being that the attempt to revolve the toothed wheel in this direction grips the shaft, and causes it to travel with the wheel.

Let me ask you again to look at fig. 14. You will see that towards the bottom of the cylinder there is a slide valve which admits the gaseous mixture, and through which—in a manner somewhat similar to that adopted by Hugon—the "firing" is done. Through this valve, also, the exhaust takes place. There is a pawl, worked by a ratchet wheel with a system of levers, by which the rack and the piston attached to it are lifted during the first portion of the upward stroke of the piston, while the charge of gaseous mixture is being drawn in preparatory to firing. The engine moving on still further, the pawl raises the slide valve; the light is applied to the gaseous mixture: this is fired, and the piston is driven upwards until the pressure beneath it falls below that of the atmosphere, in fact until the energy produced by the combustion in lifting the weight of the piston and rack, and in overcoming the pressure of the atmosphere above the piston—*i.e.*, until there is a partial vacuum formed in the cylinder below it.

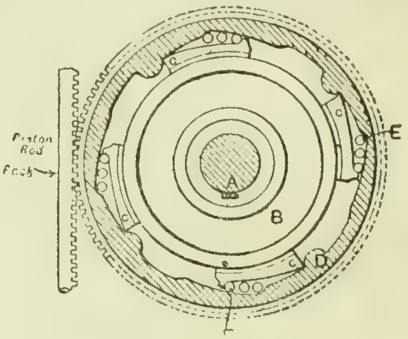


Fig 15.—Otto and Langen Loose Piston Engine Clutch.

When all this energy has been absorbed, the piston ceases its movement upwards, begins to return, being carried down not only by its own weight, but by the pressure of the atmosphere above it, which is exerted over its whole area. As I have said, in going downwards, the rack attached to it engages with the toothed wheel, and the flywheel shaft is rotated by means of the clutch. The actual work of this engine—that of rotating the shaft—is therefore done in a most appropriate and convenient way. It is done on the down stroke by the atmospheric pressure on top of the piston, added to the weight of the falling piston

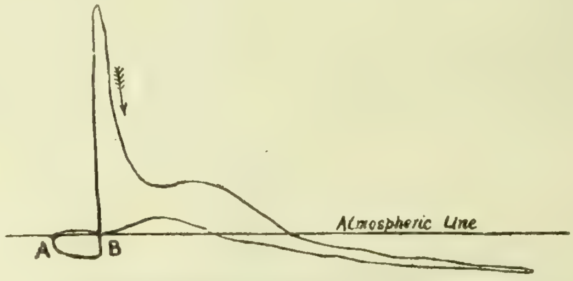


Fig. 16—Otto and Langen Engine: Indicator Diagram.

Let me ask you to look at the indicator diagram (fig. 16) of such an engine as this. This is not a diagram as actually produced, but one where the oscillations due to the weakness of the spring of the indicator have been to some extent eliminated.

Between the points A and B the piston is moving upwards, drawing the explosive mixture into the cylinder; and you will see the line is here a little below the atmospheric line. The firing then takes place, the pressure suddenly rises to about 60lb. on the square inch, falls almost as rapidly as the piston is driven upwards, and you will see that when the piston has travelled about 35 per cent of the whole stroke the pressure line falls to that of the atmosphere, and for the remainder of the stroke is below the atmospheric line—that is to say, there is a vacuum below the piston which, when the piston has reached the top of the stroke, is equal to an atmospheric pressure of as much as 10lb. on the square inch, if I may put it in that unscientific but expressive way.

The piston now begins to fall, and begins, as I have said, to do the work of rotating the shaft, and the diagram of pressure below the piston follows the lower line, which, as you will see, does not reach the line of atmospheric pressure until the piston is within 25 per cent of the end of the stroke, instead of at 35 per cent from the bottom, as it was when the piston travelled up.

The reason for this requires a little consideration. If you will again look at the diagram of the engine, you will see that the working cylinder is surrounded by a water jacket. This carries off some of the heat generated by the burning of the gaseous mixture, partially condenses the gases in the cylinder, and thus, lowering their temperature and pressure, helps to increase the vacuum below the piston; working on a practically similar principle to the condenser in a steam engine.

You will see that from the point where this line crosses the atmospheric line to the end of the stroke, owing to the exhaust valve not opening quick enough, there is a rise in pressure above the atmospheric line. This means so much resistance to the movement of the piston, and therefore to the rotation of the shaft.

(*To be continued.*)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

REPAIRS IN BOILER FIRED WITH WASTE HEAT.

To the Editor of "The Practical Engineer."

SIR,—In reply to "R. T. C." as to repairs to the hemispherical ends of furnace-fired boilers, the only objection advanced, so far as I am aware, against repairing iron boilers with steel plates is that the difference in the behaviour of the two materials under extreme variations of heat may affect the strength of the seam at the junction of the steel and iron plates, and lead to defects from straining. Many iron boilers, both at ironworks and other places, have, however, of late years been repaired with steel plates, and I believe with good results, so far as increased durability goes. One case in particular I know of, where several gas-fired boilers were almost entirely re-bottomed in 1885, and, although I have not seen the boilers, I know that they have been recently thoroughly examined, and reported in good condition. The temperature from the ignited gases from blast furnaces will probably not be so intense as that from the puddling and mill furnaces with which "R. T. C." has to deal. Perhaps some others of your readers may be able to quote from their experience of similar cases.

"R. T. C." would, I think, greatly reduce the excessive repairs required if he could introduce the furnace neck a little further under the boiler, or if he could shield the end plates with brickwork so as to prevent the flame impinging directly on to them, and not to allow the flame to come into contact with the plates at any part except when travelling in a parallel direction.—Yours, &c.,

INSPECTOR.

To the Editor of "The Practical Engineer."

SIR,—When repairs are properly carried out, I see no objection to the use of mild steel plates, but they must, of course, be carefully handled. The plates should be carefully heated in a furnace and dished to the proper shape, not forcibly drawn up to the old plate; they should fit close along every seam and every edge before marking the holes in. This is not always an easy task, but although it may be the longest job, it is certainly the safest and best. Cannot "R. T. C." arrange fire bridges, shields, or baffler walls so as to protect the plates from the impact of the severe flame. I have often seen firebrick bridges (sometimes perforated) built near the gas inlet, about 6in. from the plates, to protect them; these receive the severity of the flame and become highly heated, and give off the heat when flame is not intense, thus equalising in a measure the heating of the plates. Is the boiler kept clear of sediment? If not, blow out frequently, as, when the temperature is low, the deposit settles on the plates, and when suddenly subjected to a severe flame the plates become over-heated and cause the trouble experienced. Fuller information might elicit a fuller reply.—Yours, &c.,

CHALKLINE.

MR. WORSDELL'S COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

SIR,—In your issue of September 13th we have the particulars of a ride on one of Mr. Worsdell's engines by an American gentleman. He tells us that the ride was from Newcastle to Edinburgh; that the performance of the engine was of an extraordinary character; that the average speed attained was 50 miles per hour. Surely the gentleman must be little acquainted with the performance of other engines made by eminent English engineers, that he should consider such information startling. The predecessors of Mr. Worsdell built engines that have exceeded this speed, with as little consumption of coal, and considerably less cost per mile for repairs. Now, Mr. Editor, I have been a reader of your valuable *Practical Engineer* from its commencement almost, and I have derived much information from it; and every mechanic, both young and old, would do well if they would only avail themselves of the same privilege. I have read the various opinions of engineers on the merits and demerits of the compound and non-compound engines, which have been repeatedly published in *The Practical Engineer*. Up to the present I fail to see the superiority of the compound over the non-compound. I consider the greatest advantages to be attained are: Simplicity of construction, durability, and the use of high steam pressures and economy in repairs. If the boilers of the present non-compounds were constructed to carry a higher pressure, say from 175lb. to 180lb. of steam per square inch, better results would be got with the non-compound principle. It would be well if the builders of the compound engines would give us the cost per mile for repairs, as compared with good non-compound engines. The great aim of the present day is economy of production and maintenance. An engine may look well to the eye, yet its construction may be bad. It is not so much a question of saving coal in the working of a locomotive, as it is of saving the heavy cost of repairs. "All is not gold that glitters," may be said of the compound in this respect; and until we have sufficient data to be guided by, it will be unsafe to be led away by the idea that compounding a locomotive is the proper thing to do, and that the present non-compounds are antiquated—at least, some of our best locomotive superintendents do not think so, and are unbelievers in the theory of compounding locomotives. It is no doubt the best thing to do in the case of a marine or stationary engine, but in the case of a locomotive, where the work the engine is called to perform is so variable, extreme simplicity is absolutely necessary. In looking over the *Newcastle Chronicle* of August 3rd, the editor's remarks upon the half-yearly report are as follows—that out of £225,000 more revenue earned by the North-Eastern Railway Company this half year, compared with the corresponding half-year of 1888, £107,000 have been paid for the earning of it. This is a rather large proportion. The largest increase is in the cost of locomotive power, which takes the large share of close upon one half of the total additional expenses. Coal and coke have cost £14,000 in the department of locomotive power; also £15,000 more have been paid for wages, and £24,000 for material, which in the aggregate is £53,000 spent in the locomotive department; and £54,000 spent by the other department of the North-Eastern Railway system, equals £107,000. This does not appear to justify the idea that compound engines are economical, and, further, it is known that the cost per mile for repairs on the North-Eastern has been on the increase for the last four or five years.

As it is a question of economy, and economy only, perhaps "Loco."—in your issue of the 20th September—can explain the following figures of the North-Eastern Railway Company, compared with a line not using compound engines:—

	Half-year ending 31st December, 1888.	
	North-Eastern.	Midland.
Number of engines	1506	1822
Train miles	12,601,737	18,253,863
Cost of coal	£93,746 17 8	£118,797 19 11
Cost of coal per train mile	1·78d.	1·56d.
Repairs and renewals of engines	£234,147 2 10	£187,139 12 1
Repairs and renewals of engines per mile	4·45d.	2·46d.
Repairs and renewals per engine	£155 9 5	£102 14 0

If "Loco.," who makes the corrections in your issue of the 20th, would favour your readers with the knowledge of what the actual cost per mile for repairs of the compound and the non-compound is, I am sure he would be conferring a boon on many anxious inquirers. If the cost per mile for repairs, renewals, &c., as reported in the half-yearly report of the engineer, 1889, is referred to, I think it will be seen that the cost per mile for the locomotives of the North-Eastern was 4·45d. per mile, the highest of any railway in the United Kingdom. The North-Eastern Railway Company should work their locomotives in the most economical way, and it is not their business to try experiments to assist their engineer to push his patent, and to assist the railway of the South American Republic to work economically where coal is £3 per ton. The story of a compound engine taking 30 carriages where a simple engine could only take 18 is nonsense. A compound engine is only of use if economical; speed and power have nothing to do with the question. An engine of 95 tons, with 30 tons of dead weight, cannot take a load economically; suppose 10 per cent is saved in coal, it will amount to ·178d. per mile. Suppose they save 2½ per cent more in repairs, it will be ·111d. per mile. The margin of profit is small, and equals only ·067d. per mile, or about one-third of the cost of oil. Now, what are these heavy engines for? To answer this, let us see what the Great Northern and Midland have been doing for years. The Great Northern have run for years from London to Grantham 105½ miles in 2 hours 2 minutes, and the Midland run from London to Nottingham, 125 miles, in 2 hours 25 minutes, every day. How is it that the North-Eastern now require such engines to do their work? Their trains run at the same speed they have done for years, except that the Scotch express is a little faster, but not quicker than the Great Northern or Midland have been. Look at their first and second class receipts:—

	Half-year, 31st December, 1877.			Half-year, 31st December, 1888.		
	£	s.	d.	£	s.	d.
First-class	117,740	2	1	73,689	12	6
Second-class	83,976	1	4	33,908	17	8

Now, Mr. Fletcher's engines worked the traffic very well in 1877, and certainly the first and second class traffic does not seem more difficult to carry in 1888, particularly as the passenger train miles in December, 1877, were 4,032,528, and in December, 1888, 5,427,242.

The total receipts of the North-Eastern in the December half-year, 1877, 1884, and 1888, were:—

	£	s.	d.
December, 1877	3,295,001	6	2
„ 1884	3,299,255	4	6
„ 1888	3,352,192	1	8

In 1877 and 1884, coal was more than 10 per cent dearer than in 1888, and the gross locomotive expenses were:—

	£	s.	d.
December, 1877	495,842	17	3
„ 1884	527,135	14	0
„ 1888	532,092	16	5

When it is admitted that the expenses in 1877 and 1884 were extremely extravagant, it is not easy to see economy in 1888.

The cost for the repairs and renewals for the same half-year were:—

	£	s.	d.
December, 1877	197,424	14	9
„ 1884	201,898	14	5
„ 1888	234,147	2	10

The Midland expenses for repairs and renewals in the same half-year were :—

	£	s.	d.
December, 1877.........	174,111	15	11
„ 1884.........	183,317	15	1
„ 1888.........	187,139	12	1

The Midland traffic receipts were :—

	£	s.	d.
December, 1877......	3,270,864	13	8
„ 1884......	3,844,993	2	10
„ 1888......	4,028,467	1	10

In view of these figures, I feel quite sure that the engineers building compounds would prefer being left alone to their experiments until they are able to publish to the world that they have brought them to a successful issue.

Your correspondent, "Loco.," of Gateshead, in your issue of the 20th September, is very desirous to put his American cousin right. He tells us that it was not a 7ft. 6in. wheel compound, but a 7ft. 1½in., and he very carefully reminds us that they have just turned out a 7ft. 6in. single-wheeled passenger engine from the Gateshead shops; that it ran a trial trip from Newcastle to Berwick with 30 carriages, and that it kept up its speed equal to a non-compound with 18 carriages. Until the North-Eastern can run their engines at a less cost per mile, whether it be a saving of coal or cost of repairs, I do not think the best of our locomotive engineers will follow in the wake of compounding locomotives.

In the case of the trial trip of the last new 7ft. 6in. passenger engine taking 30 carriages, even supposing they were all full, how often does it occur in a year that it is necessary to make up a train of 30 carriages? As a rule, the number of carriages is 9 or 10, seldom 18. Then why build engines over 60 tons, when an engine of 43 tons will do all that is required? The weight of the last 7ft. 6in. single-wheeled passenger engine built at the Gateshead shops, with the tender coupled, is 95 tons, or thereabouts. It is not very difficult to see that engines of this type must tell their own tale with reference to wear and tear on the permanent way. Until the permanent way is laid down to meet this wear and tear, and there is an adequate demand for such a number of carriages to each train, I think it would be well to consider carefully the cost of such an adventure.—Yours truly,

Newcastle-on-Tyne. FAIRPLAY.

COMPRESSED AIR POWER.

To the Editor of "The Practical Engineer."

SIR,—I have read with much interest many articles in *The Practical Engineer* upon the use of compressed air; and referring to your leaderette in last week's issue about the Birmingham and Paris plant for the supply of compressed air, I quite agree that the most successful motive power will be that which, all things being taken into account, costs the least, and this compressed air certainly does not.

I have had some experience in the use of this motive power, or rather conveyor of power, and agree with you that the details of distribution are quite well understood, especially amongst miners; but whilst possessing certain advantages, such as freedom from risk of fire, coolness and ventilation of the engine-room, &c., yet the excessive cost of the plant and the great losses of compression and cooling will, now it has become generally known, lead to the use of other and more economical means—such as electricity—of conveying power.

There are many compressed air plants now working which do not give out 10 per cent of the engine power used to compress the air in actual work, and there are very few installations that give out more than 20 per cent, statements which are confirmed by the fact that no results of trials of such machinery are ever published.

As many such plants are, however, in operation, it would serve a very useful purpose if some of your correspondents would give such information as to enable engineers to get as much work out of their compressors and engines as the system is capable of.

Answers to the following and similar questions would be most useful: Whether is high or low pressure and quick or slow speed the most economical? What is the best working pressure? Whether is it best to use dry air or to cool by water injection? What is the best material for packing purposes, and what the best lubricant? How to prevent freezing, and what the best inlet valve?—Yours, &c., H. G.

Chester.

FIRE BRIDGES.

To the Editor of "The Practical Engineer."

SIR,—The bridge usually found at the back end of a fire-grate in a steam boiler is not an absolute necessity. It seems, however, to be useful, in the first place, as a support to the fuel on the bars, though in this connection it is dispensed with, for example, in the now rarely seen Salmon smoke preventer. In that contrivance the bridge was removed, and a long slope of firebrick extended 5ft. or 6ft. past the end of the grate along the furnace tube, and was supposed to become hot and serve as a heater up of the smoke from newly-charged green coal, so as to enable this to be burned by the air entering at the door. With this exception, fire bridges are usually found to be built in steam boilers. Sometimes they are carried up to too great a height, and so impede the draught that they have to be reduced, though there are cases where bad draught has lasted for months, or even for years, before it came to be accidentally discovered in a contracted bridge opening. Where there is a doubt as to a proper height of bridge, it is well to build the top course of a single brick in thickness. This can be pushed off, if desired, by means of the fire-rake, and the difference observed. The general consensus of opinion is to the effect that some bridge is, if not actually necessary, at least useful and desirable, if not also economical. The action of a bridge seems to be to concentrate over a contracted area all the products of combustion from the furnace. Such concentration seems to have the effect of bringing into closer contact the gases and air, and so completing the union, which might otherwise fail to take place through imperfect admixture consequent on stratification. The congestion above the bridge compels admixture, and with a proper air admixture combustion is completed. At the same time, it does not appear that a bridge should be otherwise than narrow. Its top width need not be greater than one brick.

A good working practical rule for bridges is to allow about twelve square inches of area above the bridge for each square foot of grate surface. Thus, an ordinary Lancashire boiler would have an over-bridge area of about 1¼ square feet. If the height of bridge be under trial, it might be about right to build it up so high as to give, say, only 1ft. area above it. Then, by pushing off the top course of bricks, the area would become, perhaps, 1½ft., if the top course were brick on side, and a little over that if brick on edge. A good proportion would be soon arrived at by trial.

Beyond the ordinary bridge, a hanging bridge is sometimes adopted, which deflects all gases upon the bottom of the furnace tube. When a draught will allow of a hanging bridge, it may be found useful as a means of promoting smoke combustion, especially if any surplus air is admitted at the first bridge; for the turning over of the gases by hanging bridges serves to promote the necessary admixture. As a rule, the force of draught available is insufficient to permit of the use of a hanging bridge. Speaking generally, the extra high bridge has more faults than the extra low one.

Where a bridge stands so as to cover a seam of rivets, or flanged seam, it ought to be occasionally removed, so as to give an opportunity for examination of the plates beneath it. Leakage is often found to take place at hidden seams, and a hole is made in the plates before even a leakage is suspected. Once yearly is not too often for removing a bridge.—Yours, &c., W. H. BOOTH.

QUERIES AND REPLIES.

101. DIFFERENTIAL PULLEY-BLOCK.—In what way are the parts of these blocks arranged so as to get excessive friction, which must equal half the load, except in some cases where special retaining mechanism is applied? I should be obliged by sketch and description of the last-named arrangement. SHINY BOOTS.

Answer.—As a quick motion of the chain causes a slow rise of the weight, the effect is the same as a lever with a long and a short arm. With a weight hanging on the short arm, only a slight frictional resistance at the end of the long arm is needed to balance it. The internal resistance in these blocks is got from the friction of the chain links, and is thus, in itself, comparatively slight. When this is insufficient, a pawl is made to engage the chain and chain-race, and this is thrown into gear by the man working the blocks.—C.

103. POWER OF BEAM ENGINE.—I am in charge of a beam engine. Its cylinder is 12½in. bore, length of stroke 3ft., making 60 revolutions a minute, the air pump 8in. bore, and worked at 50lb. pressure, and I should feel obliged if any of the readers of *The Practical Engineer* could inform me to what amount of I.H.P. it would drive.—SIMPLE.

Answer.—You do not give sufficient particulars, but I can give you the method of determining the estimated horse power. The indicated horse power can only be obtained by the use of an indicator, from which the actual average pressure per square inch is found. You do not give the amount of vacuum you have, but the rule is this: Add the amount of vacuum to average steam pressure (above the atmosphere) in the cylinder; multiply by area of cylinder (113 square inches) by twice the length of stroke, and by the number of revolutions per minute; and divide by 33,000. The result will be the estimated horse power. Not knowing the point of cut-off, we cannot tell the average pressure in cylinder, but if it is 50lb. in the boiler, suppose the average in cylinder to be 35lb., and the vacuum 12lb., then the estimated horse power will be—

$$= \frac{(35 + 12) \times 113 \times 6\text{ft.} \times 60 \text{ revs.}}{33,000} = 58 \text{ H.P.}$$

By putting in the correct figures for those assumed, you will get the answer you require.—F. C.

105. FOUNDRY CUPOLA.—What are the most approved dimensions of a cupola capable of melting four tons per hour, blast pressure; size of wind belt, number of tuyeres and dimensions of same, also whether round or square, thickness of furnace lining, and approximate consumption of coke per ton of iron?—RESURGAM.

Answer.—To melt four tons per hour, your cupola should be about 4ft. diameter inside the bricks at the tuyere zone, and should not be less than 12ft. from the base to the charging door. For this size a wind belt is not necessary, but if put, its section may be 12in. deep by 6in. wide. Two tuyere pipes 8in. diameter are enough, entering the cupola 3ft. from the bottom; cupola is circular in section, the furnace lining 9in. thick, the bricks being arranged as headers. Consumption of coke very variable, depending on the length of blow. The bed charge will be about 10 cwt. of coke, and the total consumption of coke per ton of metal melted will range from two to three cwt., according to circumstances.—J. H.

106. ANTI-CALCAIRE.—Will you kindly inform me as to what this is composed of, and what action it has on hard water? Would it be suitable for use with feed water?—MARINE.

Answer.—The ingredients of such compositions are always kept secret by the makers, for obvious reasons. While intended to soften water and precipitate lime, yet it would be impossible to describe beforehand its action on feed water in any given case, without an analysis of the water. Unless strong reasons to the contrary exist, "Marine" will find it to his advantage to keep clear of compositions in sea water; while for land boilers only actual trial can give him the information he seeks.—C.

107. Hardening Machine Parts.—I have seen machine parts after being hardened which have a nice appearance, similar to what may be seen on gun barrels. I should be glad to hear of a way of doing this. Potash or case hardening do not give the result desired.—R.

Answer.—"R" does not say what parts were hardened. If of cast iron, they have perhaps been "chilled"; but it is probable that a subsequent process of burnishing or frosting has been resorted to. The appearance being similar to that on gun barrels would seem to show that the finishing is independent of the hardening.—C.

110. Varnish for Drawings.—Will any reader kindly inform me what is the best varnish for varnishing mechanical drawings; also how it is made? C. A. B.

Answer.—For workshop drawings I have always sized and varnished them with the best carriage varnish, which answers perfectly for these copies, which are either ferro-prussiate or paper hand-made tracings, mounted upon calico or union, and stretched on cardboard. The varnish, when dry, is like a white enamel. The drawings are preserved by this treatment; the dirt can also be sponged from the surface without injury.—W. F.

111. Paddle-wheels.—How is the curve of the float obtained, as in the wheels of recent cross-channel boats?—Shiny Boots.

Answer.—The inefficiency of fixed floats is not directly due to the difference of speed between vessel and wheel. A paddle should press the water horizontally backward, that the ship may move horizontally forward; and it is evident that any pressure on the water either downward or upward is a loss. A fixed float enters the water at an angle, and so presses the water downwards, and on leaving it tends to lift the water. A feathered paddle wheel, or one in which the floats enter and leave the water vertically, is free from this defect, and so more effective. The most important effect of slip is to cause the engines to be run at a higher speed than they would otherwise be. This in itself is a disadvantage, and as curved floats "bite" the water better, slip is thus reduced, and therefore speed of revolution. No precise rule can be laid down for the curvature of floats, the conditions of efficiency with them being so numerous and varied.—C.

112. Proportions of Connecting Rods.—Why is it usual to make the neck of the connecting rod larger at the crank pin end than at the crosshead end?—A. G.

Answer.—Connecting rods are treated as struts jointed at both ends, and consequently the greatest diameter is required at the middle of their length, tapering off to both ends, as is usual in the case of those having single brasses at both ends, such as are generally fitted to trunk and return connecting rod engines. Most engineers prefer, however, for the sake of better appearance, to taper the rod from the middle to the gudgeon end, and then follow the taper down from the middle to the crank pin end. In more recent direct-acting engines the connecting rods are made tapering from the gudgeon end to the middle, and then parallel to the crank pin end.—Connecting Rod.

113. Automatic Steam Damper.—Can any of your readers inform me who makes the automatic steam dampers so often seen at Lancashire cotton mills?—S. B. S.

Answer.—I think the damper inquired for will be Cuthell's, made by Messrs. Sharpe and Co., Phœnix Foundry, Lancaster—often called the Lancaster damper. There is also a steam damper, called Barratt's, or Irving's improved Barratt, made or sold by Irving and Co., 17, Gracechurch Street, London. "Cuthell's" is perhaps the simplest and cheapest, while it is quite reliable, and gives good results. When properly adjusted, the pressure cannot vary more than 1lb. to 1½lb., and often much less than that.—Straightedge.

118. Moving Wheels out of Proper Gear.—Can any brother reader tell me how much I would lessen the life of a pair of wheels of about 3in. pitch, if I took them out of gearing about ⅜? Is there any rule for this, in plain figures?—One in a Fix.

Answer.—There can be no rule for such a problem. All one can say is that the wheels would be compelled to work under unsuitable conditions, and that their regular working, and ultimately the forms of their teeth, would be injuriously affected thereby. If the teeth are correctly formed, any departure of the pitch lines from contact increases the sliding action and throws unequal stress on the wheels; but if the teeth are badly formed, it is quite possible that an alteration of ⅜in. in so large a pitch will not much matter. One thing will follow in any case, the amount of flank clearance will be increased, and with it the amount of backlash, should the tendency to such exist.—J. H.

120. Crank Pin.—I have a crank pin to put in; it is 10½in. diameter by 10⅜in. long in that part which fits the crank eye, and 9½in. diameter by 10in. long for the working part, with 1⅝in. of a collar outside, making it 22in. long. There is no taper on the pin, and it is held in position by a key. I want to know if there is any advantage in having a hollow pin; if so, what the advantage is, and what size of hole you would recommend. Also, if a steel forging can be got with a hole in it.—Crank Pin.

Answer—Hollow crank shafts and crank pins are frequently used for first-class work. They can be obtained, of any reasonable dimensions, from Sir Joseph Whitworth and Co., Manchester. Your hollow forged-steel crank pin may have a hole 2in. diameter left through it.—W. F.

121. Boring Large Cylinders.—Will any of your readers kindly give the speed of cutter per minute allowed in boring machine for boring large cylinders? Also the traverse of cut usually allowed. I have a cylinder 60in. diameter and 4ft. 10in. length from end to end of cylinder. I am having it rebored, and want to know the rule for calculating time required to do same.—Percy.

Answer.—The speed of the tool for boring the cast-iron cylinder may be ten feet per minute if the material is not very hard; the roughing traverse thirty-two to the inch, the finishing traverse forty-eight to the inch. The proper speed and traverse to suit boring bar, shape of cutter, stiffness of lathe or boring machine, can really only be decided by experience on the spot; but the above figures are often used.—W. F.

100. Pulsometer.—What is the reason for giving the upper portions of the condensing chambers their peculiar tapered form?—Shiny Boots.

104. Brass Furnace.—Will some experienced correspondent oblige querist with a rough dimensioned sketch of the most modern double-brass furnace suitable for say two 46lb. pots?—Mechanicus.

109. Balloon Motor.—Will some reader kindly give me particulars of the motor employed by the French officer who recently constructed a very large and elaborate balloon? Perhaps some reference to the description, if it has been published, can be given.—F. B.

114. Friction in Water Mains.—What methods are used for lessening any tendency to increase of surface friction in water mains?—F. J. J.

115. Hydraulic Brake.—What is the advantage of a hydraulic brake, as compared with one of rigid materials? A sketch of one by which a nearly constant arresting force may be obtained will greatly oblige.—F. J. J.

116. Seating Hydraulic Pump Valves.—I should be very glad to know what is the best method of seating valves in a hydraulic pump, the valve being 3in. or 4in. diameter and the pressure two tons per square inch. I am afraid, if seated in the ordinary way, they would leak and get loose. Pump Valves.

117. Driving Ropes for Engines.—Would some of your readers be good enough to inform me what size of ropes, and how many, would be required for an engine 500 horse power? also what would be about the price of such an engine.—Improver.

119. Machine for Washing Mill and Furnace Ashes.—Can any reader refer me to makers and description of machinery for washing and cleaning the ashes from mill and puddling furnaces. Information will much oblige.—R. T. C.

122. Weight Applied by Safety Valve Lever.—Will one of your practical readers kindly give reliable formula for calculating weight applied by unloaded lever in safety valve calculations, as various rules are given by different engineering authorities?—J. W. B.

123. Compressed Air for Underground Haulage.—What are the advantages and disadvantages of compressed air, as compared with steam, for underground haulage?—Tabor.

124. Coil Friction.—What is meant by coil friction? If a rope is coiled twice round a fixed cylinder, and a weight of 10cwt. is pulling at one end of the rope, what is the smallest weight pulling at the other end of the rope which will prevent it from slipping on the cylinder?—Tabor.

125. Intermediate Receiver in Compound Engines.—I have been designing and fitting up a compound engine, and am desirous of knowing the true value of the intermediate receiver between the high and low pressure cylinders? A full reply will extremely oblige.—Young Engineer.

126. Angle of Advance of Eccentric.—How can I find the angle of advance of an eccentric when the rods are connected at the ends of the slot link? Any information will much oblige.—J. B.

PATENTS AND INVENTORS' QUERIES.

16. Gas Engine Patents.—What is the principal patent under which the Otto gas engine is constructed, and when does it expire?—B. F., Birmingham.

Answer.—The leading Otto patent is the famous Abel's specification of 1876, No. 2,081, which covers the alternate use of the same piston as a pump and motor, among other things, and it expires about the middle of 1890.

17. Water Gas.—What system of water gas production is the basis of later attempts, and is the patent still in force?—S. M., Leeds.

Answer.—The Lowe and Strong process, originated in America, for which the original patents have now expired, is the basis of most American systems. It consists essentially in the alternate "blowing up" of the producer by air, to ignite the whole mass, and then blowing in steam to be decomposed. The heat of "blowing up" was saved by means of a regenerator.

TO CORRESPONDENTS.

F. G. L., Sheffield.—Your letter is held over till next week.

Subscriber, Haslingden.—Edison's phonograph is not yet for sale in this country. We believe it is the intention of the agent in this country to sell them at about £20 each. Col. Gourand, of Little Menlo, near London, is Edison's representative here.

Delph, Waltham Cross.—You should study mechanical drawing and applied mechanics as likely to be most useful to you in the circumstances you mention. Your best plan is to join one of the numerous evening courses upon these subjects, and use the text books recommended.

R. W., Northowram.—The answer to your query on falling weight is perfectly correct, although it might have been arrived at with less algebra. The rule given in Joyce's "Scientific Dialogues" is quite wrong, and was framed at a time when these matters were imperfectly understood. A perfectly rigid substance, falling on a perfectly rigid surface, will cause an infinite pressure, however little the fall, and the actual pressure produced depends entirely upon the distance moved in crushing the materials; so that it would be doubled if the materials were hard enough to yield only half. We shall give a short article on the subject to make it clear.

W. J. T., Peckham.—We regret that your query was misunderstood, but we have corrected it as you wished. We thank you for your expressions of approval.

G. W., Buckwell.—We are much obliged for your note pointing out printer's error in formulæ; the index figure had dropped out. The error is a very apparent one, and can hardly mislead any one attentively following the article.

French Machinery in Brazil.—We hear from Pernambuco that French machinery to the value of about £4,000 was imported into that province last year. It was destined for the sugar mills at Bamburral and Carra-Assau, and consisted of mills and motors for cane-crushing, tubular generators, apparatus for preparing the syrup, and turbines. These machines are said to have given satisfaction, and further orders are expected for the new sugar mills now in course of erection.

MISCELLANEA.

For the purpose of constructing a ship canal between the rivers Forth and Clyde, on such a scale as will admit of the rapid and safe passage of merchant and war ships of the largest class, an influential syndicate of gentlemen in Edinburgh and Glasgow has been formed. The estimated cost is £7,000,000, and the canal will take about three years to construct.

One Hundred and Forty Miles per Hour.—The new sliding railway at work in the Paris Exhibition formed the subject of a paper read at the British Association by Sir D. Galton. The two principles upon which the system was based, he said, were—first, that the carriages slid upon a thin film of water interposed between the sledge-plates on which the carriages rested; and, secondly, the propulsion of the sliding train by horizontal columns of water acting from hydrants placed at intervals on the line. The system was originally designed in 1861, and a concession for a line was obtained in 1869, but in the war of 1870 the work was destroyed. The line shown now was an improvement upon the original invention. Sir Douglas went on to describe the sliding arrangement or skates of the train he was dealing with, the rails, and the propelling apparatus for putting trains in motion. It was not anticipated, he said, that there would be any difficulty in frosty weather, but if there was it could be provided against. One of the advantages claimed by M. Barre for the railway was easiness of movement. Then there was no noise, and M. Barre said the train could never be thrown off the rails, although that was open to question. A further advantage was that the train could be stopped almost immediately. It could ascend inclines and pass round curves, and it was claimed that it could travel at the rate of 140 miles per hour.

Overhead Wires.—Regulations have been issued by the Board of Trade dealing with cases in which overhead wires have been used for the supply of electricity. They provide that an aerial conductor in any street shall not be at a less height from the ground than 20ft., or where it crosses a street 30ft., or within 6ft. of any building or erection other than a support for the conductor, except where brought into a building for the purpose of supply. Every aerial conductor shall be attached to supports at intervals, not exceeding 200ft. where the direction of the conductor is straight, or 150ft. where this direction is curved, or where the conductor makes a horizontal angle at the point of support. Every aerial conductor shall be protected by efficient lightning protectors of pattern approved by the Board of Trade. Where any conductor crosses a street, the angle between such conductor and the direction of the street at the place of such crossing shall not be less than 60 deg., and the spans shall be as short as possible. An aerial conductor shall not be permitted to remain erected after it has ceased to be used for the supply of energy, unless the owners of such conductors intend within a reasonable time again to take it into use. A notice describing every aerial conductor erected or used for the supply of energy shall forthwith, upon receipt of these regulations, be served upon the Postmaster-General, together with a plan showing the mode and position in which such conductor is erected. The Postmaster-General may require such alteration in the position or mode of erection, or mode of use of such conductor, as he may think fit.

A Submarine Bridge.—A proposal recently brought forward by Herr Rudolf Lilljeqvist, a Swedish engineer, for effecting permanent railway communication between Sweden and Copenhagen, merits some notice as introducing a new mode—never as yet, however, put to the test of actual experience—of carrying a line beneath the sea. The distance between Elsinore and Helsingborg is about two and a half miles: and the passage is frequently blocked in winter by ice, preventing navigation. The cost of an ordinary bridge, which would of necessity have to be carried sufficiently high above sea level to offer no impediment to vessels, would be prohibitive in a country but sparsely populated and of limited financial resources; whilst the additional strength requisite in the piers to withstand damage to the structure from the floating blocks of ice would add very materially to the estimates. The proposal put forward is to construct an ordinary girder bridge of 100ft. spans and sink it to such a depth that ample room is left for vessels of the greatest draught to sail over it; the bridge being encased in cylindrical tubes, which exclude the water; the outer skin of the tube being of iron, that inside of steel, the space between being filled with concrete. The tubes enclosing the bridge are to be carried on ordinary caisson piers filled with concrete and spaced one hundred feet apart, pontoons similar to those so successfully employed in the construction of the Tay Bridge being adopted for founding. The bridge, which is to carry a single line of railway, with foundation and encasing tubes, but exclusive of the land approaches, is estimated to cost about three-quarters of a million sterling. The scheme may be described as an ingenious compromise between an ordinary bridge and a tunnel; and it is claimed that it combines the advantages of each, whilst avoiding the attendant drawbacks to the construction and heavy outlay involved in the execution of either in this particular case. The general idea, it may be added, is not altogether novel, and has previously been mooted; indeed, some years back a similar method of passing under the Thames was proposed and commenced, some lengths of the encasing tube being actually put in hand. The project, however, was abandoned, owing, it is understood, to financial difficulties, and has never been resuscitated.—*Chambers's Journal.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

September 19th.

14758 Steam Engines, T. C. Whitworth, Manchester.
14776 Railway Signals, H. F. Hill, Nottingham.
14786 Compressed Air, Ernest de Pass, London. (G. Lelièvre, France.)
14789 Thermo-motors, J. Hargreaves, Liverpool.
14803 Feeding Apparatus, G. Little and J. J. Stevenson, London.
14807 Boilers, J. T. Spencer, London.
14808 Water Pipes, A. H. Black, London.

September 20th.

14816 Fuel Economisers, W. Johnson, Kent.
14821 Valve Gear, J. R. Russell and R. B. Spence, Glasgow.
14830 Steam Engines, E. C. Mills, Manchester.
14839 Gas Engines, J. Robson, Bradford, Yorkshire.
14841 Valve, J. Phillipson, London.
14853 Planing Wood, A. Dunbar, London.
14861 Motors, H. J. Haddan, London. (F. A. Labaki and J. K. El Houlou, Syria.)
14865 Evaporating Apparatus, C. W. Guy, Little Moorfields.
14868 Hydrocarbon Engines, C. R. Binney and H. A. Stuart, London.
14869 Fluid Meters, H. H. Sporton and E. White, London.
14875 Firebars, E. H. Hill, London.
14877 Girders, H. B. James, London.
14880 Welding Metals, W. R. Lake, London. (E. Thomson, United States.)
14881 Gas-making Apparatus, A. Kitt, London.*

September 21st.

14888 Steam Boilers, T. Pressard, London.*
14898 Couplings, J. R. Darby, Dublin.
14903 Piston Valve, C. R. Crompton and H. L. Short, Nottingham.
14906 Healds, A. H. Lee, Warrington.
14916 Furnaces, J. Inwald and J. Wanka, London.*
14918 Type-setting Machine, R. Clay and J. E. Marchant, London.
14922 Gas, A. Kitson, London.*
14926 Vapour Engines, J. C. Diederichs, London.
14927 Hot-air Engines, B. Willcox, London. (L. Genty, France.)*
14931 Governing Marine Engines, R. W. Allen, London.
14935 Lubricators, C. H. Sims and F. Robinson, London.

September 23rd.

14955 Gas Valves, D. R. Ashton, Clapton.
14957 Valves, J. Thom, London.
14953 Mechanical Stokers, J. Hodgkinson, London.
14961 Valves, R. Iwanowitsch, E. Höglinger, and C. Peklinger, London.
14962 Rope-making Machinery, W. T. Glover and R. Guiltinane, Manchester.
14972 Nut Locks, W. P. Thompson, Liverpool. (J. Edgar, United States.)*
14973 Switches, W. P. Thompson, Liverpool. (L. Dunn, United States)*
14974 Ratchet Braces, T. Haggart, Liverpool.
14980 Expansion Engines, P. M. Baxter, Falmouth.
14988 Steam Boilers, H. C. Vogt, London.
14991 Electricity Meter, O. T. Bláthy, London.
14996 Twist-drill Grinding Machines, A. G. Brookes, London. (M. P. Higgins and C. H. Morgan, United States.)
14999 Cutting Oval Metal Pieces, L. Schuler, London.
15002 Water Brakes, J. T. Thompson, London.
15006 Liquid Fuel, C. L. Goodridge, London.*

September 24th.

15021 Screw-cutting Lathes, J. Barrow and W. Shanks, Glasgow.
15030 Punches, J. Draper, London.*
15032 Lubricator, J. T. Hedley, Newcastle-on-Tyne.
15033 Boiler-firing Apparatus, T. Wrigley, Manchester.
15034 Steering Gear, T. G. Stevens, Kent.
15039 Weighing Machines, W. B. Avery and W. Snelgrove, Birmingham.
15041 Pumps, K. Leverkus, Manchester.
15043 Gaseous Fuel, O. Imray, London. (E. R. Ware, United States.)
15056 Belt Fasteners, S. Elliott, Berkshire.
15075 Valves, B. Willcox, London. (J. Belleville, France.)*
15080 Machine Tools, R. A. Lee, London.

September 25th.

15109 Steam Traps, F. E. Blackmore and T. C. Andrew, Berkshire.
15123 Pneumatic Percussive Tools, T. Thorp, London.
15134 Pumps, B. Willcox, London. (J. Belleville, France.)*
15138 Submarine Cables, W. G. Stafford, London.

September 26th.

15151 Steam Boilers, J. Thomson, Glasgow.
15152 Chimneys, W. Arnold, Skelmersdale.
15158 Steam Engines, C. E. Basevi, Cheltenham.
15177 Sieving Apparatus, H. Simon, London.
15187 Steam Engines, C. Wells, London.
15188 Printing Presses, F. W. Barker, London. (J. F. W. Dorman, United States.)

September 27th.

15196 Force Pump, D. Steffano and A. A. Garside, Barnsley.
15202 Boiler Plates, R. Goodbody, Bradford, Yorkshire.
15204 Injectors, R. Goodbody, Bradford, Yorkshire.
15207 Forges, J. Brooke, Huddersfield.
15214 Feed-water Heaters, D. B. Morison, Hartlepool.*
15217 Pumping Engines, J. Tweedy and J. Patterson, London.
15237 Radiators, A. J. Boult, London.*

September 28th.

15259 Universal Joint, J. W. Newall, London.
15266 Pump, R. Wylie and A. Brown, Glasgow.
15295 Air Engines, W. B. P. Spurway, London.
15297 Boilers, J. F. Durenne, London.
15309 Axle Boxes, H. K. Austin, Birmingham.

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THE

PRACTICAL ENGINEER,

OCTOBER 25TH, 1889.

WATER CIRCULATION IN STEAM BOILERS.

The conditions attending the circulation of water in different types of steam boilers are of the first importance in determining both the economical working and life of the boilers, and accordingly it is interesting to the practical engineer to study and understand the complicated motions which proceed within the interior of steam generators when at work. In our opinion too little attention has been paid to these actions, and much would be gained if it were possible to examine them more closely under varying circumstances. A few general facts are, however, well known. When heat is applied to the bottom of a vessel containing cold water, a circulation of the fluid commences, due to the fact that the water film in immediate contact with the hot surface absorbs heat and expands. This causes it to be lighter than the colder portion, and it at once rises to the surface, and a current is set up, which continues from this cause until all the water has attained the boiling point.

The direction of flow of these currents depends upon many circumstances. If, for example, an experimental glass vessel be used, and the heat be applied through a piece of iron gauze by the flame from a Bunsen burner at a point near the middle of the bottom of the vessel, it is found that a stream rises from the heated point in an almost straight line to the surface, while descending colder streams flow down the exterior sides of the vessel, then along the bottom, until the heat of the liquid rises to the boiling point, when steam is generated. The steam bubbles may then be seen rising up through the water and breaking away at the surface, causing an elevation of the level in the centre of the liquid. The lines of flow remain the same as those which occurred previous to boiling, while the water was merely heating. This experiment is very easily made, and by its means many actions occurring in actual work are more readily understood. When the water boils, the direction of flow is readily seen, but it is made more evident during the preliminary heating by putting in a little powdered charcoal. The black particles are easily seen, and their motion can be readily followed by the eye, which allows the currents to be distinctly observed. So far as effective circulation of water and a free discharge of steam is concerned, no better arrangement can be imagined than that used in this experiment; but in actual boiler design many other circumstances must be considered as well as those arising from water circulation. To secure economy a large surface must be exposed to the action of the hot gases produced by combustion, and it is in the arrangement of those surfaces within a confined space that difficulties often arise due to conflicting currents and consequent defective circulation.

In cases where boilers are so constructed that large heating surfaces are obtained only by the use of very narrow or contracted water spaces, the conditions are most unfortunate for free circulation, and result not only in a low evaporation of water per pound of coal burned, but often cause great danger as well. Using the same glass vessel, and applying heat uniformly all over the bottom of the vessel and up the sides, the steam starts from every point of the heated surface, and is generated in a tumultuous manner, so that the water is not displaced in any definite lines of movement or flow. The steam bubbles rise up all through the liquid, and the water gets back between them with considerable difficulty. If heat be applied too rapidly, the whole of the contents of the vessel will be thrown out and the vessel entirely emptied. This will be the more easily accomplished with any given source of heat, the smaller the diameter of the vessel in which the water is heated in proportion to its depth. A glass or metal tube of ½in. internal diameter and 1ft. long, if half filled with water and heated over a good Bunsen flame, will have its contents rapidly discharged whenever boiling commences. Similar tubes, if used as part of the heating surface of a boiler, would be constantly emptied by the generation of steam, and then filled again for an instant when all the water in contact was evaporated.

In the vertical type of boiler also, when the annular water space surrounding the fire-box is too narrow, the generation of steam may be so rapid as to eject nearly all the water, and the plates in contact with the fierce heat of the fire may be dry for a good part of the time at work. The evolution of steam in this case, instead of helping fresh water particles to get at the heating surfaces, as it should do, actually retards them, and makes it difficult for the surface to be in contact with the water, as it ought to be. In such boilers the water level often fluctuates rapidly while at work, because of the alternate expulsion of the water in the annular space by the generated steam, and its return again when the heating surface has become dried, and the evolution of steam is thereby arrested until the surface is again wetted. These annular water spaces surrounding the fire should always be sufficiently wide to permit a continuous upward flow of generated steam from the interior hot surface, and a continuous downward flow of water around the external surface against which no hot gases are impinging. It is difficult to conceive any type of boiler more perfectly adapted for free evolution of the generated steam, and the production of definite lines of water flow, than the ordinary Lancashire kind. Here the flow of heat into the water is most rapid near the furnace end of the flues, and consequently the generation of steam is most rapid at these positions. This causes a general flow of water from the front to the back of the boiler; but as steam is generated freely all along the upper surfaces of the flues, there is also a circulation from those positions towards the exterior shell. These are the main currents proceeding in a Lancashire boiler, but there are, of course, numerous secondary lines of flow, produced by local differences of temperature and steam generation. While in the act of heating-up, before generating steam in any quantity, the circulation in a Lancashire boiler is apt to be defective, and the water above the flues becomes hot before that below them. This evil is reduced considerably by the usual mode of arranging the external flues, which carry the hot gases along the sides and bottom of the boiler before they are discharged into the stack. Notwithstanding this arrangement, however, a considerable pressure of steam may be raised while the boiler front under the flues feels cold to the touch. When work is commenced, the rapid generation of steam soon causes movements sufficiently energetic to bring the whole of the contained water into circulation. In marine boilers, where necessarily the hot gases pass away without getting under the exterior of the boiler, this evil is severely felt, and the difference of temperature is so great as to cause serious straining of the plates. A number of inventions have been introduced to cause a mechanical circulation, and inject the heated water from the upper portion to the lower portion, some of which are in extensive and successful use, especially for marine purposes. It is better, whenever possible, to avoid the necessity for such artificial circulation.

It is exceedingly difficult to predict from the design of any novel form of boiler the effectiveness of the circulating currents. Some years ago we were asked to make some tests on a new form of gas-fired boiler, in which most elaborate arrangements had been made, according to the inventor, to secure effective circulation. The boiler, in so far as concerned its heating surface, was of the vertical multitubular kind, and the hot gases were discharged into an upper smoke box from the tubes; a secondary steam and water receiver stood alongside of the boiler, and communicated with it by two large free circular connecting pieces. The water level in the receiver was considerably higher than the upper tube plate, and the generated steam was supposed to pass from the tubes by the upper connecting piece, while water flowed into the tubular portion from the lower connecting piece. We gravely doubted the safety of the arrangement, and our doubts were confirmed when we found, after only one hour's work, that the upper tube plate and the upper ends of the tubes had become nearly red hot. The steam had generated so rapidly in the upper portion of the boiler that the tube plate and upper portion of the tubes were kept almost dry, and that notwithstanding the considerable column of water tending to keep them covered. We need not say that this new form of boiler was condemned at once.

The subject of water circulation in various types of steam boilers is one which will repay the care and study of any engineers sufficiently familiar with their construction and detail, as it is not only interesting but vitally important. We shall accordingly be much pleased to hear from any of our readers who may have given the subject special attention, or who have any interesting experience on the matter.

ENGINE-KEEPERS' ASSOCIATION.

ONE of the most encouraging signs of advancing skill and knowledge among engine attendants is seen in the interest taken in engine-keepers' associations. In another part of this impression will be found a report of the opening meeting of the Glasgow and West of Scotland Engine-keepers' Association, for the session 1889-90, at which Mr. Deas, the well-known engineer of the Clyde Trust, delivered an address. He very properly pointed out the great importance of competence and knowledge in the safe discharge of the responsible duties of the engine-men, considering the interests at stake, and the enormous powers of destruction which could be called into sudden action by carelessness or ignorance. Mr. Deas also stated that it would ultimately become the law of the land that no person would be allowed to take charge of engines and boilers on land, any more than at sea, who had not proved competence before duly appointed examiners. Whether this prophecy be correct or not, we hail with pleasure the success of the Glasgow and West of Scotland Engine-keepers' Association, as such associations will undoubtedly do much to improve the position and raise the standard of education and intelligence among the men.

BOILER EXPLOSIONS IN TWELVE MONTHS.

FROM the report of Mr. Thos. Gray, the assistant secretary of the Marine Department of the Board of Trade, which is just published, we observe that in the twelve months ending June 30, 1889, inquiries on 67 boiler explosions were held. By these explosions 33 persons lost their lives, and 79 were injured. These numbers are considerably in excess of the average for the six previous years, during which, in a yearly average of 47 explosions, there were 30 lives lost per annum. The past year is therefore responsible for a loss of three lives above the average of the previous six years.

One-third of the explosions occurred on board vessels, and were reported under a duly-organised system, which enables the Board of Trade to obtain full information of any explosions occurring on board ship. There is no similar organisation on land, and it is feared that many explosions, in which serious results have not occurred, are never reported at all.

One-half of all the explosions were due to the use of defective or worn-out boilers, while defective design or construction and undue working pressure accounted for nearly a third. Ignorance and recklessness caused one sixth. Considering the great number of boilers in constant use throughout the country, the number of explosions is not astonishing; still, when one-half occurred through defective and worn-out boilers, it shows that there is still room for a considerable increase in the exercise of caution and discrimination among steam users. Far too many steam users purchase old boilers in hope of economy, without sufficient examination on their behalf by competent engineers.

SIR DANIEL GOOCH.

SIR DANIEL GOOCH, another of the engineers—now becoming sadly too few—who connect us with the time of the Stephensons and the introduction of railways, died at his residence, Clewer Park, near Windsor, on Tuesday of last week. Of recent years he was best known as the chairman of the Great Western Railway, but his life was an exceedingly active one as an engineer previous to his becoming known as a financier. He served his apprenticeship at Stephenson's famous engine-works, Newcastle-on-Tyne, and was appointed by Brunel as locomotive superintendent to the Great Western Railway when only twenty-one years of age. He was at first fully employed in designing locomotives, in which work he was particularly able and successful, as shown by the fact that his original broad gauge engine designs have been adhered to steadily since the year 1851.

Besides being a most admirable engineer, he was also an inventor and investigator. He invented the fixed link, still known under his name; and, in conjunction with Brunel, he made experiments upon train resistance with a dynamometer carriage specially fitted for the purpose. He was also concerned in the successful accomplishment of Atlantic telegraphy, and was the first to send a message through the successful cable laid by the Great Eastern. Sir Daniel Gooch was a remarkable man; and, after an active, useful, and successful life, he died at the age of 73 years, leaving four sons and two daughters. He was a self-made man, and rose to his great position by sheer ability and hard work.

BOILER EXPLOSIONS.

Board of Trade Reports.

Report No. 326 deals with the explosion of a Cornish boiler at Carthen, near St. Austell, whereby one man was killed and two others slightly injured. The boiler was used at a clay works for driving the engine working pumps. It is 32ft. 2in. in length, and the internal diameter of the shell is 6ft. The internal tube is 3ft. 6in diameter, and the plates were $\frac{7}{16}$in. thick and of iron. The end plates were $\frac{1}{2}$in. thick. The explosion was due to the collapse of the flue through the entire length, as shown in our illustration. The plates are nearly flattened, and fractured, both longitudinally and circumferentially, in several places, particularly at the back end of the tube. The tube was too weak for the conditions under which the boiler was worked. The boiler appears to have been worked usually at 40lb. pressure, but on the day of the explosion, the engine was stopped a little for some slight repair in the air pump. The pressure accumulated unduly, as the attendant seems to have overloaded the safety valve to prevent the steam discharge from disturbing a boiler coverer at work upon the top. However, having regard to the extreme length of the flue (32ft. 3in.), and without strengthening hoops, it appears undoubted that the boiler was too weak even for that pressure.

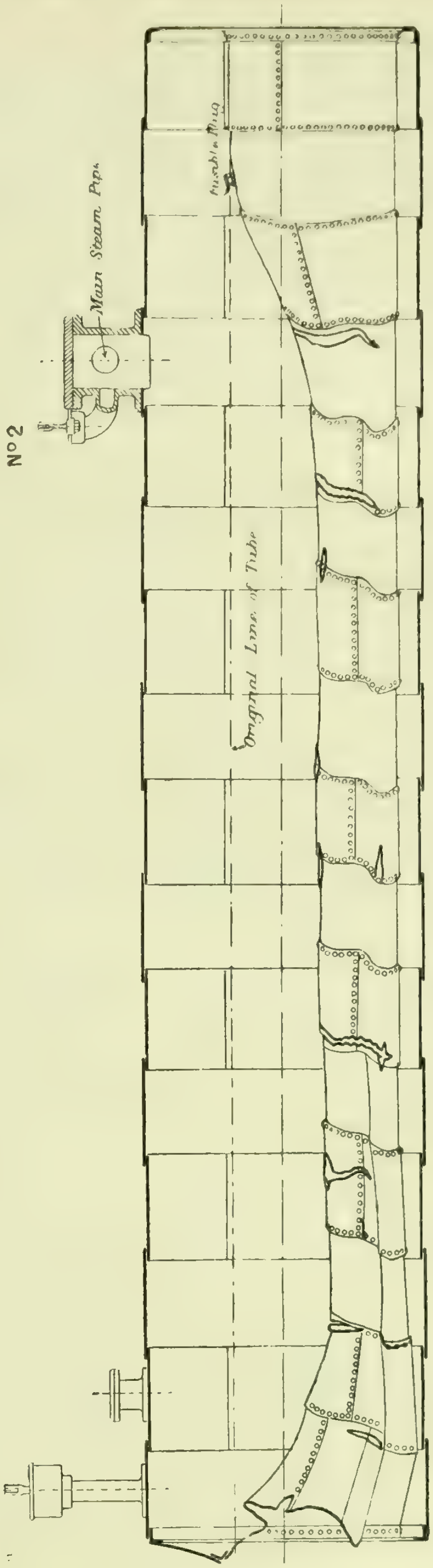
Report No. 327. This report describes an explosion which can only be called so in the terms of the Act, as it was caused by the failure of the joint of a manhole door on board the s.s. Alexandra, owned by the Hull, Barnsley, and West Riding Junction Railway and Dock Co. It occurred on the 11th March of this year. Unhappily one man was killed; but no other person was injured. The joint had been improperly made, and blew out under ordinary working pressure. The boiler was not inspected or insured by any company or association. It was comparatively new, in good condition, and of the marine tubular type.

Report No. 328. This was an explosion of a vertical crane boiler, which occurred at Dunstan on the 21st December, 1888, and was due to the boiler being completely worn out and entirely unfit for the ordinary working pressure. The boiler was completely destroyed, and fortunately no one was killed or injured. The boiler was 13 years old, and was insured and inspected by the Newcastle-on-Tyne Steam Boiler Insurance Company.

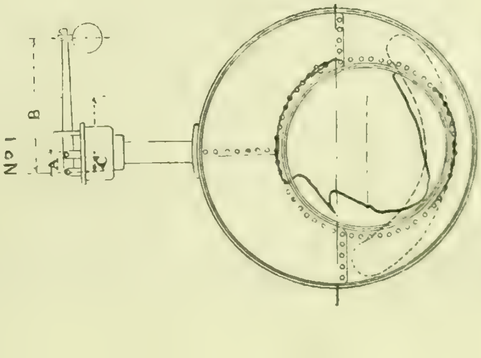
Report No. 329 deals with an explosion of a boiler of the locomotive type, which occurred at Church on 4th March, 1889. The boiler was used on a tramway engine owned by the Blackburn Corporation Tramways Co. Limited, and one man was killed. The jointing of the mudhole door blew out because of bad design and imperfect jointing. The engine was one year old, and was not insured or inspected by any company or association.

Report No. 330. This was an explosion of a vertical cylindrical boiler on board a small screw tug, Elizabeth, at Tarbut Roads, river Shannon, on the 2nd February of this year. No person was injured. The boiler was old and badly wasted, and the top cross tube became so thin that it was unable to stand the pressure, and it gave way and allowed the water from the interior to extinguish the fire, and so disable the vessel. The uptake was in very bad condition, though it did not cause the accident.

Report No. 331. The explosion occurred at the Victoria and Railway Ironworks, Gipsy Lane, Derby, on the 25th of February, 1889. Three men were injured, but not seriously. This was a part of a boiler of a peculiar kind, constructed to utilise the waste gases from a puddling furnace. It consisted of a vertical boiler coupled to a horizontal one by two communicating pipes. The gases entered the fire-box of the vertical boiler first, then passed to the internal horizontal flue of the horizontal boiler. The internal horizontal flue collapsed and ruptured, and the contents of the boiler issued with great force, hurling portions of the brickwork for a considerable distance. The flue plates had wasted on the fire side to about $\frac{5}{16}$in., and as the pressure had risen to 71lb.



Longitudinal Section Showing The Collapsed Tube.



Back-End of Boiler

BOILER EXPLOSIONS. REPORT No. 326.

per square inch, it was more than the tube could stand in its deteriorated condition.

The tube was slightly elliptical at one end; it measured 32½in. vertically and 31¾in. horizontally. Calculating the ultimate resistance of this tube to collapse by a formula found in a report dated March 2nd, 1882, with reference to an explosion of a boiler at Brierley Hill, a modification of Sir W. Fairbairn's formula, and assuming the original thickness of the plates to have been ⅜in., and wrought iron, Mr. G. E. Brown, the engineer surveyor-in-chief, calculates that 89lb. per square inch was the collapsing pressure when new. The margin of safety was far too low. The formula used was—

$$\frac{375023 \times \text{the square of the thickness of the plate in inches}}{\text{Length in feet} \times \text{diameter in inches}} = \text{collapsing pressure.}$$

NOTES ON BREMME'S PATENT VALVE GEAR.

By G. A. C. Bremme, C.E.

The following notes, although made specially with reference to this gear, will most likely prove of general use and interest.

Valve gear, even in its most simple form, is a complex mechanism for which no exact and at the same time comprehensive formula can be deduced. The proportions of details most suitable for a given case, and the relations between valve oscillation and crank angle, or the corresponding piston position, must be determined empirically by means of model and the drawing board, which requires time and labour. For this reason only comparatively few engineers become sufficiently acquainted with a new valve gear so as to be able to form a just opinion on its merits and practical advantages.

The mechanism known as Bremme's valve gear, and now extensively used, consists, briefly stated, in an eccentric rod used as a lever of the first order and guided by a radius rod.

Diagram fig. 1 represents this valve gear as applied to a number of inverted marine engines, and producing an equal cut-off for down and up stroke under the usual conditions, viz., that the steam is admitted at the outer edges of the valve, and that the valve is directly attached to the eccentric rod by the valve rod E T.

It is assumed that the piston is on its down stroke, and the crank has made the crank angle a. The line X X through the centre of the crank shaft is at right angles with the centre line of the valve spindle. The eccentric C K = r coincides with the crank, and is on the same side of the crank shaft. a and b are the distances between the centre lines of engine and valve spindle, and the parallel line through the fixed centre F in line X X.

The actual length K H of the eccentric rod is $l = (a^2 + r^2)^{\frac{1}{2}}$ and the radius rod H G = F G, so that when the crank is at either dead centre the centre H covers the fixed centre F, and the lengths l and m of the eccentric rod are in proportion with the distances a and b. As this valve rod E T is of considerable length, the valve oscillations are practically identical with the oscillations (O) of the centre E of the eccentric rod with regard to line X X. The gudgeon G is movable on an arc described from the fixed centre F within an angle δ from the neutral line on either side. This angle should not exceed 25 deg. The crank shaft turns in the same direction in which the gudgeon G is moved from the neutral line.

It will be easily perceived that during the down stroke of the piston the centre E remains below the line X X, and during the up stroke above this line until the exhaust closure takes place, that is, when the centre E comes in the line X X.

The general relations between valve oscillations (O), and the crank angles (a) are expressed by the following formula:

$$O = \frac{a+b}{a} V + \frac{b}{a} r \cos. a. \qquad (1)$$

In this equation V represents the ordinates of the arc described by the end H of the radius rod, or the distances of centre H from line X X. The formulæ for determining their value for a given crank angle are complicated, and for the present purpose their actual values are not required.

Referring to the enlarged diagram, fig. 2, it will be seen that the ordinates V of the concave part of the arc below the line X X are shorter than those of the convex part of the said arc above line X X for practically equal crank angles, and that they have respectively their greatest value when the eccentric is in line with the eccentric rod.

The event of cut-off takes place when the oscillation O is equal to the lap of the valve. The expression $\frac{b}{a} r \cos a$ in the equation (I.) decreases as the crank angle (a) increases, and becomes negative when a exceeds 90 deg., but its value is the same for the same crank angle in the down and up stroke.

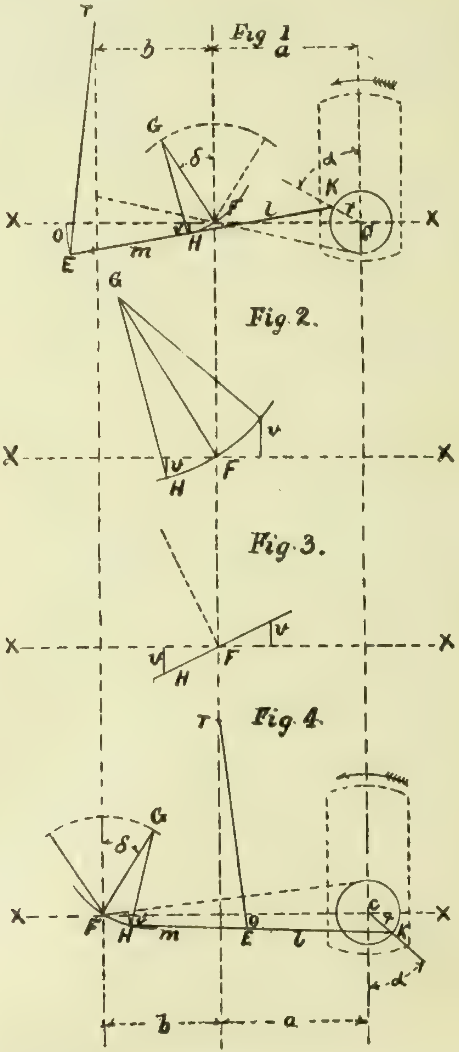
If

L = length of main connecting rod,

and

R = length of crank, then in marine engines $\frac{L}{R}$ = from 4 to 4½.

With a ratio of $\frac{L}{R} = 4$, and for a piston position of, for instance, 0·6 of the stroke, the crank angle a would be 95 deg. for the down stroke and 109 deg. for the up stroke. To effect equal cut-off for down and up stroke with equal lap and lead it is necessary that the corresponding ordinates V must be less for the down stroke than for the up stroke, and the gudgeon G must be located accordingly.



As a result of careful investigation the following data may be taken as a guidance in applying the gear to marine engines when equal cut-off with equal lap and lead is desired:

Length of radius rod H G = F G = $1\frac{1}{2} r \frac{L}{R}$
„ K H of eccentric rod $l = 8 r$ or more
„ H E „ $m = \frac{3}{4} l$
Lap of valve, equal for both edges, from $\frac{1}{2} r$ to $\frac{9}{16} r$.

The maximum openings are unequal, and as three to four for down and up stroke. This difference causes no practical inconvenience, as the smaller one is brought into calculation.

In some cases constructive advantages are gained by locating the gudgeon G on the opposite side of line X X to that shown in fig. 1, and as the opinions as to the necessity of equal cut-off for down and up stroke are divided, this may be done with good results by making the radius rod of extra length.

When the steam is admitted at the inner edges of the valve, or when a bell-crank lever is inserted between the valve rod and valve spindle, the position of the eccentric, and if under these conditions equal cut-off is desired also, the location of the gudgeon must be opposite to that shown in fig. 1.

The following is a convenient rule for locating the gudgeon G, viz.: Place the crank at its top centre, and for equal cut-off locate the gudgeon on the same side of line X X with the eccentric.

When the centre H of the eccentric rod is guided by means of a slide along a straight line, *i.e.*, when the radius rod becomes infinitely long, the corresponding ordinates V become equal (see fig. 3). In this case the maximum openings are equal, but equal cut-offs cannot be obtained with equal lap and lead.

The ideal valve gear would give with equal lap and lead, and equal cut-off also, equal opening to steam, and, in fact, do more than there is any practical necessity for.

The great advantages of Bremme's valve gear are its exceptional simplicity and the absence of the risk of bending the valve spindle when reversing, &c.

Diagram fig. 4 shows the arrangement of valve gear described in Hackworth's patent. The eccentric rod is used as a lever of the second order, and guided by a radius rod. The relations between valve oscillation and crank angle in this case are expressed by the formula

$$O = \frac{a}{a+b} V + \frac{b}{a+b} r \cos a \qquad (2)$$

On comparing this with the above formula (I.) it will be seen that an inferior result is obtained. The valve motion is too sluggish.

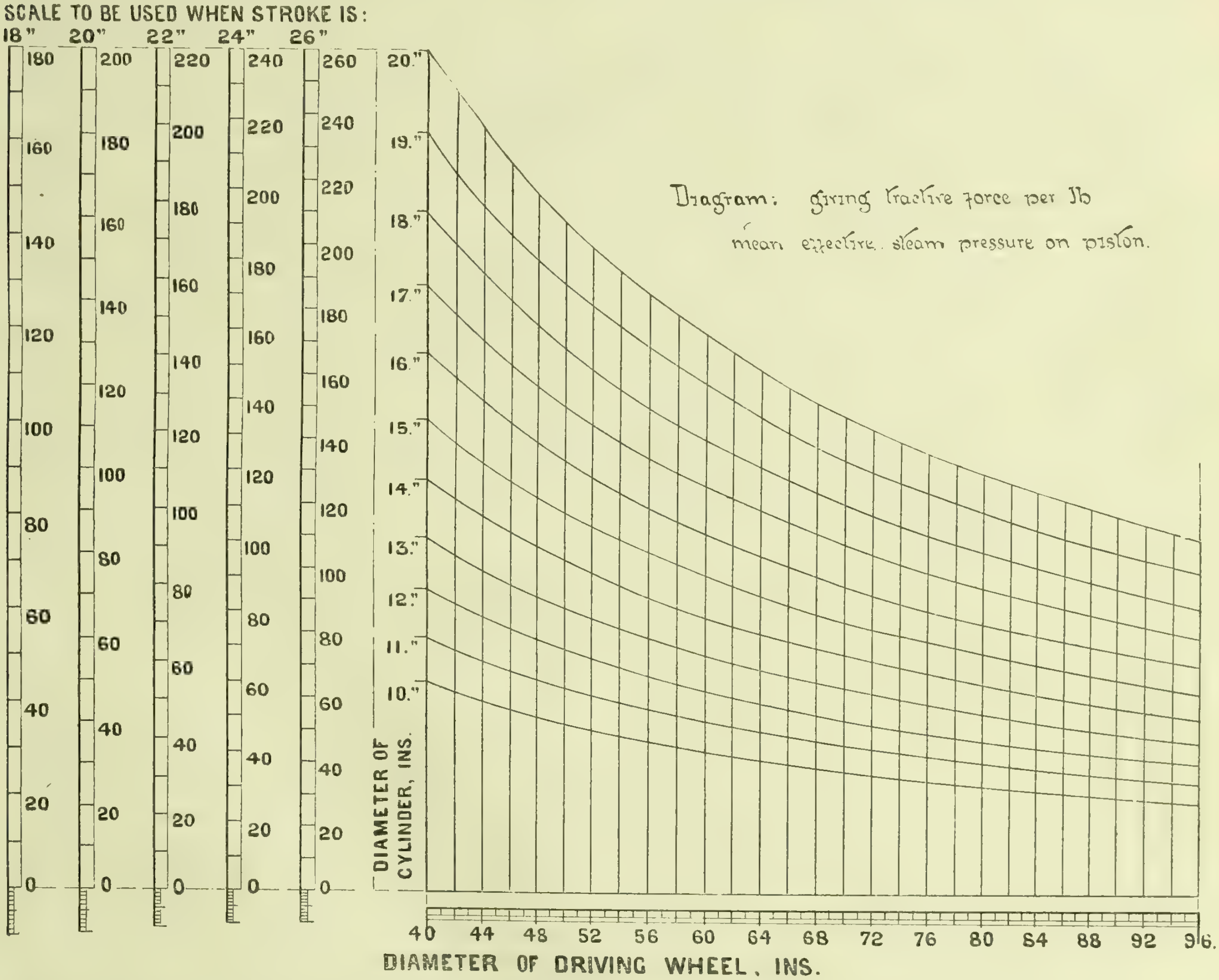
It has been alleged that the author had profited by the specifications of Hackworth's patents, which is not the case. As a matter of fact, a professional search did not reveal the existence of these patents, and the author became acquainted with them only long after the publication of his own patent.

TRACTIVE POWER OF LOCOMOTIVES.

The following diagram, giving the tractive power of locomotives in pounds per pound of mean effective steam pressure on the piston, will be found useful when dealing with questions relating to locomotives, as to the size of cylinders for a given tractive force, maximum diameter of driving wheels, &c., and is plotted from the well known formula

$$T = \frac{D^2 \times L}{M}$$

in which T = tractive power in pounds per pound effective steam pressure on piston
D = diameter of cylinder inches
L = length of stroke inches
M = mean diameter of driving wheel inches



and the mean tractive power of the locomotive would be
T × the mean effective steam pressure pounds per square inch, as obtained from the indicator diagram.

As an example of the use of the diagram, let us take the case of an engine having cylinders 18in. diameter by 24in. stroke, driving wheel 5ft. diameter, mean pressure of steam by indicator 60lb. per square inch. Required the tractive power: At the point marked 60in. on the scale for diameter of driving wheel at the base of the diagram, with a pair of dividers measure the length of the ordinate from the base line up to the line for 18in. diameter of cylinder marked on the left of the diagram, and transferring this to the scale to be used when stroke is 24in., which is the stroke of the engine under discussion, read off 129·6, which, multiplied by 60, the mean steam pressure, gives 7,776lb. as the mean tractive force.

Again, suppose the tractive power required, length of stroke, diameter of driving wheel, and mean steam pressure be given to find the diameter of cylinder, first reduce the tractive power to its value in terms of pounds per pound of steam pressure by dividing the mean tractive power by the mean steam pressure, then taking with a pair of dividers this value from the scale to be used for given stroke, and setting this distance up as an ordinate on the diagram over the point marked on the scale for diameter of driving wheel corresponding with the given diameter, and read off the required diameter of cylinder.

Working in the same way, the length of stroke, maximum diameter of driving wheel, &c., for a given tractive power can be readily ascertained; also this diagram will offer a means of readily comparing the powers of different sizes and types of locomotives.

GLASGOW AND WEST OF SCOTLAND ENGINE-KEEPERS' ASSOCIATION.

The opening meeting of the session of the above association was held on the 10th inst. in the Waterloo Rooms, Glasgow. There was a large gathering to hear an address by James Deas, Esq, C.E., of the Clyde Trust. In the regrettable but unavoidable absence of Bailie Wallace (president), Mr. Munro, chief engineer of the Scottish Boiler Insurance Company Limited (vice-president), was called upon to occupy the chair. The Secretary (Mr. McGregor) read the annual report, in the course of which he stated that 105 certificates of competency had been granted to members who had successfully passed the examination of the board. He described the objects of the association, viz., the diffusion of practical knowledge in the keeping and working of steam boilers and engines safely and economically.

Mr. Deas, after a few introductory remarks by the Chairman, then delivered his opening address, choosing for his subject, "The Engine-keepers' Association; its objects, and how best to attain them." From Mr. Deas' position in the engineering world, it is needless to say that the subject was treated in a masterly manner, and one which riveted the attention of his audience from the opening to the close. He spoke, by way of introduction, of the improvements in steam boilers and engines from the days of the immortal James Watt, who first wrought out these great inventions, which had slowly but surely been converted from the toy of early days into the giant force of our day, and had brought London within nine hours of Glasgow, and New York within six days of Queenstown. It was this mighty force that enabled the mineral wealth of the West of Scotland, which in Watt's time lay buried many fathoms deep, to be economically brought to the surface, and made Glasgow one of the great workshops of the world. He then went into the objects of the association, which are "the mutual improvement of its members by the delivery of lectures and papers, with discussion thereon, on subjects pertaining to the safe and economical working of steam engines and boilers, and for providing steam users with competent certificated engine-keepers." It was to him a matter of surprise, and anything but creditable to steam users in general, that it was not until 1886 that such an association was founded, and the only excuse that could be given for such apathy on this subject was that what was everybody's business was nobody's business. However late, the inauguration of this association deserved not only the thanks of the members and steam users, but also those of the people at large. When we consider the great interests at stake and the enormous engines of destruction both to life and property which are in the hands of engine-men, it is incumbent on all steam users to see that their engines and boilers are in the hands of competent men. This cannot be better effected than by an association such as yours, whose board of examiners consists of men of skill and eminence. The certificates granted by such a board could not fail to command the respect of steam users, and he would therefore urge upon all engine and boiler attendants the necessity of being provided with such a passport of efficiency. The tendency of legislation on this subject to make such examinations compulsory has been growing of late years, and it took no prophet to foretell that in a very short time this would become the law of the land. In such an event, the Government department which might have this under their charge would find their hands strengthened and receive every assistance from such an association as this. It was an evidence of the signs of the times that the Trades' Congress, at their annual meeting at Dundee, a few weeks ago, passed a resolution recommending that no person should be placed in charge of an engine or boiler without having undergone an examination to prove his practical fitness for such employment.

Mr. Kay and Mr. Lamberton also addressed the meeting, and after some supplementary remarks by the Chairman, endorsing Mr. Deas' views, votes of thanks to the lecturer and chairman were passed with acclamation.

PETROLEUM DEPOSITS IN BURMAH.

Dr. Noetling, of the Indian Geological Survey, who was despatched to Upper Burmah to investigate the economic geology of the country, has lately presented a report, in which the primitive methods of working the petroleum deposits are described. Around Twingoung and Beme he found oil-bearing sandstone. At the former place there are 375 wells, of which 166 are quite unproductive; of the remainder, 120 are constantly used, while 89 are used intermittently. The greatest depth of a Burmese oil well is 310ft.; but the vast majority do not reach a greater depth than 250ft., for after that the difficulties as a rule are such that the Burmese are unable to cope with them, although the best part of the sandstone remains untapped. "All over the place," says Dr. Noetling, "where the Burmese wells are situated, nearly 100ft. of oil-bearing sandstone remains untouched, and its wealth of oil unraised." The figures given in the report show that where the owner of the well is also the capitalist, he obtains a return of 22·6 per cent at least, in addition to the return of all his capital in ten years. Dr. Noetling describes the native working of the wells as devoid of all system and method, "the beautiful soil being robbed of its riches in an aimless, fitful manner." At one place a well is stopped at the very commencement of digging, at another an old well disused for years is being worked again. Here the black soil is so richly saturated with oil that it stands about in pools, while close at hand a well is being worked at high pressure. Everywhere the native work is ill-regulated and unreasonable. When European capital and methods are applied, the Burmese oil fields will yield three times as much as they do at present. A greater number of wells can be sunk into the strata, and with regular, systematic, economical working, will give a good yield, for the two oil fields referred to contain an area of about 16 square miles. At the same time, Dr. Noetling warns the public in India and Burmah against "wild ideas about beating or competing with American or Russian oil;" but there appears no reason why the Burmah oil wells should not at least supply the home market, which took a million gallons of Russian kerosene last year, while the import of Russian and American oil to the adjoining Indian markets is enormous.

NATIONAL ASSOCIATION OF COLLIERY MANAGERS.

An ordinary meeting of the South Staffordshire branch of this association took place on October 8th, at the Walsall Science and Art Institute; Mr. W. Fairley, president, in the chair. Mr. W. Bridgett read a paper on "The Safety Lamp, and Wherein is its Safety." He first alluded to the high favour in which the Kepplewhite-Gray and Marceaux lamps were held, as was shown by a previous discussion at that branch. He found, however, that extra care was required in handling a bonneted lamp, because of the heat to which the bonnet was raised. What they needed was a simple lamp not liable to extinction by accident, and yet easily extinguishable when inflammable gas was found. To have a really safe lamp they had to limit their illuminating power, and with all the improvements which have been made they had only half the light necessary. The result of the Government inquiry showed that refined seal oil was superior to refined rape oil, but the illuminating power of the latter was improved by the addition of petroleum. He went into details as to the treatment and management of safety lamps, and the difficulty of using them in the examination of hollows in the mine, especially in non-fiery mines. In conclusion, he remarked that to make the safety lamp more safe there must be more intelligent men in mines.—The President complimented Mr. Bridgett on the excellence of his paper, and said managers of mines ought not to be continually tapping the barometer for indications of danger, but should be always on the watch and always keep a good ventilation going through. He commented, in connection with theories as to the coincidence of earthquakes and explosions in mines, that on the previous day there was a low barometer, whilst that day's paper contained reports of an explosion in Scotland and an earthquake in Cornwall. He also alluded to the subject of ventilation of mines by furnaces, and said they wanted ventilation by mechanical means, and not by fires; but he was satisfied that the North of England viewers would be the last to exterminate fires. They would stick to them to their dying day; but the day was coming when furnaces in mines would be extinct.

The electric light on the Eiffel Tower, Paris, is reported to be visible at Orleans, 69½ miles distant.

ENGINE PATTERNS.—VIII.

Figs. 66—68 illustrate double cylinders, cast with feet, guides, and steam passages in one piece. This is practically a duplicate of the cylinder described in article vi., p. 580, and some of the figures there shown will apply in altered proportions to this. These double cylinders are employed for a special type of crane, being bolted to a bedplate with their axes in the horizontal direction.

In these figures A A are the cylinders, B B the guides, C the foot, D the steam passage block with its inlet E, F the exhaust block with its outlet G, H the steam chests, J the hole through which the body of the force pump is inserted, K the oil cup, L the waste oil receptacle.

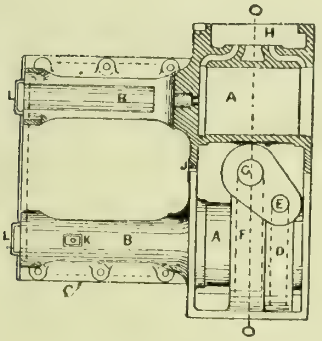


Fig. 66.—Plan.

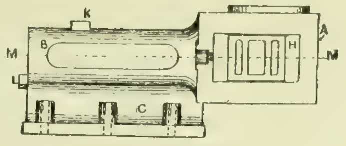


Fig. 67.—Elevation.

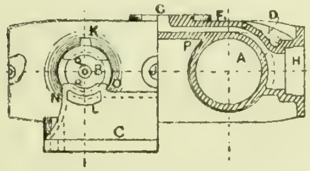


Fig. 68.—End View. Fig. 68.—Section O O.

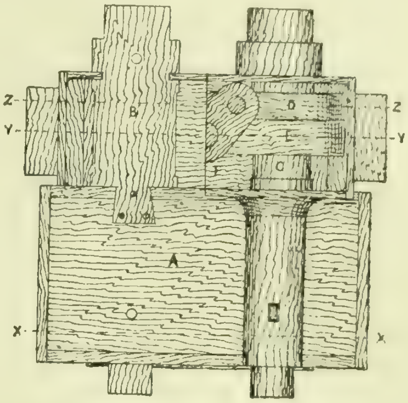


Fig. 69.—Plan Joint Face. Fig. 69.—Plan.

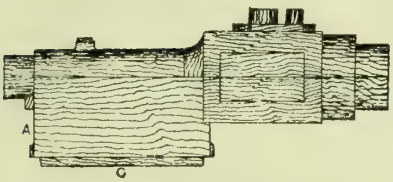


Fig. 70.—Elevation.

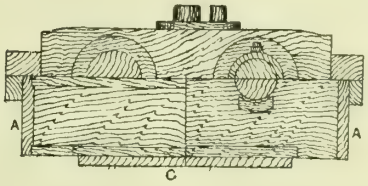


Fig. 71.—Sec. X X, fig. 69. Fig. 71.—End View, fig. 69.

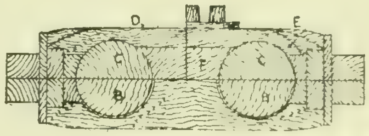


Fig. 72.—Sec. Z Z, fig. 69. Fig. 72.—Sec. Y Y, fig. 69.

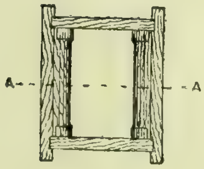


Fig. 73.

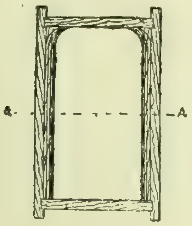


Fig. 74.

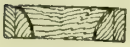


Fig. 73.—Section A A.

Fig. 74.—Section A A.

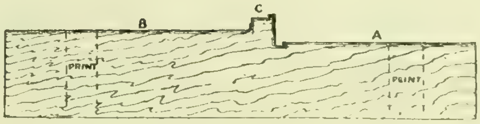


Fig. 75.

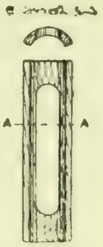


Fig. 76.—Sec. A A.

There is only one practical way of moulding this, viz., as it lies in fig. 66, and with the pattern divided along the line M M, in figs. 67 and 68. Then, if we look at the casting in end view and section, fig. 68, we see at once what parts have to be cored. They are the bore of the cylinders and guides, the steam chests and passages, the undercut parts at N, O, and P ; and in order to ensure a strong pattern, the hollow also underneath the foot C.

Figs. 69—72 show the construction of the pattern. In some respects it resembles that shown in article vi., p. 580. The whole of the foot and the lower half of the guides are represented by a large boxed-up print A. The lower half B of the cylinder is dovetailed into this print, the upper half C is turned in one piece with the upper half of the guide, and the flanges with their hollows are fitted into grooves turned therein. These and other points are clear enough from a comparison of these illustrations with those figures and the descriptions given on page 580. I will, therefore, note only the more special features in this pattern.

In figs. 69 and 72 the blocks D and E, fitted side by side, form the steam and exhaust pipes respectively. As they bridge over the space P in fig. 68, they would not deliver unless the space P were cored out. A print F, therefore, figs. 69 and 72, is fitted underneath, extending between the cylinder flanges in the one direction and between the pattern joint and the under side of the passage blocks in the other. The core box for taking out this space is shown in fig. 73.

Looking at the end view, fig. 71, and comparing it with the end view, fig. 68, we see that the space O on the casting has no correspondence on the print. This is cored out with the box in fig. 74.

On page 581 I showed a half core box made for taking out the cylinder bore, the stuffing box, and the guides. In this I show an alternative and cheaper method. Here the core is struck up against the board in fig. 75, the edge A striking the cylinder core, B the guide core, and C the stuffing box ; but the core is circular, while the guides are pierced with two holes at the sides (see fig 67). These were cut out on the box on page 581. Here we fasten the cores on the main core, which is struck with the board, and the box used for the holes is shown in fig. 76. The cores made in this box are either rammed separately, dried and nailed in the circular core, or they are rammed directly in their final positions upon the cylindrical core.

The facings Q, in fig. 68, are cut out of the cylindrical core when it is dried. On page 581 the facings were put in the box, fig. 48, F.

In figs. 69, 70, and 71, the print A receives the two cores which form the sides of the foot C with the hold-down lugs seen in figs. 66 and 68. The core box is therefore like that in fig. 49, p. 581. The print G, in figs. 70 and 71, carries the core for the interior of the foot, and its box therefore is like fig. 50, on page 531. The shapes of the boxes for the steam and exhaust passages are clear. The plan of the joint face of the exhaust box is almost identical with that in fig. 37, p. 529, but with the outlet G in fig. 68 in addition. The steam passage box does not differ in mode of construction, but only in outline (see fig. 68, section D). The boxes for the oil covers and waste oil cups are like figs. 52 and 57 respectively, on page 581. The forms of steam chest and passage boxes are clear, from a comparison of fig. 66 with similar illustrations. J. H.

INSTITUTE OF MARINE ENGINEERS.

Bilge Pumps.

A meeting of the Institute of Marine Engineers was held in the Langthorne Rooms, Broadway, Stratford, on Friday evening, 10th October, at 7·30, when a paper on bilge pumps and their connections was read by Mr. Wymer. The meeting was presided over by Mr. W. J. Craig.

Mr. Wymer, in the opening portion of his excellent and practical paper, referred to the importance of the bilge pump, and the great difficulties frequently experienced at sea in keeping the rose boxes clear, when, through stress of weather, the water accumulates in the bilges, the danger to the vessel becomes so great that it is often a very critical time for both ship and crew. In these days more attention is paid to the bilge connections in all steamers, but in the early days of steamships it was a source of great worry and hard work to the engineers to keep the bilges free from water. Even yet, in other than the leading lines of steamers, the style of bilge pump and its connections are frequently of faulty design. No doubt many valuable lives, as well as ships, have been lost for want of a good bilge pump, or owing to a defective arrangement of pipes and connections.

The pole style of pump plunger is the worst form possible for a pump which has to lift water from any distance below the level of itself, and frequently the care and attention of the engineer, when in a gale of wind, is almost wholly devoted to the bilge connections, and in many cases the engineer on watch has to strip himself and crawl below the platform into the bilge in order to clear the roses, thus compelled to leave for the time being his other duties in the engine rooms. Mr. Wymer showed a design of mud box which he would advocate for all steamers. In place of engineers having to go down into the bilge to clear the roses or pipes, the mud box should be placed on the engine room platform, with a pipe leading direct to the bilge, having an open end and no rose, the perforated plate and reservoir for the *debris* being in the mud box on the platform, where it could be examined and cleaned readily, and from where also the direct pipe could be examined and cleared of any solid obstruction by means of a rod.

The discussion which resulted at the conclusion of the paper was maintained by Messrs. J. McF. Gray, James Adamson (hon. sec.), Sommerville, Rowe, Hawthorn, and Bruce, in the course of which several experiences were detailed, illustrative of the serious defects which have existed, and still exist, in the bilge and ballast pumps and their arrangements.

One case, from his own experience, was cited by Mr. Hawthorn, where, during bad weather, the ballast tank gave out and flooded the engine room, the coal bunkers emptying themselves into the bilges and choking the pumps. The greatest difficulty was experienced on the part of the engineers in keeping the water out of the furnaces, as the bilge suction pipes became filled with coals, and, though cleared time after time, the pumps could hardly keep the water from gaining upon them, with all their labour. By dint of strenuous effort the steamer was got into port, but it was only by an effort, and had the haven of safety been further away, the ship would have been lost.

A parallel case was related by the honorary secretary in his experience at sea, some eleven or twelve years ago, when overtaken by a typhoon, off Formosa. From the seas shipped and the water otherwise accumulating, the engine room and stokehole were flooded to the flooring plates. With the roll of the ship the stokehole plates, firing tools, &c., began to float hither and thither; the fires in the low furnaces were put out by the water, the others being merely kept alight by hand-firing, the firemen dodging the heavy plates as they passed to and fro at every roll of the ship. The bilge pumps were choked by the coals and *debris*, the rose plates on the skin of the ship in the bilges were continuously being cleared, only to fill up again each time. The pipes were then cut above where they were choked, and a man stationed to keep them clear, the engines meantime, for want of steam, just moving, and the pumps throwing very little water. The water was also being baled out of the stokehole by ash-buckets through the ventilators, and only by persistent efforts on the part of the engineers was the steamer kept afloat until the extreme violence of the typhoon was over.

In these and other illustrations, which were given, the great importance of having a good system and arrangement of pumps and connections was shown, as no doubt danger, if not destruction, often results from want of attention to what is too often treated thoughtlessly as being of very minor importance in the economy of the engine room fittings and appliances.

Mr. Wymer replied to several questions and remarks put forward in the course of the discussion, and related several instances which had come under his notice, illustrative of the ways in which different men behave in emergencies. One, by sharp discernment and prompt, fearless action, adopts an expedient or uses the means, unlikely or otherwise, which lie to his hand, while another may succumb under the difficulty without an effort.

The proceedings were of an interesting, and frequently of a lively character, and the Institute is not only sustaining the character it has already made, but advancing in strength and authority, if we may judge from the large and influential attendance its meetings command.

Votes of thanks were proposed and seconded to Mr. Wymer and the chairman by Messrs. Crook and Roberts and Messrs. Ruthven and Bruce respectively, and the meeting closed with an announcement from the Secretary: (1) That on Saturday, 19th October, at 7 p.m., a paper on "Forced Draught" would be read by Mr. Jos. Williams, from Birmingham; (2) the reading-room and library are open every evening from five to ten; (3) the general business meeting will be held on Friday, November 1st, at 7 p.m., to be followed by a paper on the "Progress and Development of the Marine Engine," by Mr. A. Beldam; (4) he had received letters from various parts of the world complimentary to, and manifesting interest in the Institute; these were indicative of a progress which he hoped would continue and be maintained.

THE IRON AND STEEL INSTITUTE.

Alloys of Iron and Silicon.

Mr. R. A. Hadfield (Sheffield) read a paper, giving the results of experiments with alloys or mixtures of which metallic iron and silicon form the principal constituents. He said the alloying of elements other than carbon with iron was a comparatively new field, and at the request of the British Association Committee he had investigated the effect of higher percentages of silicon. In the blast furnace silicon could not be reduced unless carbon was also present, and yet when reduction of silicon occurred with the production of highly silicious iron, carbon was practically absent in the resultant material. It was now proved that silicon alloyed with iron, provided carbon was absent, or only present in small amounts, gave good tests as to toughness and malleability. It was quite true that alloys of carbon, silicon, and iron were brittle, or even dangerous, but the cause was not due to silicon only, but to the combination of silicon with carbon and iron. The writer did not claim that silicon should take the place of carbon. Smaller quantities of carbon produced the requisite hardness and different temper required in the industrial application of steel, and in fact silicon alone did not produce a steel that would harden by water-quenching, thus in this respect resembling manganese steel. Whilst it might not be advisable to use silicon as a hardener in making steel, it was important to have proved that the brittleness noticed in ordinary so-called silicon steel was due rather to the combined presence of the two hardeners, silicon and carbon. The effect of silicon upon iron in its forged condition was as follows: The material (·24 per cent silicon) did not forge well, cracking somewhat whilst being hammered, but the other samples (·79 per cent to 5·53 per cent silicon), when forged at a fair yellow heat, required no special care, thus clearly showing that silicon, even up to as high as about 6 per cent, does not destroy the malleability of the metal iron. When, however, it exceeds this percentage, the material is red-short, crumbles at a low heat, and, notwithstanding the low percentage of carbon present (·25 per cent), becomes really a species of cast iron. If the carbon had been higher, the point at which malleability ceases would have been with a much lower percentage of silicon; nor was such red-shortness removed by the addition of manganese. Apparently silicon, up to $1\frac{1}{2}$ or $1\frac{3}{4}$ per cent, added to iron, although increasing the limit of elasticity and raising the tensile strength, did not impair ductility; but after this the further increase of tensile strength was only obtained with a serious loss of ductility. The annealed flat bending pieces experimented with gave good results, bending double without fracture, more like soft steel; and after being bent double the pieces were flattened close together cold, without showing signs of fracture. The writer's experience has always been that silicon is quite fatal to welding, notwithstanding that the contrary might be expected from the fact that silica is of such material assistance in welding wrought iron.

TEAL'S PORTABLE HOIST.

The Franklin Institute has awarded a John Scott legacy premium and medal for a form of differential block or hoist produced in America, which we illustrate here. In principle it resembles the well-known Weston differential block, but instead of the chain wheels differing slightly in diameter and moving together, they are of the same diameter and move on separate spindles, but are so geared to each other that one wheel runs faster than the other.

Referring to the illustrations, fig. 1 is an elevation of one modification of this hoisting block; it is contained in the ordinary malleable frame, with suspending hook. The endless chain E F passes over the chain or sproket wheels A C, and under the hoisting hook pulley D. The diameters of A and C are the same, but the toothed wheels to which they are attached are of different diameters, and are connected by the intermediate wheel B. It is evident that when the chain E F is moved in the direction of the arrows the chain is taken on the wheel A quicker than it is paid off from C, and therefore the loop, or bight, E D F, shortens, and the load is lifted. When it is moved in the contrary direction the weight is lowered.

The hoisting, however, is done by the hand chain X, seen in fig. 2, which acts on a wheel H, driving the spindle of the intermediate toothed wheel B. This gives a great purchase over the load, and has the advantage that a slow motion is given in hoisting, and rapid lowering can be accomplished by pulling on the load chain E, F.

Tests were made by a committee of the Franklin Institute, which we give here, comparing different hoists with the Teal, from which it appears that the new hoist gives considerable advantages.

Copy of Report of Tests of Portable Chain Hoists, made at the "Novelties" Exhibition, Franklin Institute, October 20, 1885; also Report of Tests of Teal's Hoist under same Headings.

Make.	Capacity.	Shortest Distance between Hooks.	Movement of Hand Chain to Movement of Hook.	Weigh Lifted.	Weight Required to—		Per cent of Power Wasted in Friction.
					Start Load.	Keep Load Moving	
	Lb.	In.		Lb.	Lb.	Lb.	
Harrington	2000	18	60	1005½	44	41	59·02
Olsen	2000	21	47¼	1005½	66	54	60·6
Wharton	2000	20	52½	1005½	79½	68½	72 05
Box	2000	18½	42½	1005½	87	73	67·78
Reid	500	18¾	38½	282	35½	20	63 40
Teal	1000		38½	350	21·7	20	54·6
					Average 20 tests.	Average	Main chain did not run freely as it should.

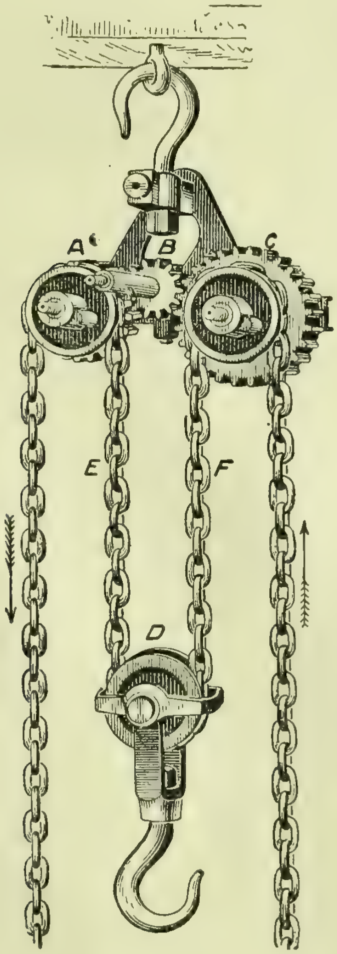


Fig. 1

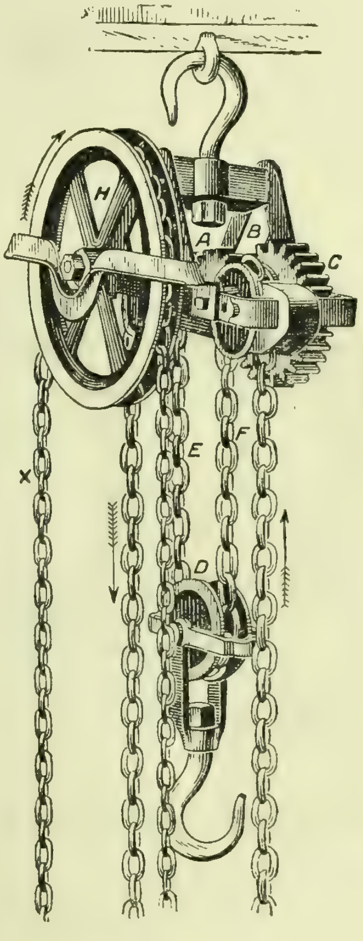


Fig. 2.

The advantages are stated as the combination of a slow and powerful motion to lift the load by means of a hand chain and a quick movement for lowering by a pull directly on the lift chain.

We are indebted to the *Journal of the Franklin Institute* for our illustrations.

The Hydraulic Railway.—Sir E. Watkin having given facilities for experiments with the water railway, M. Pilter and M. Barre, the president and the engineer of the Chemin-de-Fer Glissant, accompanied by the general manager and the engineer of the Metropolitan Railway, have inspected a stretch of ground at Neasden, where it is intended to construct an experimental line two miles in length.

THE GLOBE COMPOUND AUTOMATIC ENGINE.

CONSTRUCTED BY MESSRS. JOHN MUSGRAVE AND SONS, LIMITED, ENGINEERS, BOLTON.

(*For description see page 735.*)

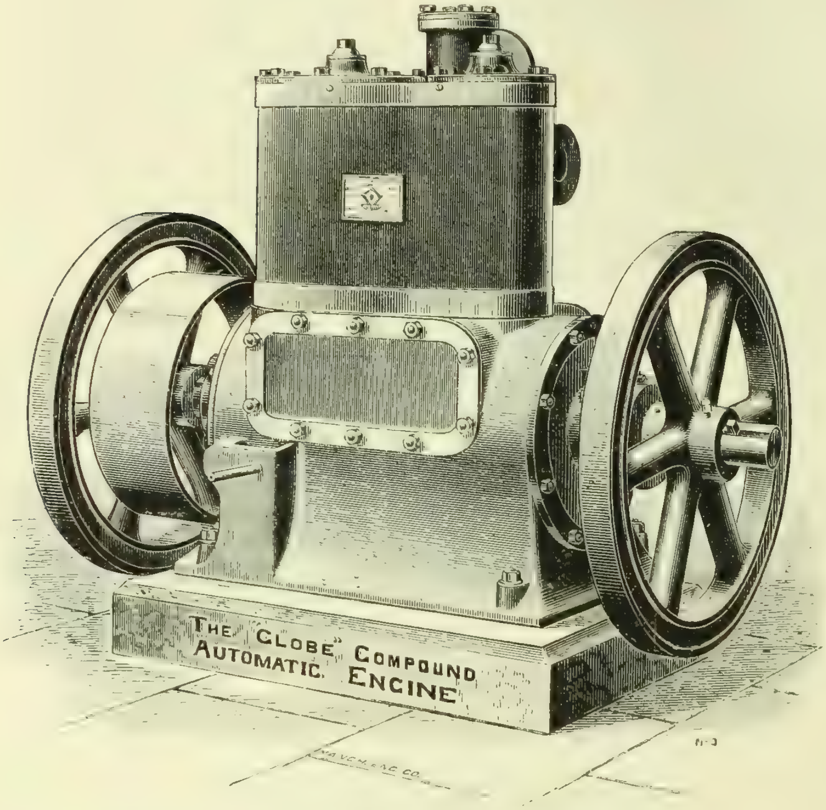


Fig. 1

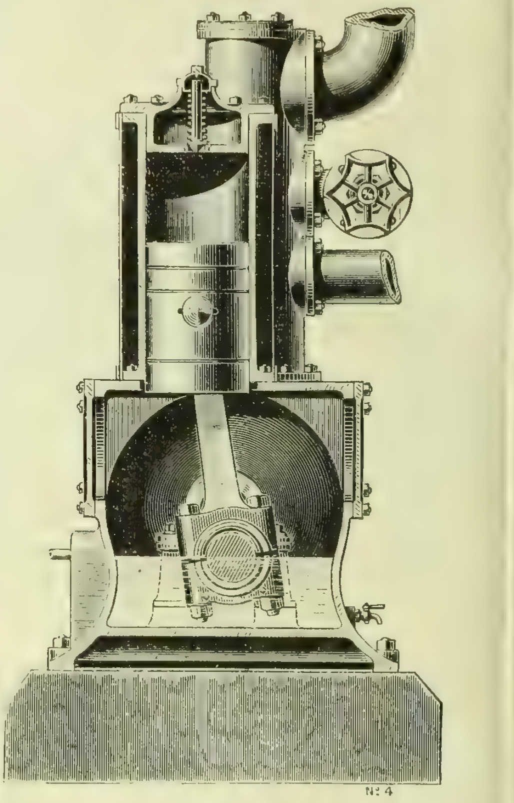


Fig. 3.

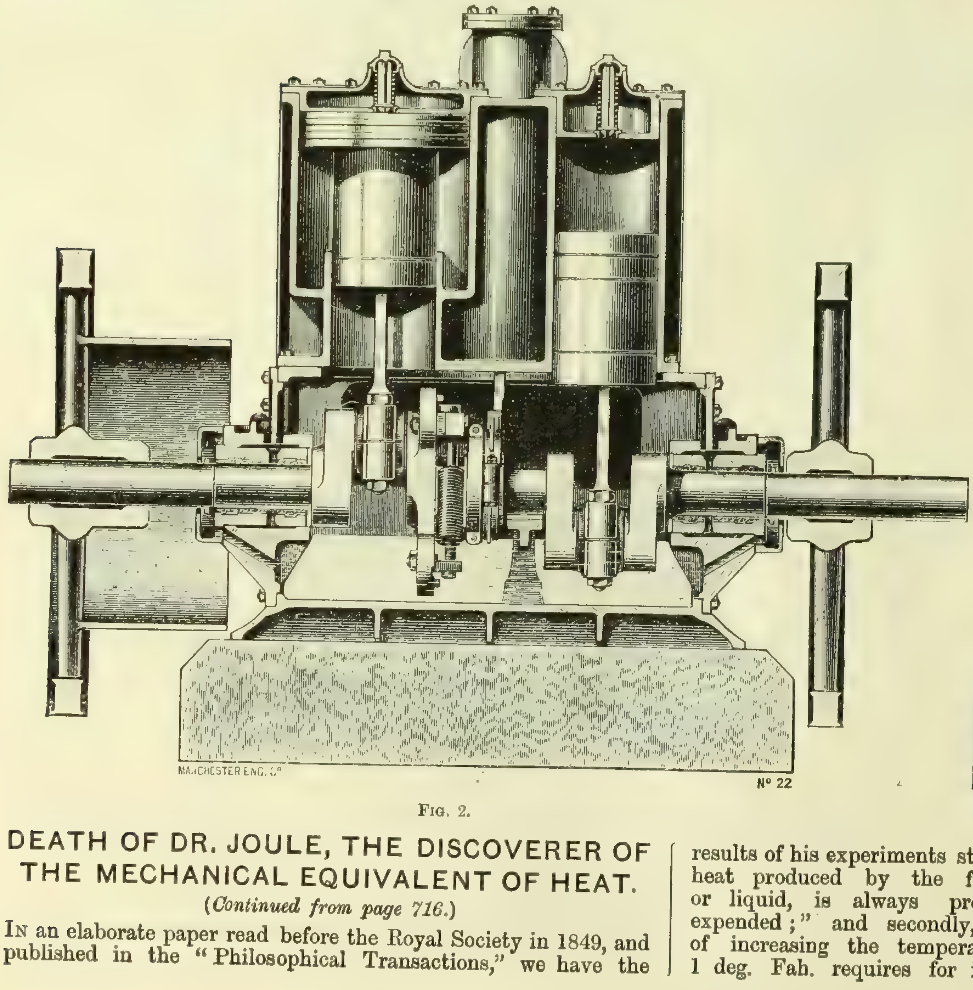


Fig. 2.

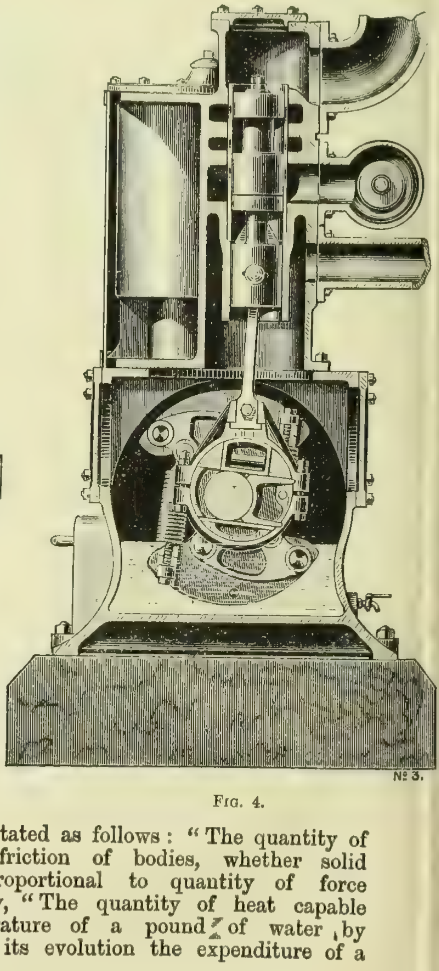


Fig. 4.

DEATH OF DR. JOULE, THE DISCOVERER OF THE MECHANICAL EQUIVALENT OF HEAT.

(*Continued from page 716.*)

In an elaborate paper read before the Royal Society in 1849, and published in the "Philosophical Transactions," we have the results of his experiments stated as follows: "The quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to quantity of force expended;" and secondly, "The quantity of heat capable of increasing the temperature of a pound of water by 1 deg. Fah. requires for its evolution the expenditure of a mechanical force acquired by the fall of 772lb. through the space of one foot.

Prior to the successful issue of Mr. Joule's researches the true principle of the dynamical theory of heat was not experimentally demonstrated. It is true that the idea upon which he laboured had revealed itself to several minds, and a number of investigators had contributed with more or less success to its elucidation. Among these were Faraday, Grove, and Dulong, but to Mr. Joule unquestionably belongs the honour of first demonstrating the law of mechanical equivalence between work and heat. For this achievement the Royal Medal of the Royal Society was awarded him in the year 1852. It was presented to Mr. Joule by the late Earl Rosse, who referred in high terms of appreciation to the discovery for which it was awarded as one which united in itself a practical as well as a profound scientific interest. But prejudices are strong, and the world, even the scientific world, was slow to appreciate the value of the discovery Mr. Joule had made. Eight years after he had received the Royal Medal of the Royal Society he was called to occupy a still higher place of honour. Men of science had by this time more fully grasped the benefits accruing from his researches and experiments, and we find him the recipient of the Copley Medal of the Royal Society in 1860. It was presented to him by Sir Edward Sabine (the president), who, in handing it to Mr. Joule, referred to the honour he had previously gained, and said: "Both awards refer to the same experiments, and are substantially for the same great step in natural philosophy. You are all aware that a great principle has been added to the sum of human knowledge—one fruitful in consequences in a thousand ways, and which, being accepted among undisputed truths, is now embodied without question alike in the most wide-ranging speculations and the most matter-of-fact practice. The award of two medals for the same researches is an exceedingly rare proceeding in our society, and rightly so. The council have on this occasion desired to mark by it in the most emphatic manner their sense of the special and original character and high desert of Mr. Joule's discovery." It thus appears that Mr. Joule's discovery had now taken its place among the unquestioned truths of science. But he was not to be allowed to enjoy the fulness of his honours undisturbed. There were others who claimed a share in the valuable discovery he had made, and in 1862, in a lecture delivered at the Royal Institution, Dr. Tyndall pressed the claims of Mayer (Jules Robert Mayer, a physician at Heilbron, in Germany) to a share in the honour of the discovery. He pressed these claims in a manner which aroused the objections of scientific men, particularly of Sir William (then Professor) Thomson and Professor Tait, and a long controversy ensued.

Dr. Joule has, however, himself explained his views on this part of the subject, and it is interesting to see what he thought about it. M. Seguin had made a very important advance towards the establishment of the mechanical theory of heat in the year 1839, but Mr. Joule says that neither in M. Seguin's writing in 1839, nor in Mayer's paper in 1842, was the theory established. To do this required experiment. "Mayer," he says, "appears to have published his views for the express purpose of securing priority. He did not wait until he had the opportunity of supporting them by facts. My course, on the contrary, was to publish only such theories as I had established by experiments calculated to commend them to the scientific public, being well convinced of the truth of Sir John Herschel's remark, that 'hasty generalisation is the bane of science.'" "I therefore fearlessly assert," writes Dr. Joule, in August, 1862, "my right to the position which has been generally accorded to me by my fellow physicists of having been the first to give decisive proof of the correctness of this theory." Here we find a proof of the quality of the man. He does not blazon forth of his own free will the fact of his eminence in the great discovery. Only in self-defence is he induced to assert his place. Study and research for their own sakes was the principle on which he laboured, and not until he had fully mastered his subject, not until by oft-repeated and probably often disheartening experiments he had established the accuracy of his theory, did he care to come before the world. Although Dr. Tyndall advanced all he could on behalf of Mayer, he did not fail to recognise the great merits of Joule. In one of his lectures he thus spoke of him: "It is to Mr. Joule, of Manchester, that we are almost wholly indebted for the experimental treatment of this subject. With his mind firmly fixed on a principle, and undismayed by the coolness with which his first labours appear to have been received, he persisted for years in his attempts to prove the invariability of the relation between heat and ordinary mechanical force. The results of his experiments leave no doubt upon the mind that under all circumstances the absolute amount of heat produced by a definite amount of mechanical force is fixed and invariable. Subsequently Dr. Tyndall, addressing Dr. Joule, said: "You worked independently of Mayer, and in a totally different way you brought the mechanical theory to the test of experiment, and in this way proved its truth." Mr. Joule, by his discovery, placed the key in the hands of scientific men by which they were to unlock the casket of knowledge. The application of the dynamical theory of heat to cosmical phenomena has, in the hands of Sir William Thomson and other philosophers, yielded sublime views of the nature of solar heat, and of the constitution of the universe; but it must not be forgotten, in estimating the value of the researches of him who has gone, that as early as 1847 Dr. Joule, before such investigations had been made, delivered a lecture in Manchester, in which he explained the phenomena of shooting stars, and also stated that the effect of the earth falling into the sun would increase the temperature of that luminary.

The friendship formed between Joule and Thomson in 1847 grew rapidly. A voluminous correspondence was kept up between them, and several important researches were undertaken by the two friends in common. Their first joint research was on the thermal effects experienced by air rushing through small apertures. The results of this investigation gave for the first time an experimental basis for the hypothesis assumed without proof by Mayer as the foundation for an estimate of the numerical relation between quantities of heat and mechanical work; and they show that for permanent gases the hypothesis is very approximately true. Subsequently Joule and Thomson undertook more comprehensive investigations on the thermal effects of fluids in motion, and on the heat acquired by bodies moving rapidly through the air. They found the heat generated by a body moving at one mile per second through the air sufficient to account for its ignition. Dr. Lyon Playfair and Dr. Joule have also published in the "Memoirs of the Chemical Society" an account of a conjoint investigation into the volumes occupied by bodies both in the solid form and when dissolved in water, and have obtained results of an unexpected nature, as well as of great value. Dr. Joule was also engaged with Dr. Scoresby in an inquiry on the applications of electro-magnetism, a subject upon which Dr. Joule, as we have already shown, worked diligently in the earlier stages of his career. Among successful experimentalists in this branch of science the name of Dr. Joule takes a high place.

Cognate to the subject of electro machines is that of the air engine. It has long been suspected that important advantages might be derived from the substitution of air for steam. Dr. Joule described an air engine in a paper before the Royal Society in 1852, but with the accompanying statement that "experimental science has not yet yielded conclusions sufficiently certain to give confidence to the practical machinist, and coal still holds its place as the prime mover of machinery."

Early in his career Dr. Joule had paid considerable attention to the study of molecular physics, and the result was a number of valuable papers, including one on "Heat and the Constitution of Elastic Fluids," which was read before the Manchester Literary and Philosophical Society in 1848. In it he developed Daniel Bernoulli's explanation of air pressure by the impact of the molecules of the gas on the sides of the vessel which contains it, and, from very simple considerations, he calculated the average velocity of the particles requisite to produce ordinary atmospheric pressure at different temperatures. The average velocity of the particles of hydrogen at 32 degrees Fahr. he found to be 6,055ft. per second, the velocities at various temperatures being proportional to the square roots of the numbers which express those temperatures on the absolute thermo-dynamic scale. His contribution to the theory of the velocity of sound in air was likewise of great importance, and is distinguished alike for the acuteness of his explanations of the existing causes of error in the work of previous experimenters, and for the accuracy, so far as accuracy was required for the purpose in hand, of his own experiments. We have already given evidences of Dr. Joule's inventive talent and skill, and as a further instance it may be mentioned that in 1863 he described to the Manchester Philosophical Society a new thermometer which he had constructed, and by which he was able to detect the heat radiated by the moon. When the moonbeam passed gradually across the instrument the index was deflected several degrees, first to the right and then to the left, thus showing that the air in the instrument had been heated a few thousandths of a degree by the influence of the rays.

(To be continued.)

Professor Gunning estimates that the average quantity of water passing over the Niagara Falls is 26,200,000,000 cubic feet per 24 hours, rather more than two-thirds of which pass over the Horseshoe Fall.

DISCUSSION ON COMPOUND MARINE BOILERS.

TABLE No. I.

Particulars of Marine Boilers and Feed Heaters. Drawing No. 1.

Name of Steamer.	When Built.	Heating Surface in Boiler.	Heating Surface in Feed Heater.	Feed Surface to Boiler Surface.	Temperature Raised.	Fire Gases Utilised.	Boiler Pressure.
		Feet.	Feet.		About	About	Lbs.
Plantyn	1879	3580	134	1 to 26·6	15°	140°	80
Pieter de Conninck	1881	5697	216	1 to 26·4	15°	140°	80
Sorrinto	1881	3992	158	1 to 26·9	16°	145°	80
Marsala	1882						
Clan Cameron	1882	4018	204	1 to 19·68	20°	150°	85
Clan Campbell							
Clan Forbes							
Clan Ogilvie							
Clan Grant	1883	5899	397	1 to 14·85	25°	160°	85
Taormina	1884	3992	414	1 to 9·64	35°	180°	80

TABLE No. II.

Particulars of Compound High and Low Temperature Marine Boilers. Drawings Nos. 2 and 3.

Name of Steamer.	When Built.	Heating Surface in H.T. Boiler.	Heating Surface in L.T. Boiler.	L. T. Surface to H. T. Surface.	Temperature Raised.	Fire Gases Utilised.	Boiler Pressure.
Bleville	1886	1768	3392	1·91 to 1	150°	400°	160
Caloric	1887	1613	3505	2·17 to 1	140°	450°	160

Referring to the paper in our last issue, Mr. James Howden said that Mr. Kemp had given a very interesting account of his attempts to utilise as much as possible of the heat of the fire gases generally allowed to go to waste in the ordinary manner of working marine boilers. By the adoption of this extensive heating apparatus, Mr. Kemp informed them that he had gained the substantial saving of 15 per cent, comparing results with those obtained in other steamers having similar engines and working at equal power. Though 15 per cent was very considerable gain, yet when one looked at the great extent of the apparatus—for the comparatively small engine power—it must strike one forcibly that the saving effected by feed heating in this way was obtained at a very considerable cost. These trials of Mr. Kemp also afforded an additional proof of the fact that water, instead of being, as was generally supposed, a good conductor of heat, was a very bad conductor, compared, for example, with air, which he himself had used for a number of years for utilising the same waste heat of the escaping gases from steam boilers. He instanced a case of the New York City, of exactly the same power as the Caloric, which had furnished very reliable means of proving the superiority of the heat-absorbing power of air. The dimensions of these feed heaters, as given by Mr. Kemp, after deducting the space occupied by the 118 tubes in each heating vessel, left a capacity for 5,256lb. of water in each, and as 8,633lb. of feed water were supplied per hour, the time taken in passing through one feed-heating vessel was therefore 36½ minutes, and 2 hours and 26 minutes in passing through the four heating vessels. In the boiler of the New York City the air-heating chamber, through which the whole air of combustion passed, had a total heating surface of 225 square feet, and the capacity of the chamber was 16·8 cubic feet. The coal consumed on the trial, at which he was present and ascertained the results, was 1,030lb. per hour; and as 20lb. of air was used for combustion per pound of coal consumed, the total weight of air passing through the heater per hour was 20,600lb. The temperature of the air on entering the heater was 70 deg., and on leaving 250 deg., so that the air was raised 180 deg. in temperature in passing through the heater. The volume of air entering the heater was accordingly 13·4 cubic feet per pound, and leaving 17·86 cubic feet per pound. The average volume of air per pound in the air heater might therefore be taken as not less than 15 cubic feet per pound. As 20,600lb. of air passed through the heater per hour, 5·75lb., or 86·25 cubic feet, passed through per second, and as the total capacity of the air-heating chamber was 16·8 cubic feet, it followed that the air-heating chamber was replenished 5·13 times every second, so that each particle of air was less than one-fifth of a second in contact with the heating surface in passing through the heater. This gave, so far, the means of comparing the relative absorbent powers of air and water. In the Caloric there were 8,633lb. of water raised 140 deg. in temperature per hour by contact with 3,505 square feet of heating surface, but each particle had been in contact with, or under the effect of, the heating surface for 2 hours 26 minutes; while in the air heater of the New York City, 20,600lb. of air per hour had been raised 180 deg. by contact with only 225 square feet of heating surface, but where each particle had also only been in contact with the heating surface ·194 of a second. The time the air had been in the one case, and the water in the other, and under the heating power in their respective apparatus, and taking the values of the specific heat of the 8,633lb. of water raised 140 deg. per hour in the Caloric, and the 20,600lb. of air raised 180 deg. per hour in the New York City, the relative values were, water 1, and air ·7178. The air was, however, increased in temperature by contact with only $\frac{1}{16}$th of the heating surface with which the water had been in contact, so that the air had absorbed, even under much less favourable conditions as to time in contact, 11·4 times more heat in the case of the New York City than the water had in the Caloric, for equal areas of heating surface. This, however, did not show fully the superior heat-absorbing powers of air over water, for, to test these fairly, equal weights of each should pass over equal surface, under the same temperature in equal times. He had begun the construction some time before of an apparatus to test these fluids under these conditions, but had not yet been able to complete it. He might mention that he had tried feed heating by utilising the heat of the escaping gases over 27 years ago, but the feed heater and the boiler were combined. He gave an instance of testing the saving of heat from the furnace gases in a boiler which he tested privately, and as it gave satisfactory results, he built afterwards, in the same year (1862), a boiler of larger size, on the same principle, for the steamer Ailsa Craig. He spoke of the tubes becoming corroded, and said that owing to this the boiler was removed within two years of its being fitted in the steamer.

The President asked what were the temperatures of the gases before entering the air heater, and when they left it?

Mr. Howden said the temperature before entering the air heater was somewhat over 600 deg. The exact temperature could not be ascertained, as the temperatures were taken by a mercury tube thermometer graduated to 600 deg. When the mercury rose slightly above 600 deg. it burst the thermometer, so that it had to be withdrawn when it rose to 600 deg. The temperature of the gases leaving the air heater on these trials was from 430 deg. to 450 deg., varying a little according to the condition of the fires.

Mr. Kemp, in reply, said Mr. Howden had given them a long dissertation on air and water, but he did not mean to follow him in that. But the president had just asked Mr. Howden how much the waste gases were utilised in the boiler by the air heater.

Mr. Howden said, as he had already mentioned, he was not quite sure of the temperature of the waste gases before entering the air heater, only that it was above 600 deg.; but as the temperature on leaving was from 430 deg. to 450 deg., and the air was raised 180 deg., the heat utilised must at least have been 180 deg.

Mr. Kemp said that he understood that in Mr. Howden's experiments he had utilised 180 deg. of the waste gases, while in the Caloric they were 450 deg., and the gases were delivered at 225 deg. where they passed through the low-temperature boiler. He (Mr. Kemp) had explained in the paper that in the first low-temperature boiler the temperature of the water going in was at 130 deg., and that it came out at 165 deg.; that although the gases were only 225 deg. coming out, they were effective in giving out heat to that boiler. As to whether Mr. Howden's boiler or his (Mr. Kemp's) boiler was the most economical, he did not know; but it was scarcely fair in Mr. Howden claiming for his a greater degree of economy, seeing that in the case of the Caloric's boilers the fire gases were utilised to a much greater extent than in the boilers of the New York City. Now, the fire gases that were utilised, and the heat of the water, the one was a check upon the other; but as to which system would turn out the most successful or economical had yet to be proved. He was trying to prove it, and he had written the paper under discussion to inform them of what he had done, and if he got over the pitting of the tubes he had no fear for the effectiveness of the boiler. The four successive low-temperature boilers have all different temperatures, but all have the same pressures.

THE GLOBE COMPOUND AUTOMATIC ENGINE.

Not many years back, engineers would have been surprised and incredulous if told that single-acting steam engines would again come largely into use. They would have reasoned that the days of single-acting engines were over, at least for powers of any great magnitude. Many conditions of modern work, however, have demanded alterations in the common types of engines which can best be met by at once going back and utilising the single-acting open-ended cylinder. These engines are very different from the older types, and many large firms now number among their manufactures high-speed single-acting engines with variable automatic cut-off, giving the greatest economy to be attained by the use of the compound and triple-expansion principles.

Messrs. John Musgrave and Sons Limited, of Bolton, have produced an excellent compound engine of the single-acting type, and automatic in its variable cut-off action. It consists essentially of one small high-pressure cylinder and one large low-pressure cylinder, placed side by side, and inverted over a pair of cranks set at a half circle apart, with a valve chest and distributing valve arranged vertically between the two cylinders.

Referring to our illustrations, fig. 1, p. 732, gives an external view, showing the general appearance of the engine. Fig. 2 is a longitudinal section through the cylinders, fig. 3 is a transverse vertical section through the H.P. cylinder, and fig. 4 is a similar section through the valves, showing also the governor. From these illustrations it will be seen that the engine is of the most compact, ingenious, and simple design.

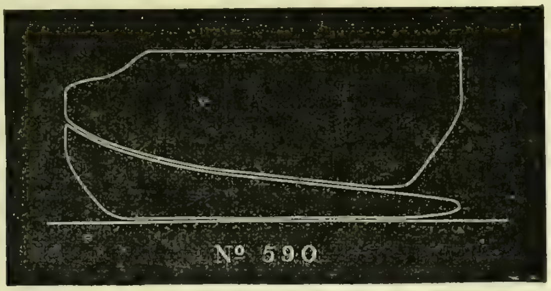


Fig. 5.

The action is as follows: Steam is admitted by the valve to the top of the high-pressure cylinder, pressing the piston down and turning the crank and its connections. As the piston moves downward, the valve, actuated by the governor, cuts off the admission of steam, and a portion of the stroke is made with expanding steam. Just before the high-pressure piston reaches the bottom of its stroke, the valve opens communication between the high and low pressure cylinders, and, as the cranks are opposite, the low-pressure piston is then at the top of its stroke, and is immediately pressed downward by the steam discharged from the high to the low pressure cylinder. As the low-pressure piston moves down, the high-pressure piston is moving up towards the top of its stroke, displacing the steam in its cylinder, which passes over to the low-pressure side.

When the stroke is partially completed, the valve cuts off communication between the two cylinders, and the steam remaining in the high-pressure cylinder is compressed, resisting the upward momentum of the piston and bringing it gradually to rest at the top of its stroke, ready to commence the next downward stroke; meanwhile the low-pressure piston completes its downward stroke with expanding steam. Just before the low-pressure piston reaches the bottom of its stroke, the valve opens communication with the atmosphere, if non-condensing, or with a condenser, if condensing.

In the latter case a vacuum is immediately formed in the cylinder to start the piston on its upward stroke, relieving the crank pin of the work of lifting it. If now no means were provided for counteracting the effect of the vacuum pulling the piston upward, the connecting rod would be lifted away from the crank pin, and a bad knock each stroke would result; but there is an annular space left below the large piston, so proportioned as to form by the displacement of the piston itself a vacuum sufficient to overcome the upward momentum of the piston, bringing it gradually to rest at the top of its stroke, as seen in the section, fig. 3.

The cranks being exactly opposite each other, the reciprocating parts—*i.e.*, pistons and connecting rods—mutually balance each other, and so reduce the vibration that it is not noticeable, even when running at very high speeds.

When the governor is in correct adjustment, it will not commence to operate until the engine is running within one per cent of its regular speed, and it will move through its entire range before the engine is running one per cent too fast. This is admirable work, and means that with an engine adjusted to run 300 revolutions per minute under full load it will not run faster than 304 or 305 when without load. A piston valve of special design is used, which is not only balanced as regards steam pressure, but from the method of construction is made absolutely tight, and the tendency is for it to remain tight instead of wearing loose and leaking after running a short time.

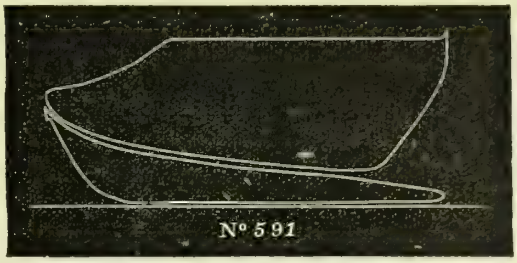


Fig. 6.

The automatic governor is situated in the crank case, between the two cranks, where all its working parts are constantly deluged with oil. It embraces some new features, among which are, that the parts subjected to centrifugal effort—*i.e.*, the governor weight, and springs—are not affected by the reciprocating strains, and a much more even speed is maintained with less expenditure of force in the governor. The movement of the weights regulating the cut-off is conveyed to the main eccentric through a secondary eccentric, which relieves the weights of all strain imposed by the working of the valve, and allows them to take their true position, due to the speed, without reference to the effort required to move the valve and its connections, a point which, we believe, no other governor of this class has.

The crank case is constructed to hold a body of water and oil, and the cranks, connecting rods, eccentric, and governor pass through this oil at every revolution, giving a constant and thorough lubrication to all the working parts. A stream of oil and water also passes constantly over the main bearings, and is returned through suitable channels to the crank case, to be used over and over again. An overflow is provided for the escape of the excess of water, so the level in the crank case cannot get too high. This overflow is so constructed as to retain the oil and allow the water only to escape.

The wearing parts of the engine are all easily and cheaply renewed, and as from the constant and copious lubrication the wear is very slight, the expenses of repairs are very low.

Relief valves are provided in the covers of both high and low pressure cylinders, so that any water accumulating, from the boiler priming or other cause, is at once discharged without damage to the engine. These valves are shown at figs. 2 and 3. The steam ports and passages are very clearly indicated at fig. 4. Figs. 5 and 6 are diagrams taken from a Globe compound engine, with a Tabor indicator, from which it will be seen how small is, the loss of pressure between the high and low pressure cylinders, the exhaust line of the high-pressure diagram almost coinciding with the admission line of the low-pressure one in both cases. These results are highly satisfactory, and are most creditable, not only to the performance of the Globe engine, but also to the Tabor indicator used for testing.

Not the least of the advantages of engines of this type is the fact of the complete enclosure of working parts from dust and grit, and the copious lubrication, due to the parts practically working in an oil bath.

Honorary Examinations for Marine Engineers.—The quarterly examinations of the Board of Trade for certificates of competency as extra first-class engineers have just been held at the different ports in Britain. Eight candidates presented themselves, and the following were successful: George W. Buckwell, Newhaven, Sussex; John E. Hackett, Liverpool; James C. S. Pease, Southampton. All the successful candidates were pupils of Lockie's Nautical Academy, Leith. This is the highest honour granted by the Board of Trade to marine engineers, and of the fifty-five engineers who hold this certificate, thirty have been Mr. Lockie's pupils.

HEAT ENGINES OTHER THAN STEAM.—III.

(Continued from page 718.)

Let us now consider that further improvement made by the inventor of the Otto and Langen free-piston engine, which has rendered the gas engine the admirable apparatus for its purpose which it is.

This improvement consisted in so arranging the "cycle" of operations, and the proportions of the length of the cylinder and the stroke of the piston, that the gaseous mixture in the cylinder is compressed and stratified; that is to say, in the improved Otto engine (more commonly now known as the Crossley engine) there is, close to the piston when explosion takes place, a layer of the products of combustion from the previous stroke (these products of combustion being, as you will realise, incapable of themselves burning), and that then there is a layer of weak explosive mixture, and the charge gets stronger and stronger of gas, due to the arrangement of the air and gas inlet valves, till the back of the cylinder is reached, and here, where ignition takes place, the mixture is at its strongest.

Further than this, the arrangement of the "cycle" is such that the efficiency and economy of the engine are increased by the fact that, prior to the explosion, the inlet valve has been closed, the stratified charge has been, so to say, bottled up in the cylinder, the piston has come backwards, and the stratified charge has been compressed so that, at the moment of combustion, it has a pressure of, say, 40lb. on the square inch.

This compression will, according to the second law governing the expansion of gases, give you, for an equal increment of heat, a pressure very much in excess of that which would arise if there were no compression; and the stratification will give you a charge of gaseous mixture which will readily ignite at that part where it is richest of gas, and will burn, not with explosion, but only with very, it may be with extremely, rapid burning, and where the power generated by combustion will thus be somewhat gradually applied to the piston, and through it to the crank shaft.

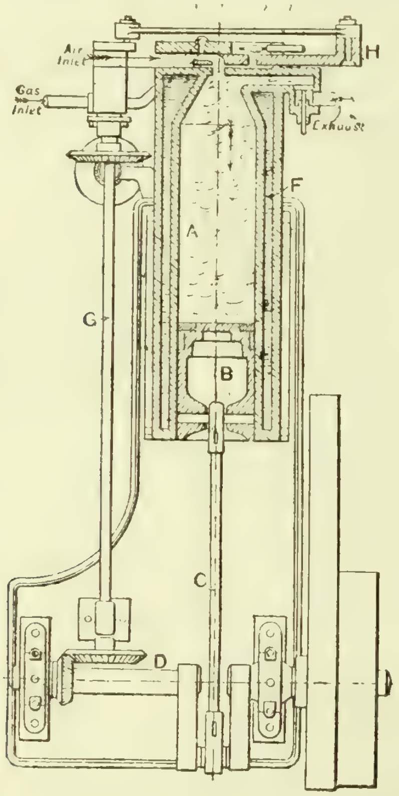


Fig. 17.—Otto and Crossley Gas Engine. Plan.

Having now stated to you, as shortly as possible, the advantages appertaining to this improvement, I will ask you to consider the "Otto" engine, which is, I suppose, to a greater extent the gas engine of the day than is any other. It is the engine in which stratification and compression were first made a thorough and practical success.

In order to understand this engine, I must deal again with the question of "cycles." If you will remember, in the "Hugon" and the "Lenoir" engines there was, as in the steam engine, an impulse for each stroke of the piston—that is to say, two impulses per revolution of the crank shaft. Now, in the "Otto" engine we have only one impulse for each four strokes of the piston—that is to say, one impulse for each two complete revolutions of the crank shaft.

Let me ask you to look at this model, which shows, by the varying colours displayed in succession in the cylinder, the sequence of operations taking place there; or, in other words, gives you, by the variation of these colours, the "cycle" which occurs.

We will commence with the first "out-stroke" of the piston. When this is taking place, the slide valve admits the charge of gas and air—in the order already explained—this charge being drawn into the cylinder by the forward movement of the piston; the slide valve then closes the ports, and on the first "in-stroke" the piston compresses the charge into the space you will see at the back of the piston, between it and the cylinder cover. The charge is then ignited, the piston makes its second stroke outwards—this being the power stroke—and the motion being made because of the combustion of the gaseous mixture. Then the flywheel carries the piston again inwards, the second in-stroke is made, a portion of the burned gas being expelled through another port in the slide valve into the atmosphere. Our engine is now in the same condition as it was when we started, and the "cycle" is complete, for on the next forward movement the charge of gas and air will be drawn in. You will realise that the essence of this cycle is the compression and stratification; but you will also see that, ignition taking place only once in every two complete revolutions, a certain time is allowed, during which the water jacket will have time to cool the cylinder. I will return to this point of cooling again directly.

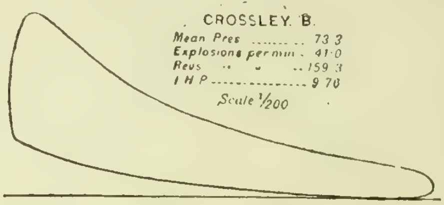


Fig. 17a.

Let us now look at the diagram, and see what the engine itself is like. Fig. 17, on this page, shows you a plan section through the cylinder. You will see here the deep piston, marked B, to which one end of the connecting rod C is directly jointed, the cylinder being single acting, and, therefore, open-ended; the other end of the connecting rod can take hold directly of the crank on the crank shaft D. On this crank shaft there is a bevel wheel, driving, by means of another bevel wheel at right angles, a longitudinal shaft G, carrying at its extreme end, and at the back of the cylinder, the rod which works the slide valve. The exhaust valve, which is under the cylinder, is worked from this horizontal shaft by a cam and a rocking lever, not shown on the diagram. The outside appearance of the engine is, as most of you know, practically the same as that of a horizontal steam engine with a long cylinder.

I have already shown you one of the indicator diagrams obtained from such an engine as this. Fig. 17a is another, and is one of those taken by the judges in the electric motor trials, to which I have had so frequently to refer.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

FIRE BRIDGES.

To the Editor of "The Practical Engineer."

Sir,—In reply to your correspondent, "Engineer," I may state that one function of the bridge wall at the end of the furnace is to retard the escape of the products of combustion into the flues, and thus to promote their better admixture with air, and so assist combustion. Hence, a furnace bridge may be too low as well as too high, but it is undoubtedly a great mistake to build a bridge wall so high that it affects the draught. In an ordinary Lancashire boiler, with say 2ft. 9in. furnace tubes, the distance between the top of the bridge wall and the crown of furnace tube in the middle should never be less than 9in., and may be made 12in. with advantage.

They should not be built too thick, as it is always advisable to cover up as little plate surface as possible with bricks. A 4½in. wall, however, is so soon knocked down by a touch from the fire-rake or stoker, that the wall should not be built of a less thickness than 9in. This width, however, need never be exceeded. Many instances of severe external corrosion under bridge walls have come under the writer's notice, where leakage has taken place from a seam or a rivet under the wall, and the moisture becoming absorbed by the brickwork, without having been noticed, has led to the wasting of the plate surface in contact.

Hence, when a seam of rivets is under the bridge, and especially a ring seam, it is advisable to have the brickwork entirely removed when preparing the boiler for thorough inspection.

Some years ago, I remember a case where a firm, with several boilers, were working with their engines under speed, and the stokers were unable to keep the steam up. By knocking a course of bricks off the bridge wall in each boiler the draught was immediately improved, combustion became more perfect, and in a very short time the steam was blowing off at the safety valves, and the difficulty was to keep the steam down rather than up.

In this case the furnace seams had been continually giving trouble, fire-bars had been warped and destroyed, and all through the practice of building up the bridge walls too high. It is especially important, where sedimentary or greasy feed water is used, that the fire bridges should not be built too near the furnace crown.

Wilson recommends, as an approximate rule, that the bridge be built so that the air passage above may be about one-sixth the area of the fire-grate.—Yours, &c., Azim.

To the Editor of "The Practical Engineer."

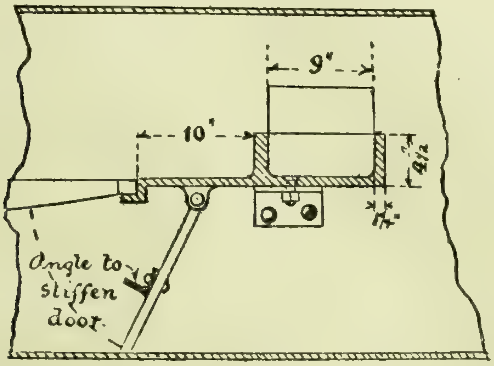
Sir,—The query propounded by "Engineer" as to the height and width of fire bridges is one concerning which I presume there must be a variety of opinion, as I have come across bridges of all widths, from 9in. to 2ft., and in odd cases 3ft. or more. I am not aware that a fire bridge serves any purpose other than acting as a stop to prevent the fuel being thrown or pushed into the flue tube beyond the furnace; or that there is any advantage in building it higher than is necessary for that purpose, or of greater width than is required to ensure sufficient stability to prevent the bridge being pushed over—say 9in. to 12in. high and 9in. wide. On the other hand, a bridge built too high may not only injure the draught, as in the case cited by "Engineer," but may cause straining by too severe and too local impingement of the flame against the plate immediately over the bridge, and the evil from this cause may be aggravated if there is also a seam close to the bridge.

As regards "Engineer's" remark concerning the requirements of insurance companies, I believe he will find that the removal of a fire bridge is not pressed for unless a seam, and more especially a ring seam, is covered by the brickwork. In all cases the furnaces of boilers should be arranged so that no seams are covered.—Yours, &c., C. T.

To the Editor of "The Practical Engineer."

Sir,—In reply to "Engineer," in your issue of the 4th inst., the fire bridge is used simply to make good the draught and to prevent fuel being thrown or pushed into the tube or off the bars, and should never exceed 9in. in thickness, and be kept as low as possible, to give effect to the full force of the draught. When built too high, it reduces the area of the tube, and its effect is practically the same as closing the damper; it stops or impedes the draught, as "Engineer" found by experience. Where a boiler has Galloway tubes, a high bridge is a very great mistake, as it practically acts as a shield to keep the heat off the tubes. The reasons for removing bridges are many. It often happens that they are built on a ring seam, and I have come across several instances where, on removing bridges, serious corrosion and damage have been found. In one instance, where a Cornish boiler was examined, the bridge, 2ft. wide, was not removed at the time of examination, and the boiler was found to be in a satisfactory condition. It, however, emptied itself before next morning. The water was found to be coming from under the bridge, which on being removed revealed the plate underneath to be completely destroyed, caused by a ring seam under the bridge having leaked a little. Brick bridges are a relic of the past, and are fast being superseded. Many of the best firms of boiler-makers are now fitting back dead plates, with a door hinged on the underside, fitting the circle of the tube. These are very handy when flue cleaning, as they can be opened and a rake put through for pulling out the deposit, instead of throwing it over the bridge. There is another idea which can be utilised where the metal bridges are being put in. I have given a few friends particulars, and where in use they are highly appreciated. I forward a sketch, which may interest "Engineer" and others of your practical readers. The arrangement consists in making the dead plate and bridge carrier some 10in. or 11in. wide in front of the bridge; this space is for the purpose of pushing the fire on to when cleaning off. Every boiler tender and fireman knows what hard work it is cleaning a fire out half at a time; but by using a dead plate as suggested, when the fire is pushed on to it the fireman has the whole grate exposed to his drag, and the operation is properly performed, and the fire pulled forward at once and with ease.—Yours, &c., S. Hewitt.

Bradford.



OVERHEATING IN VERTICAL BOILERS.

To the Editor of "The Practical Engineer."

Sir,—I have been urged to protect the upper part of the chimney tube of a vertical boiler, 4ft. 6in. diameter, against overheating, where it passes through the steam space in the upper part of the boiler. The fire-box is 3ft. 10in. in diameter, and the tube carrying away the smoke is 10in.

Will there not be a risk of a liner inside this tube interfering with the draught and crippling the power of the boiler? I should also be glad of any hints from some of your practical contributors as to the best mode of lining the interior of the tube. Will fire-clay hold in a plain tube such as this without trouble from falling away; or is there some means of securing it? Some tubes, I understand, are now made with the upper part above the water level enlarged to accommodate an internal lining of some kind.

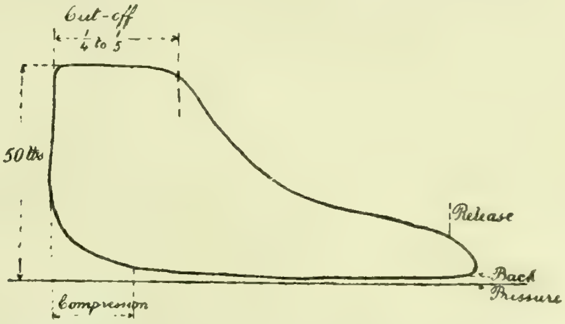
I have seen a suggestion somewhere, either in a back number of *The Practical Engineer*, or in some contemporary, to make the upper tubes of boilers of this class taper with the larger diameter at the top of the boiler, something like a Galloway cross water tube, so that it could easily be replaced at any time by a new one, in the event of repairs being required.

Can any reader inform me whether there is really much risk of overheating in the working of these boilers, and, if so, what is the best mode of guarding against it? An early reply from some practical engineer who has had experience in this direction would be greatly esteemed by yours, &c., A Steam User.

INDICATOR DIAGRAM PRACTICE.

To the Editor of "The Practical Engineer."

Sir,—The diagrams of the small engine sent by "Wrought Iron," present for solution the following problem: Given the diagrams to be correctly taken and to truly represent the action of the steam within the cylinder, to design a valve gear and set it to give indicated cards like that illustrated. First consider the compression, as it is undoubtedly excessive, but by itself, not the worst feature, for if the exhaust port opened sufficiently, the resulting pressure from this compression would not exceed boiler pressure. The exhaust port probably is not opened more than a small part of its width at the back end, and it is closed far too soon. There are two causes to look to for the erroneous action; first, an ordinary slide valve with no lap, which has no angular advance of its eccentric, can have no compression corner. I will send cards if the editor permits, with this fault almost as bad as the opposite extreme now under remark. But as the advance of the eccentric required by outside lap gives the early compression, it also gives the corresponding early release. These diagrams do not show this early release; therefore the excessive compression is not caused by angular advance, but by an abnormal condition of things, such as excessive exhaust lap on that end of the valve, due, no doubt, either to a blunder or an oversight, for it is impossible to conceive it due to design. One other cause of back pressure I have come across is a choked port, and sometimes exhausting into heaters. Nearly all here have heaters of their own mysterious design, which nearly always cause spasmodic back pressure.



I should take out the valves, examine their width and breadth of ports and passages, cut off the inside lap; it may be in the port breadths or in the valve, or in both. If the single main valve has no outside lap, put on some, so that a fair compression may be obtained, but don't throw away your cut-off gear, for after clearing your obstruction you want to cut off about ¼in. the stroke; the cards so obtained will then be somewhat like the above.

With regard to the front end, the same throttling takes place on the steam side. The cause is the same, viz., malformation, or gross obstruction.

The other points on these cards indicate correct admissions at the centres, and reasonably correct, although wiredrawn, cut-off points.—Yours, &c., Cast Iron.

[We shall be glad to receive the indicated cards referred to for comment.—Ed.]

QUERIES AND REPLIES.

99. STRUT.—I want to find what a round rod of wrought iron, say 3ft. long and 2in diameter, will carry with safety when acting as a strut. Again, given the length of a rod (round), and the load it has to carry, to find what the diameter should be.—LUTON.

Answer.—*Re* my answer to the above question, I find the area of the strut is omitted. Correcting this, the formula stands—

$$P = \frac{16 \times 3{\cdot}1416}{1 + {\cdot}0005\left(\frac{36}{2}\right)^2} = 43{\cdot}2 \text{ tons,}$$

and $\frac{43{\cdot}2}{6} = 7{\cdot}2$ tons, safe load for general purposes,

and $H = \sqrt{2000\left(\frac{16 \times 3{\cdot}1416}{43{\cdot}2} - 1\right)} = 18$ = ratio between length,

and diameter, $\therefore \frac{36}{18} = 2$in. diameter of strut.—J. R.

106. ANTI-CALCAIRE.—Will you kindly inform me as to what this is composed of, and what action it has on hard water? Would it be suitable for use with feed water?—MARINE.

Answer.—Anti-calcaire is doubtless an alkaline carbonate, such as a commercial soda ash, or carbonate of soda. It removes the *temporary* hardness (carbonate of lime) from water, by precipitating the lime as a white precipitate, but it does not remove the permanent hardness (sulphate of lime). Milk of lime will answer the same purpose as anti-calcaire. It is suitable for use with the feed water, but the water should be allowed to stand in tanks after the addition of the alkali, so as to allow the precipitate to fall to the bottom of the tank; otherwise this precipitate will collect as mud at the bottom of the boiler. I know of one case where silty and muddy river water has to be used for several boilers on a large works. This water contains a large quantity of carbonate of lime in solution. While it is being pumped into tanks, 10 to 15 grains of milk of lime is added to the gallon of water; this dirty water is then allowed to stand for an hour or two, until it becomes as clear as the purest spring water. Of course the addition of this milk of lime prevents the accumulation of scale and dirt in the boilers. After several months working, there is simply a thin scale formed by the permanent hardness of the water, caused by the presence of sulphate of lime in it.—W. F.

110. VARNISH FOR DRAWINGS.—Will any reader kindly inform me what is the best varnish for varnishing mechanical drawings; also how it is made? C. A. B.

Answer.—The best transparent paper varnish of the colourmen is a good preservative, but the drawings must be first sized over, to prevent the turpentine in the varnish from saturating the paper, and rendering it blotchy.—J. H.

Answer.—The best varnish for applying to mechanical drawings is mastic varnish. Canada balsam varnish is sometimes used on account of cheapness, and it answers the purpose very well. As to making it, I would advise you to purchase it, as a first attempt at making it would probably be a failure, and consequent spoiling of your drawings. Do not forget to well size your drawings before applying the varnish.—J. R.

Answer.—The best varnish for varnishing drawings is one composed of Canada balsam, diluted in oil of turpentine, proceeding as follows: First stretch the drawing upon a frame, and give it three or four coats of isinglass size. This should be done with a broad, flat brush, taking care that the drawing is well covered each time, and allow it to dry thoroughly between each coat. The varnish is then put on evenly in a flowing coat, and left in a warm room, free from dust, until thoroughly dry. If "C. A. B." has had no experience in this class of work, I should advise him to experiment a little before attempting to varnish a drawing of any value.—BALSAM.

112. PROPORTIONS OF CONNECTING RODS.—Why is it usual to make the neck of the connecting rod larger at the crank pin end than at the crosshead end?—A. G.

Answer.—The connecting rod is made larger at the crank end from theoretical considerations, this part of the rod having a momentum, due to the velocity of crank and weight of connecting rod end, which the guide end is not subject to, thus tending to a bending action along the whole length of the rod, being, of course, greatest at the enlarged end.—J. R.

114. FRICTION IN WATER MAINS.—What methods are used for lessening any tendency to increase of surface friction in water mains?—F. J. J.

Answer.—The surface friction in water mains may be reduced by the system of coating the pipes according to a process patented by Dr. R. Angus Smith, first adopted by the Manchester Waterworks, and which has been very generally followed. The process is as follows: The pipes are payed over with linseed oil as soon as the sand is cleaned off and the pipe still warm from casting, for it was found that if rust, however slight, had taken place on the surface of the pipe, the coal-pitch coating to be described peeled off, and was of no use. Before coating, the pipes are heated in order to drive off any rust or dampness and allow the coal-pitch to more easily penetrate the pores of the iron, which are, to some extent, opened by the heating. The pipes are then immersed, and will be sufficiently coated if slowly let down by a crane and drawn up again out of the vertical pan of boiling coal-pitch, after the naphtha and naphthaline were distilled from the coal-tar; the residuum, being hard and insoluble, requires an admixture of mineral oil to enable it to acquire, when boiled, the proper fluidity for the operation. The smooth surface thus obtained materially adds to the volume of the water discharged. When freshly done, the increase over the ordinary formulæ for calculating the quantity which a pipe would deliver has been found to be upwards of thirty per cent, and this method has the great advantage also of preserving the pipes for many years, the coating being both inside and out.—COALTAR.

115. HYDRAULIC BRAKE.—What is the advantage of a hydraulic brake, as compared with one of rigid materials? A sketch of one by which a nearly constant arresting force may be obtained will greatly oblige.—F. J. J.

Answer.—The advantage of a hydraulic brake is supposed to consist in the greater control which it exercises over the act of lowering, and in its increased safety. The disadvantage is the liability of the water to freeze in winter and crack the cylinder, unless it is drained away when not required for use. A sketch of a good brake, the invention of W. Matthews, Esq., M.I.C.E., is given in the "Proceedings of the Institution of Civil Engineers," vol. l., p. 101. It is patented. Some of these are at work in foreign countries, but the only one, I believe, in England is fitted to the 40-ton mammoth crane on Tynemouth North Pier.—J. H.

116. SEATING HYDRAULIC PUMP VALVES.—I should be very glad to know what is the best method of seating valves in a hydraulic pump, the valve being 3in. or 4in. diameter and the pressure two tons per square inch. I am afraid, if seated in the ordinary way, they would leak and get loose. PUMP VALVES.

Answer.—The most secure method of fixing a valve seating which is subject to a very great pressure is to provide the seating with two or more lugs or ears, and by this means secure the seating by studs and nuts to the pump casing. Another effective method is to make the bottom of the seating hole of the same diameter as the bore of the seating, and bedding the valve seating on the shelf thus formed in the pump casing.—J. R.

120. CRANK PIN.—I have a crank pin to put in; it is 10½in. diameter by 10⅝in. long in that part which fits the crank eye, and 9½in. diameter by 10in. long for the working part, with 1⅜in. of a collar outside, making it 22in. long. There is no taper on the pin, and it is held in position by a key. I want to know if there is any advantage in having a hollow pin; if so, what the advantage is, and what size of hole you would recommend. Also, if a steel forging can be got with a hole in it.—CRANK PIN.

Answer.—The advantages of a hollow pin would be less weight and cool running, by reason of the current of air passing through its centre. As to the diameter of hole, this cannot be determined off-hand, as it will depend on the maximum pressure on the crank pin tending to shear the pin at the neck, and sufficient section of metal must be left to resist this. There should be no great difficulty in obtaining a forging of this class, and certainly none if by the Whitworth process. Why should not a steel casting suit crank pin, which would be much cheaper and stronger.—PIN.

121. BORING LARGE CYLINDERS.—Will any of your readers kindly give the speed of cutter per minute allowed in boring machine for boring large cylinders? Also the traverse of cut usually allowed. I have a cylinder 60in. diameter and 4ft. 10in. length from end to end of cylinder. I am having it rebored, and want to know the rule for calculating time required to do same.—PERCY.

Answer.—The speed for boring cast iron greatly depends upon the nature of the metal to be operated upon. The boring speed usual for such metal as steam cylinders should be made of, is from 10ft. to 12½ft. per minute. The rate of feed should be about 1-12th to 1-16th of an inch per revolution, and rather coarser for finishing. The boring speed for a cylinder 60in. diameter would be about one revolution in one and a half minutes.—J. R.

Answer.—In boring cast-iron cylinders, the common speed for the tool is 15ft. per minute; the pitch of the screw for advancing the cutter is usually ¼in., with a star wheel having six arms. The advance of tool per revolution will then be $\frac{1}{6} \times \frac{1}{4} = \frac{1}{24}$in., and the surface bored per minute $= \frac{15 \times 12}{24} =$ 7½ square inches, or 450 square inches per hour. The time required to bore a cylinder at this rate will be found from the rule—

$$\frac{\text{Circumference in inches} \times \text{length in inches}}{450} = \text{time in hours.}$$

For a cylinder of the dimensions given, the time occupied in boring will be

$$\frac{60 \times 3{\cdot}1416 \times 58}{450} = 24{\cdot}3 \text{ hours.}$$

ORION.

122. WEIGHT APPLIED BY SAFETY VALVE LEVER.—Will one of your practical readers kindly give reliable formula for calculating weight applied by unloaded lever in safety valve calculations, as various rules are given by different engineering authorities?—J. W. B.

Answer.—First find the centre of gravity of the lever and measure its distance from the fulcrum; call this x, and if d be made to represent the distance from the fulcrum to the centre of the valve, and w the weight of the lever, which may be taken as acting downwards through its centre of gravity, then to find the load on the valve due to the weight of the lever, we have

$$\text{Load on valve} : w :: x : d$$

$$\text{or load on valve} = \frac{w \times x}{d}$$

And if w be taken in pounds and the area of the valve be A square inches, then pressure in pounds per square inch on valve due to weight of lever $= \frac{w \times x}{A \times d}$.

NOTE.—The position of the centre of gravity of the lever may be found, with sufficient accuracy, at any rate for the present purpose, by finding the point on which it balances, and calling this its centre of gravity.—GRAVITY.

Answer.—If "J. W. B." means the weight on the valve due to the lever alone, it will be represented by $W \times \frac{a}{c}$,

where W = weight of the lever,
a = distance of the centre of gravity of the lever from the fulcrum,
c = distance between fulcrum and centre of valve,

or pressure per square inch, due to the weight of the lever $= W\frac{d}{c \times x}$, where x = area of valve.

123. COMPRESSED AIR FOR UNDERGROUND HAULAGE.—What are the advantages and disadvantages of compressed air, as compared with steam, for underground haulage?—TABOR.

Answer.—Almost the only disadvantage of compressed air for underground haulage as compared with steam is its excessive working cost, added to the great cost of the machinery in the first instance. Of course the formation of ice in the exhaust ports of the hauling engines is a disadvantage, but this can generally be remedied by having large ports and exhausting from both sides of the cylinders. The exhaust air is sometimes a considerable aid to ventilation. Steam, on the contrary, cannot be taken very far into the workings (air can be taken anywhere), owing to condensation, to the nuisance of the hot pipes, damage caused to roof, &c., by the heat and escape of steam. The exhaust steam also is very difficult to deal with, except near the shafts, as condensing water can seldom be had conveniently. Where circumstances are favourable, steam is much the most economical motive power, both in first cost and working expenses.—H. G.

124. COIL FRICTION.—What is meant by coil friction? If a rope is coiled twice round a fixed cylinder, and a weight of 10cwt. is pulling at one end of the rope, what is the smallest weight pulling at the other end of the rope which will prevent it from slipping on the cylinder?—TABOR.

Answer.—When a rope is coiled round a band or cylinder the friction exerted by each portion of the rope is accumulated, so that the total friction is very great. It will be found by experiment, or it can be demonstrated mathematically, that with one coil of rope round the barrel, the weights which balance, when hung on the two ends of the rope, will be in the proportion of about 1 to 9. With two coils the ratio will be about 1 to 81. In the case mentioned, therefore, the weight required to prevent slipping with two coils, and 10cwt. at one end of the rope, will be 10cwt. 81 = 14lb., about.—Hydra.

125. Intermediate Receiver in Compound Engines.—I have been designing and fitting up a compound engine, and am desirous of knowing the true value of the intermediate receiver between the high and low pressure cylinders? A full reply will extremely oblige.—Young Engineer.

Answer.—In the receiver compound engine the great object to be kept in view is to so arrange the cut-off in the high and low pressure cylinders that the receiver pressure may be as nearly as possible uniform, or, in other words, the *drop* must be inconsiderable, to obtain the maximum efficiency. Should drop occur to any extent, a serious loss of power is the inevitable result. The volume of the receiver is about one to one and a half the volume of the high-pressure cylinder. The value of the receiver is that it is an absolute necessity for engines having their cranks at right angles to each other.—J. K.

Answer.—The value of the intermediate receiver lies in its enabling us to work our engine on the compound principle, and yet have our cranks or right angles, which gives a more even driving moment, and renders the engines more handy for starting, &c.; and if the size of the receiver be made such that there is no "drop," or, in other words, the back pressure in the small cylinder corresponds with the pressure in the receiver, and further, that the steam is taken from the receiver by the large cylinder at the same rate as it is supplied by the exhaust from the small one, thus maintaining the receiver pressure constant, to accomplish this the cut-off in the large cylinder must be adjusted so that the weight of steam taken by it is the same as that exhausted from the small cylinder. If then no drop occurs, there will be no loss of efficiency. On the other hand, if the pressure in the receiver be less than the terminal pressure in the small cylinder, or, in other words, the steam is allowed to expand into the receiver, there will be a loss.—C. B.

100. Pulsometer.—What is the reason for giving the upper portions of the condensing chambers their peculiar tapered form?—Shiny Boots.

104. Brass Furnace.—Will some experienced correspondent oblige querist with a rough dimensioned sketch of the most modern double-brass furnace suitable for say two 46lb. pots?—Mechanicus.

109. Balloon Motor.—Will some reader kindly give me particulars of the motor employed by the French officer who recently constructed a very large and elaborate balloon? Perhaps some reference to the description, if it has been published, can be given.—F. B.

117. Driving Ropes for Engines.—Would some of your readers be good enough to inform me what size of ropes, and how many, would be required for an engine 500 horse power? also what would be about the price of such an engine.—Improver.

119. Machine for Washing Mill and Furnace Ashes.—Can any reader refer me to makers and description of machinery for washing and cleaning the ashes from mill and puddling furnaces. Information will much oblige.—R. T. C.

127. Distilled Water.—I require 20 gallons of distilled water in 10 hours. I propose to obtain this by means of a coil in a cylinder 1ft. 6in. diameter, and 4ft. high. Please show how I can find the size and length of coil to be used, and how much cold water must be admitted in cylinder. Pressure of steam in coil to be condensed, 40lb. Assistance with above will be greatly esteemed.—Doubtful.

128. Compression and Release in Engines.—How is the required amount of compression in a steam engine determined, and at what part of the stroke should release commence? An answer will much oblige.—A Beginner.

PATENTS AND INVENTORS' QUERIES.

18. Right of English Patentee to Foreign Patents.—If I patent the article in England alone, could any other person, unauthorised by me, secure a patent on the Continent or America?—D. A., Manchester.

Answer.—If you apply for provisional protection in this country, you have seven months' priority in all countries in the International Patent Union—that is, if you apply for a patent in any of those countries within seven months of the date of your English provisional, your foreign application will be dated the same as your English one. France is in the union, but not Germany. In Germany, the first importer of an invention not published abroad can get a patent. In America, you are allowed two years from the date of your English patent in which to apply for an American patent. If you do not apply within that time, your invention cannot be patented in America, but becomes public property there.

19. Rights under Prior Application.—Would a prior application for a patent for a similar article, though different and inferior in construction, annul my claim? and would my claim annul the prior application?—D. A., Manchester.

Answer.—It depends entirely upon the degree of similarity between the inventions. You cannot patent what is already known by prior specification, and no subsequent specification can be said to annul a previous one. In an unsuccessful invention there is always something wanting, which, if supplied in a later invention, naturally makes a good patent.

20. S. G. D. G. in French Patents.—Can you tell me what S. G. D. G., after the word Breveté (=Patented), means in France?—Valve Gear, Cheltenham.

Answer.—S. G. D. G. is the contraction for *Sans garantie du Gouvernement* (Without the guarantee of the Government), which indicates to the French public that a patent is held entirely at the patentee's risk, and is not necessarily valid.

TO CORRESPONDENTS.

Collapse, Parkhead.—All official publications, such as "Reports on Boiler Explosions," &c., are printed and published by Messrs. Eyre and Spottiswoode, the Queen's printers, East Harding Street, Fleet Street, London, E.C., from whom all such publications may be purchased.

MISCELLANEA.

Electric Lighting at West Bromwich.—The Gas Committee of the West Bromwich Corporation will recommend to the council, at a special meeting, to resolve that an application be made to the Board of Trade for a license or provisional order authorising the local authority for the borough of West Bromwich to supply electricity under the Electric Lighting Acts.

H.M.S. Victoria.—The official gun trials of the new first-class armour-plated battleship Victoria, recently built at Elswick at a cost of over £800,000, were commenced in the North Sea the other day. The Victoria is equipped with two 110-ton breech-loading guns, one 10in. and ten 6in. breech-loading guns, and 21 quick-firing guns. The Victoria is to be commissioned shortly as flagship of the Mediterranean fleet.

Long Rails.—An American paper from Philadelphia states that at a noted steelworks rails are being made 60 feet long for the Pennsylvania railway. This is about double the usual length; and it is quite probable that it may be economical. But the Americans would do well to lay down heavier sections of rails, such as the weights that the Midland, the North-Eastern, and the London and North-Western lines use in this country.

Disaster at a Gas Exhibition.—A New York telegram states that a remarkable disaster took place at Jerome, Indiana, on Tuesday, Oct. 8th. The proprietors of a natural gas well had invited a number of engineers, journalists, and others to witness an exhibition of their works, and when the company were assembled a pipe became displaced, causing a huge flame to shoot among the people. Two persons were burned to death. Several others were fearfully injured, and in the panic which ensued many were crushed and maimed.

A Compound Engine in a Strange Land.—An English locomotive has been running for a month on the Pennsylvania Railway. It was sent there to demonstrate the value of the "compound" principle in the locomotive. One of the chief papers of New York, the *Sun*, describes this locomotive as doing splendid work, but adds that "its attachments are clumsier and less convenient" than those of the American engine. Seeing that the English locomotive has gone over 3,000 miles from home, its "attachment" thereto should not be so strong. But there was a time when English engines were not such strangers to American lines.

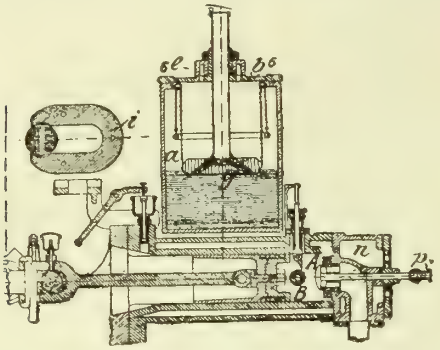
Conference of Miners.—The National Conference of Miners, which was adjourned from Manchester, was resumed in Birmingham on October 8th. Amongst the delegates were Messrs. B. Pickard, M.P., T. Burt, M.P., C. Fenwick, M.P., and W. Crawford, M.P. Delegates were present from Lancashire, Yorkshire, Derbyshire, the Midland Counties Federation, South Derbyshire, Warwickshire, Monmouthshire, Old Hill, Cumberland, Leicestershire, the Forest of Dean, Somerset, and Bristol, representing in all 227,500 men. At the Manchester conference a committee was appointed to obtain levies from the various districts represented and to pay money to men who might be on strike for higher wages. The conference was adjourned to see how far the 10 per cent. increase promised by the employers would be paid. It was reported that £12,480 16s. 11d. had been received towards the strike fund, and that £11,870 6s. 6d. had been paid to men on strike in Somerset, Lancashire, Yorkshire, North Staffordshire, and Derbyshire since July.

Storage of Petroleum.—At a meeting on October 8th of the Birmingham Watch Committee a discussion arose on the conditions under which inflammable oils were stored in various parts of the borough. It was stated that there were a great number of places in Birmingham altogether unsuitable for its storage which were nevertheless utilised for that purpose, and consequently became extremely dangerous. The Petroleum Acts, 1881 and 1889, only applied to a product or any other spirit giving off an inflammable vapour at less than 78 deg. Fah. There were eighty shops licensed to keep the product of petroleum known as benzoline, all of which were kept in compliance with the above Acts. But any quantity of the common petroleum or lamp oil can be stored provided it is only one degree above the specified flashing point. Inquiries had disclosed the fact that there were, in addition to the large stores, over 600 premises in the city where common petroleum was sold. Of these the committee had visited 97, and found about 13,000 gallons of common petroleum stored. Several of these dealers were also licensed for the sale of benzoline, from 2,000 to 10,000 gallons being on the premises. In very many instances the premises were unsuitable for the keeping of this inflammable oil, as most of them were also occupied as dwellings, with six, eight, or ten in the family. In one place a can of oil was placed by the fireside, and was poured out by a little girl. As regards large stores, one dealer was licensed to keep 10,000 gallons of benzoline in store, and in an adjoining one he had 33,000 gallons of common petroleum. The committee found that in some instances the fire insurance officials had restricted the quantity of oil kept within the building, and they were of opinion that these officials might, with a little extra supervision as to the quantity of oil and to the storing of goods and general cleanliness, be the means of greatly reducing the risk from fires in such shops and stores. The committee recommended that the attention of the Home Secretary should be called to the matter in the report.

ILLUSTRATED PATENTS.

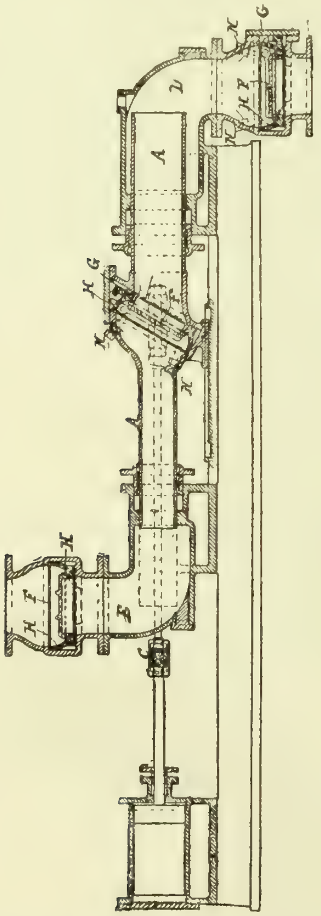
6088. Gas Engines. W. P. Thompson, Liverpool. (*E. A. Durand, 43, Rue de Turbigo, Paris.*)

Carburetter.—In the hydrocarbon reservoir *a* a balanced float *g* of cork floats on the top of the liquid ; the float carries the air-supply pipe *d* which slides through the cover *b*, and terminates in the float in a layer of iron shavings supported on a perforated metal plate. The air after passing through the shavings and liquid is drawn off through the port *e* in the cover. The exhaust hot air or hot water may be passed through a coil in the hydrocarbon. *Igniting.*—There are in the cylinder two electric terminals consisting of an adjustable point and a toothed wheel B; at the period of ignition the wheel is rotated against the point by ratchet gearing. The electric current is generated by a magneto-electro machine *i*. *Valves.*—To clean the exhaust valve the end of the spindle is provided with a milled head *p* that it may be easily turned on its seat. It is opened by cam mechanism and closed by a spring. *Heating air supply.*—The air enters the motor through the chamber *n* surrounding the exhaust valve and pipe.—April 28, 1888. [11½d.]



6249. Pump Valves and Valve Boxes. J. C. R. Okes, London.

These are specially adapted for use in pumping sludge or other thick fluids. The valves are hinged or otherwise mounted on cup-shaped plates provided with seatings, and are inserted through holes in the valve boxes, so that by removing the covers that close the said openings the valve plate with its valve can be readily withdrawn for repairs, &c. The drawing shows a direct-acting steam pump fitted with such valves. The hollow plunger A works in the casings D, E, and is reciprocated by rods from the cross-bar C. The valves F are hinged to the plates H inserted through openings G in the valve boxes. These plates are pressed down on to seats by set bolts N, or they may be bevelled at their forward end so as to fit under lugs in the chamber and be tightened by end set-bolts.—April 27, 1888. [8½d.]



6146. Valves. A. Delton, Usine de la Madeleine, France.

Relates to plug cocks, and to piston and sluice valves, and consists in means for preventing jamming. Fig. 1 shows the application to a plug cock. The shell is lined with a vertically divided sleeve B which is prevented from turning by a stop. The outside of the sleeve is taper while the inside next the plug C is cylindrical. The shell is bored taper to fit the outside of the sleeve. The plug can thus be tightened or loosened by raising or lowering it. Cylindrical piston valves may be similarly fitted. Fig 2 shows the application to a sluice valve. One seat, or both as shown, are faced with wedged-shaped plates *d* attached loosely to the seats by studs *l*. The backs of the plates are taper while their faces are parallel. The valve has facing plates *h* of superior metal, and is also fitted with projections *t*, *t* overlapping the wedged-shaped plates *d*, which are thus jammed between the valve and the casing when the valve is lowered. The valve is actuated by a screw spindle *g*.—April 25, 1888. [11½d.]

FIG 1

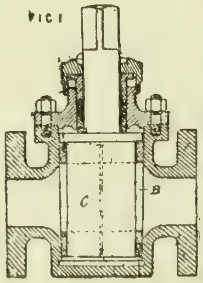
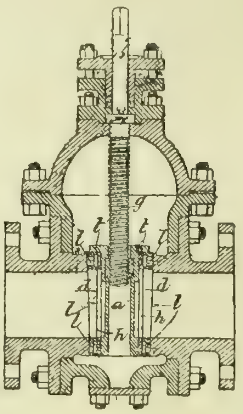


FIG. 2



Copies of these specifications may be obtained on application to H. Reader Lack, Esq. *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

September 30th.

15315 Rotary Engines, W. N. Hutchinson, Eastbourne.*
15321 Friction Clutch, P. V. McMahon, Waterford.
15345 Spanner, G. W. Bird, London.
15351 Metal Tubes, W. P. Thompson, Liverpool. (W. Schroeder and P. Boecker, jun., Westphalia.)*
15356 Steam Generators, B. Willcox, London. (J. Belleville, France.)*
15364 Wheels, T. Birks, London.
15370 Micrometers, W. R. Lake, London. (L. S. Starrett, United States,)
15372 Metal Bars, G. Brisker, London.*
15375 Tram-car Starters, J. W. Howe and H. J. Jordan, London.

October 1st.

15376 Motors, A. McFarland, London.*
15387 Electrotyping, Ernest de Pass, London. (C. Juncker, France.)
15417 Driving Cranks, J. F. Fleat and F. W. Cleveland, London.
15421 Water Gas, H. G. F. de Beaumont, London.
15426 Gas, M. A. Morse, London.*
15428 Welding Metals, T. F. Rowland, London.*
15429 Cylinders, T. F. Rowland, London.*
15431 Valves, C. Vogel, London.
15432 Condensers, R. Marsden and J. Pickard London.
15437 Air Brakes, P. Jenson, London. (H. J. Ubert, United States.)*
15443 Axle Bearings, G. F. Simonds, London.
15449 Electrical Cables, W. T. Glover, London.

October 2nd.

15456 Sawing Machines, J. Hill and I. Hill, Derby.
15458 Spanners, C. A. Miller and F. J. Miller, Birmingham.
15460 Injectors, J. Hall, Manchester.
15465 Furnaces, D. Rennie, Glasgow.
15468 Girders, C. Auty, London.
15469 Steam Engines, W. Wilson and F. J. Burrell, London.
15473 Lubricator, J. F. Hall and J. Verity, London.
15489 Electricity Meters, F. Teague, London.*
15495 Oil Can, F. Bèlohlawek, London.*

October 3rd.

15503 Pistons, G. Herrod, Sheffield
15508 Fire Detector, M. Dickinson, Manchester
15515 Railway Keys, H. K. Bamber, Abergavenny, Monmouthshire
15516 Crank Shafts, C. Thompson, Newcastle-upon-Tyne
15519 Stuffing Boxes, W. Harcliffe, Manchester
15536 Winding Engines, J. Wild, Oldham
15538 Screw, E. C. Wren, London
15548 Measuring Liquids, J. J. Tylor, London.
15549 Metallic Linings, J. Chaudron, London*
15552 Furnaces, T. H. Roberts and T. Underhill, London
15566 Tram Cars, C. Pilcher, London

October 4th.

15567 Propelling Vehicles by Electricity, J. Kincaid, E. Manville, and J. E. Waller, London
15570 Jacks, S. Fallows, and G. Haworth, Halifax.

The Practical Engineer,

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

NOVEMBER 1ST, 1889.

ON SOME CAUSES LIMITING USEFUL EXPANSION IN STEAM ENGINES.

AMONG many practical engineers the idea is quite common that the greater the ratio of expansion in any steam engine and the lower the terminal pressure in a cylinder, the greater is the economy attained. Engineers constantly engaged in testing steam engines, and the larger firms and their leading draughtsmen, know full well, of course, that this idea is incorrect—that, in fact, we can have too much of a good thing, and lose heavily in economy by expanding too much, as well as by expanding too little.

We well remember a young engineer—a man of great intelligence but insufficient experience—producing with pride a diagram for our inspection, in which the expansion line fell to the atmospheric pressure at the end of the stroke. He had designed a very simple form of automatic variable cut-off gear, and he said that now he had done all that could be done to make a non-condensing engine economical, he had exhausted all the energy the steam had to give. As he also seemed under the impression that this diagram expanding to atmospheric pressure indicated the most economical load under which the engine could work, we pointed out to him that this by no means followed. We know the reasons are simple and easily understood, but the combination of circumstances renders the problem a difficult one, and it will be interesting to go over them carefully.

If a mass or volume of steam could be introduced into a cylinder at full boiler pressure, doing work upon the piston without condensing or losing any heat to the enclosing surfaces, and then expanded to the atmospheric line, also without loss of heat to the surfaces, then it is quite true that the greatest economy possible would coincide with complete expansion. But as in all steam engines there is a considerable initial condensation as the steam enters the cylinder, and a very great part of this loss occurs at the very beginning of the stroke, it follows that in every type of engine there is a point of cut-off at which the engine will give the greatest indicated power for the least consumption of steam; that is, for every steam engine there is an indicated power which will give the best possible result in economical steam consumption. If the engine be worked at a higher power than this, the steam, and therefore fuel, consumption will be greater per indicated horse power per hour; and if it be worked at a lower power, the consumption will also be higher per indicated horse power. It is not our purpose to point out here the best ratio of expansion for different types of engine, because that ratio varies with the steam pressure used, the type of engine, number of cylinders, and the dimensions and proportions of the cylinders.

As the conditions are somewhat numerous, we shall first discuss shortly the causes which act in a non-compound engine tending to limit the useful ratio of expansion. In such an engine, if the cylinder, piston, and cylinder cover temperature could be maintained at the full temperature of the steam at its highest pressure, then when the steam enters the cylinder at the beginning of its stroke, it is evident that there is no reason why it should lose heat, and therefore it would not condense at all. The cylinder cover and piston, however, cannot be kept up to the same temperature as the steam by any usual means, because at the end of each stroke the surfaces are in contact with the exhaust steam, which is necessarily colder than the live steam. This is especially true of the piston, for while high-pressure steam is being admitted on one side commencing the stroke, the other side is in contact with the cold exhaust steam, and remains in contact with it during the whole effective stroke. At the end of the stroke the working steam has been considerably reduced in temperature and pressure by expansion, and the surfaces in contact with it have been cooled down. Meanwhile, the exhaust steam being discharged has been steadily cooling the surfaces in contact with it, and until the exhaust closes, and compression commences, it has been abstracting heat, and the cylinder cover and piston are nearly at their coolest just at the time when live high-pressure steam is to be admitted to perform the return stroke.

The first work the steam must do on entering is to raise the pressure in the steam port and clearance to the highest point, and in doing this it is resisted by the cooling action of the port walls, the piston, and the cylinder cover. Condensation goes on very rapidly at first, till the surfaces are raised in temperature, the greater part of the loss occurring during the earliest portion of admission of steam. When the piston has moved on a little, the temperature of the surfaces has increased enough to reduce the rate, and probably in many engines, when the piston has arrived at the point of cut-off, condensation has nearly ceased. In such a cylinder, it is evident that the greater the expansion the lower is the temperature of the exhaust, and where a condenser is used the range of temperature due to expansion is very considerable. Whether the expansion is great or small, however, the internal surfaces of steam cylinders strongly tend to take a temperature equal to that which water takes when boiled at the lowest pressure of the exhaust, for another reason. The condensed water produced at the early part of the stroke is nearly, if not quite, as hot as the high-pressure steam, and it remains in the cylinder during the stroke. As pressure falls, due to expansion doing work, part of this water re-evaporates, but as the steam cools whilst doing work, it liquefies partly. This is not due to loss of heat by contact, but to change of heat into work, and it cannot be considered a loss at all. As the piston approaches the end of its stroke, the liquid evaporates again, and in the later parts of its stroke the expansion line may be almost isothermal or hyperbolic. Some water, however, remains in the cylinder, and whenever the release occurs, and allows the pressure to fall to atmosphere, then the water boils, and it at once reduces the temperature of the metal with which it is in immediate contact to 212 deg. Fah., or, if the engine be condensing, to a temperature corresponding to the vacuum. In an expansion engine, then, of the simple type, increased expansion and condensation tend to increase loss by cylinder condensation.

Before it could be said, therefore, with regard to any particular engine, that a greater expansion or earlier cut-off would give greater economy, we require to know whether in that particular engine the point of cut-off already adopted is such that an earlier cut-off would increase the cylinder condensation to a greater extent than it increased the power produced by expansion.

When a cylinder is efficiently jacketed with live steam, then the range of change of temperature of the cylinder walls can be greatly limited, but this interferes but little with the temperature of the piston, which is almost as exposed as before to the cold exhaust steam. As the piston forms a large part of the cooling surface at the beginning of admission, less condensation occurs when it is as small as possible. Simple, or non-compound engines, are, therefore, most economical when the stroke is long in proportion to the diameter, and that proportion is best which exposes the least possible cooling surface in comparison with the volume or weight of steam enclosed. Take, for example, two steam cylinders: in one the point of cut-off is so proportioned that the length of space traversed by the piston to the cut-off is equal to one-half of the diameter of the cylinder; take the total surface of the enclosing walls, neglecting port and clearance, as 100, then the surface exposed by the piston would be 25, and the cylinder cover also 25, while the circumference would expose 50. Suppose now that the same volume of steam be contained in a cylinder double the diameter. As double diameter gives four times the area, the point of cut-off would be one-fourth of the distance moved by the piston in the first cylinder, or one-eighth of the diameter of the second cylinder. The united surface of piston, cover, and cylinder circumference would now be 225 against 100, or 2¼ times that of the former, and as the piston surface would be 100, the cylinder cover surface 100, and the circumference of the cylinder only 25 when the whole volume of steam was admitted, it follows that not only is the surface to which the high-pressure steam is exposed two and a quarter times greater than that of the first cylinder we have supposed, but the piston itself exposes 100 area, almost one-half. As it cannot be heated by steam jacketing, it follows that initial condensation would be much greater in this cylinder. Taking cylinders of equal capacity, then, with the same ratio of expansion, a cylinder of large diameter and short stroke exposes more cooling surface to high-pressure steam than a cylinder of small diameter and long stroke. For simple expansion engines, then, it is better that the stroke should be long in proportion to the diameter, and this is actually the case in good practice. Sometimes high speed of rotation is advocated as a means of minimising condensation, by giving the steam less time of contact; but as the greater condensation is sure to occur before the piston has moved an appreciable part of its stroke, and there are practical difficulties, it is better to proportion cylinders for the least possible cooling surface.

The compound and triple-expansion systems allow of a favourable proportion of cooling surfaces for the high-pressure steam, as the high-pressure cylinders are comparatively small, and the length of the space containing the steam at the moment of cut-off is relatively great. This is probably quite as much the cause of the superior results obtained from the engines as the lessened range of temperature occurring within each cylinder. The two factors combine to realise in practice the economy to be expected from the use of high-pressure steam. Increase in pressure beyond a certain point in any particular non-compound engine will only result in an increased loss by initial condensation, which more than compensates for the increase in power due to expanding more. The great advantage in the compound and triple-expansion systems consists in the fact that the proportion of initial condensation is not increased, and sometimes it is diminished, even with the use of higher pressure steam.

In conclusion, then, there is a point of cut-off and steam pressure in every individual engine—simple, compound, or triple expansion—for a given piston speed, at which the engine will give its best results. This point of cut-off will be earlier—that is, the best ratio of expansion will be greater—the higher is the steam pressure used, the greater the dimensions of the engine, and the higher the piston speed.

PROPOSED NATIONAL MEMORIAL TO DR. JOULE.

At a meeting of the Council of the Royal Society, held on Thursday, the 24th inst., it was unanimously resolved to appoint a committee to consider the erection of a national monument to the late Dr. Joule.

In a letter to the *Times*, Sir Henry Roscoe states that "It is only proper that the Royal Society, representing, as it does, British science at once in its highest and evident form, should take the initiative in promoting the national recognition of one whose services to science and to mankind are conceded by all scientific men to be only second to those rendered by Newton himself."

With this proposal we are in complete accord, and as engineers, and more especially steam engineers, are under a deep debt of gratitude for the knowledge given them by Dr. Joule, we hope that practical engineers will respond to any call which may be made upon them to further this end.

MILFORD HAVEN AND ATLANTIC LINERS.

The Anchor liner City of Rome arrived in Milford Haven last week, and landed passengers for London and other parts of England. This is the first call made in an attempt to further shorten the journey between this country and America. Although the swift liners, such as the City of Paris, City of New York, Umbria, and Etruria, now make the run from Sandy Hook to Roches Point within six days, yet considerable delay still occurs at Queenstown, and often some delay on entering the Mersey. Milford Haven can be safely entered in all weathers and at all times, and the dock of twenty acres in extent, and having from 34ft. to 37ft. depth of water, can be entered at once at high tide, and, with slight delay, by lock at any other state of the tide. The lock is 450ft. long, and so can accommodate large vessels. If the passage from New York direct to Milford Haven could be accomplished in six days, as is hoped, then passengers could be landed in London in six days six hours from New York, a saving of time of some eighteen to twenty-four hours. Milford Haven has often been referred to as a possible rival to Liverpool for the Atlantic passenger traffic, but the attempts to realise the idea have hitherto been failures. This new attempt is enterprising and energetic, and it is hoped success may attend it. The railway terminus and all arrangements are carried out in the most complete manner, a special train being provided by the Great Western Company to travel to London at the rate of 46 miles per hour.

STEAM PIPE EXPLOSION ON A CUNARD LINER.

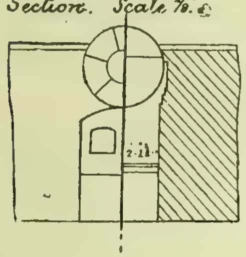
THE Cunard steamer Cephalonia, which left the Mersey on Thursday morning, the 24th inst., put into Holyhead the same evening, owing to a serious explosion in the engine-room. It appears that one of the steam pipes in the engine-room burst and seriously injured five men, four of whom have since died. These steam pipe explosions are becoming far too common, and something should be done at once to make them more reliable. The somewhat crude process of brazing copper pipes depends so much on the personal skill and care of the operator, and overheating leaves so little obvious trace, that with the high pressures now in use copper pipes must remain objects of considerable suspicion to those whose safety depends upon their soundness.

EXPLOSION OF TWO BOILERS AT DEAFHILL COLLIERY.

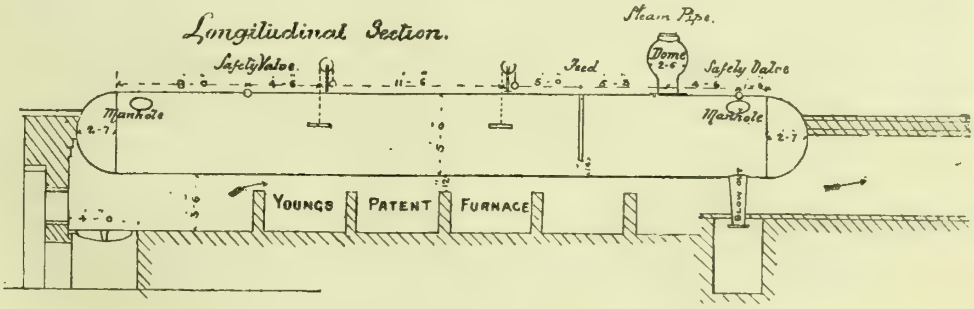
Two boilers at work at Deafhill Colliery, Trimdon, Durham, exploded on Saturday, September 21, of this year, and one man was killed. Mr. John Waugh, of the Yorkshire Boiler Insurance and Steam Users Co. Limited, has just issued his report upon this explosion, from which we extract the following leading particulars and illustration :--

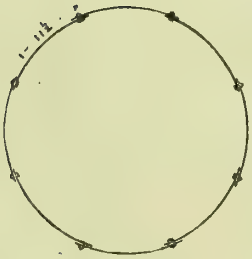
The two boilers which exploded were part of a group of four, all of the same type, build, and equipment, coupled together and used for the generation of steam for pumping and fan engines, the daily working pressure being 35lb. ; they were cylindrical, hemispherical-ended, and externally fired, and stated to have been made by Abbott, of Gateshead, in 1868. They were 45ft. 3in. over all in length, and 5ft. diameter, the original thickness of plates being ⅜in., single riveted throughout with 2in. pitch of rivets. The boilers are of peculiar construction, being composed of eight plates in circumference and eight plates in length, *the longitudinal seams being lengthway of the plate and in line the full length of the boiler*, the transverse seams breaking joint half a plate. It will thus be seen that the cylindrical parts of the boilers were composed of no less than sixty-four plates.

Half Elevation and Section. Scale ⅛".

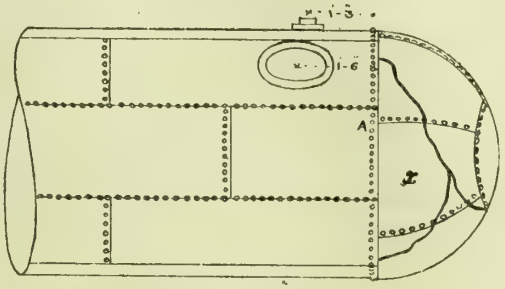


Longitudinal Section.

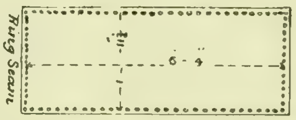




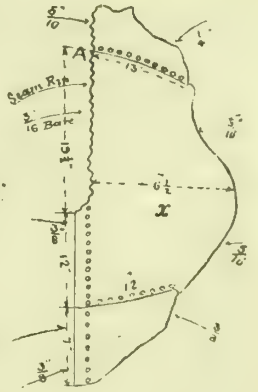
Section



Elevation showing position of primary rupture. Seam Rip through 7 Rivet-Holes at A.



Showing arrangement of Shell Plate to form the circle. Scale ⅜".



The boilers appear to have received every attention and fair usage, and the steam pressure was 33lb. or 34lb. immediately before the explosion.

Externally the plates directly over furnaces, owing no doubt to the lime deposits of the feed water, have been slightly buckled by over-heating and otherwise deteriorated ; in some cases plates have been renewed, and in others stop rivets have been put in to prevent extension of fractured rivet holes in both longitudinal and transverse seams. I could not find any signs of leakage about these seams ; otherwise the plates are in good order. Internally, the plates are corroded over whole plates of boilers for a good $\frac{1}{16}$in. deep for an area 6in. or 8in. broad. On the back end of No. 4, on the right-hand side within the above named area, the thickness of plate has been reduced to about ⅛in. over a limited area ; there is evidence that a seam rip has existed for a length of seven rivets in ring seam of lap of hemispherical end, just where the greatest reduction in the thickness of plates has taken place ; no sign of leakage is shown on fire side of this rip. There is not the slightest evidence that low water existed at the time of the explosion, and it is highly improbable that the eight weights on the safety-valve levers had all been moved to the end of the levers.

I am of opinion that the cause of the explosion is attributable in the first instance to the bad design of the boilers ; that is to say, if the boilers were made in 1868, the builder did not avail himself of the then knowledge of the art, but that he adopted a then antiquated and exploded mode of construction which may have been in vogue some 50 years ago. Instead of using the plates *circumferentially in the direction of the fibre*, he used them *crossway of the fibre*. I have taken several plates from the exploded boiler and tested them, and the average tensile strain of the plates so tested in the direction of the fibre is nearly 19 tons per square inch, whilst the tensile strain crossway of the grain is only 17 tons. What the qualities of the plates were when the boiler was built it is difficult to say, as there is no brand upon any of the plates. The tensile strain is very low, and below that of the lowest class of plate used for the construction of shells of boilers.

In conclusion, Mr. Waugh strongly recommends that owners of boilers built on the same principle should lose no time in having their boilers inspected and reported on, so as to avoid similar disasters.

ON Monday a boiler burst on board the French steamer Ville de Brest, in Tunis Bay. Four men were killed.

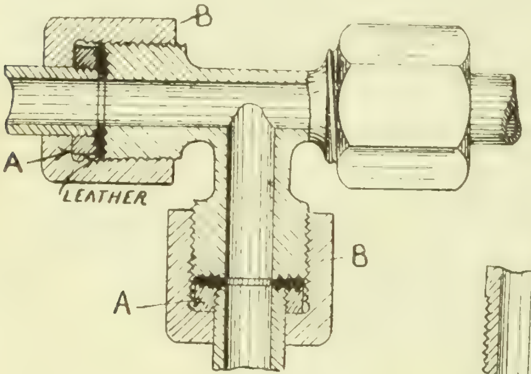
HYDRAULIC MACHINERY EMPLOYED IN THE CONCENTRATION AND TRANSMISSION OF POWER.—VIII.

CONNECTIONS.

In our last article, which appeared some few months since (see page 358), we treated of the manner in which the ordinary cast-iron pipe joint for hydraulic service supply is made, and we there gave full particulars of the principles involved in proportioning all areas for this purpose. In the present article we wish to advance somewhat in the same direction, and so complete the systems of connecting pipes other than those provided with cast flanges. It is not always possible or convenient to arrange cast-iron mains or conduits for conveying the hydraulic pressure, in which case it is desirable to be able to attach, at any required position upon the pipe employed, a means of connecting one portion with another, or of attaching a branch to the main supply.

Pipes of wrought iron, steel, or copper, under 3in. diameter, may be very readily jointed together for low pressures by means of a right and left hand screw coupling socket nut, which draws the ends together into metallic contact; the end of one pipe being turned truly flat, and the other to a truly sharp edge, as shown in fig. 37. The objection to this mode of coupling arises from the difficulty experienced in releasing the pipes, it being impossible to undo the joints unless the pipes have room to separate when the nut is unscrewed, which, in many cases, would be quite impracticable.

FIG. 38.



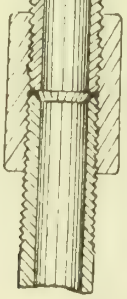


FIG. 37.

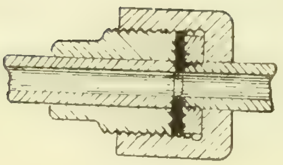


FIG. 39.

The more common, although more costly, method of jointing wrought-iron pipes is illustrated at fig. 38.

The end of one pipe is screwed to receive a collar A, and before this collar is placed upon the screwed portion a nut B is passed over the pipe, so that the nut is then made, as it were, a part of the pipe. The end of the junction piece, or T-piece, is also similarly screwed, and a leather washer is inserted between the ends, as shown. The connection of copper pipes is usually effected by the method illustrated at fig. 39, the socket being brazed on to one and the flange brazed on to the other end.

Having now examined the various methods by which the water under pressure is to be conveyed to any desired position, and having examined the systems for securing the joints of any machine against leakage, whether the pressure be a high or a moderate one, it is an easy transition from hydraulic pressure pipes, or conveyers of power, to hydraulic pressure machines, or transmitters of power. We imagine that probably no machine or appliance is more commonly used, but at the same time more misunderstood, than the ordinary hydraulic lifting jack.

We will not, however, again illustrate the usual section of jack, as this has been done in a previous number of *The Practical Engineer.* The hydraulic jack, fig. 40, we show with the improved lowering arrangement, first introduced, we believe, by Mr. Butters, M.I.C.E., of the Royal Arsenal, Woolwich.

The hydraulic jack is in reality a hydraulic press combined with a hydraulic pump, so as to form a compact and portable forcing machine; and having in the one appliance a combination of the prime mover and pump, we are afforded an opportunity of describing both the elements of the hydraulic press and the hydraulic pump in one common illustration.

The foot or ram *a* of the jack consists of a plunger, 2in. in diameter, working preferably in a steel cylinder A, the upper portion of the cylinder casting being rectangular, and forming a cistern for water and a chamber for the pump. The plunger or ram *a* is provided with a groove *b*, which works on a short feather or key *c* let into the cylinder body to prevent any turning motion. The top of the ram is covered, and has attached to it a cup leather *d* or cup of moulded indiarubber, ½in. deep, by means of which it is enabled to work quite water-tight within the cylinder. The pump plunger *e* is 1in. in diameter, and works in a small brass pump *f*, screwed into the upper part of the jack cylinder; it is packed with a leather ring or lace *g*, and is completely immersed in the water or liquid contained in the pump cistern or chamber *h*. Immediately beneath the pump plunger is a mitred valve *i*, opening downwards to allow the water to pass on the top of the ram; the spindle of this delivery valve projects a short distance up into the pump barrel. The inlet or suction valve *j* is placed horizontally on one side of the barrel, and has a passage *k* communicating from its inlet to the upper part of the barrel at such a point that when the plunger is at work its packing never descends below the orifice; but when the plunger is pressed down beneath its working stroke so as to touch the bottom of the barrel, and at the same time to force open the outlet valve, the orifice is above the packing and permits the water from the cylinder to escape past the plunger into the cistern, and by so doing causes the jack to lower its load. Thus, when it is desired to lower the load by the jack it is only necessary to depress the handle a little below the working limit. This, however, could not be done steadily if there was a great pressure of water in the pump barrel, so the plunger has a hole *l* bored up its centre and out at one side near the top above the packing; and near its lower end a valve chamber is made, in which is fitted a triangle-shaped spindle *m*, each end of which forms a conical valve, the upper end closing the upper opening in the chamber, and the lower end the lower opening, there being a slight play in the valve, so that both openings cannot be closed together. When the plunger is pushed down quickly, the inertia of the valve closes the upper orifice as the plunger descends, and thus prevents the water from passing up, while in the up-stroke the valve falls by its weight and closes the lower orifice, thus preventing the air from being drawn in. When it is desired to lower the jack, the handle is lowered gently, the little valve *m* remains down, or remains midway in its chamber in equilibrium, so that the water passes around it and escapes from within the pump barrel to the cistern, and the bottom of the plunger can then be brought quite gently on to the top of the outlet valve spindle *i*, which, when pressed down, allows the water from within the cylinder A and under the pressure of the load or ram head to escape through the pump plunger valve *i*, and through the side passage *k* into the cistern, and the jack can thereby be lowered as slowly as may be desired. The plunger is actuated by a short lever *n* fixed on a spindle *o*, one end of which passes out of the pump chamber or cistern through a stuffing-box and terminates in a square, on which the handle *p* for working the pump fits. This cistern is filled by means of the charging hole *r*.

The cover *u* of the jack is screwed on water-tight, but there is a small screw *s* in the side of the chamber, which requires to be slackened when the jack is at work, to allow of the air passing in and out. The ratio of power to resistance in the jack is 64 to 1.

The ram *a* being 2in. diameter and the pump plunger *e* only 1in., the areas are as 2^2 to 1^2, that is 4 to 1. The handle is 16 times longer than the lever working the pump plunger, so that the total gain is $16 \times 4 = 64$ to 1.

In an experiment made by Mr. W. Anderson (recently appointed inspector-general of ordnance factories), to estimate the loss by friction upon a similar jack, he found that to lift a load of 3,738lb. a pressure of 76lb. was required on the handle, which should have produced a lifting force of 64 × 76lb. = 4,864lb., instead of which, however, the load actually lifted was only 3,738lb.; so that the duty done was $\frac{3738}{4864} = \cdot 77$. An efficiency, therefore, of 77 per cent of the actual work spent upon the handle.

A second trial, with a load of 1,046lb., required a pressure of 22lb. on the handle to lift it, giving a duty of 74 per cent. To lift four tons, the load for which this jack is constructed, we shall require to exert a total effort of 8,690 ÷ ·77 = 11,636lb.; or, reducing this to the power actually to be put upon the handle, to produce this amount, we get 11,636 ÷ 64 (the total gain of leverage multiplied by ratio of areas) = 182lb. as the hand pressure necessary. This large amount would require the best efforts of two men to be given if the load of 4 tons is to be raised.

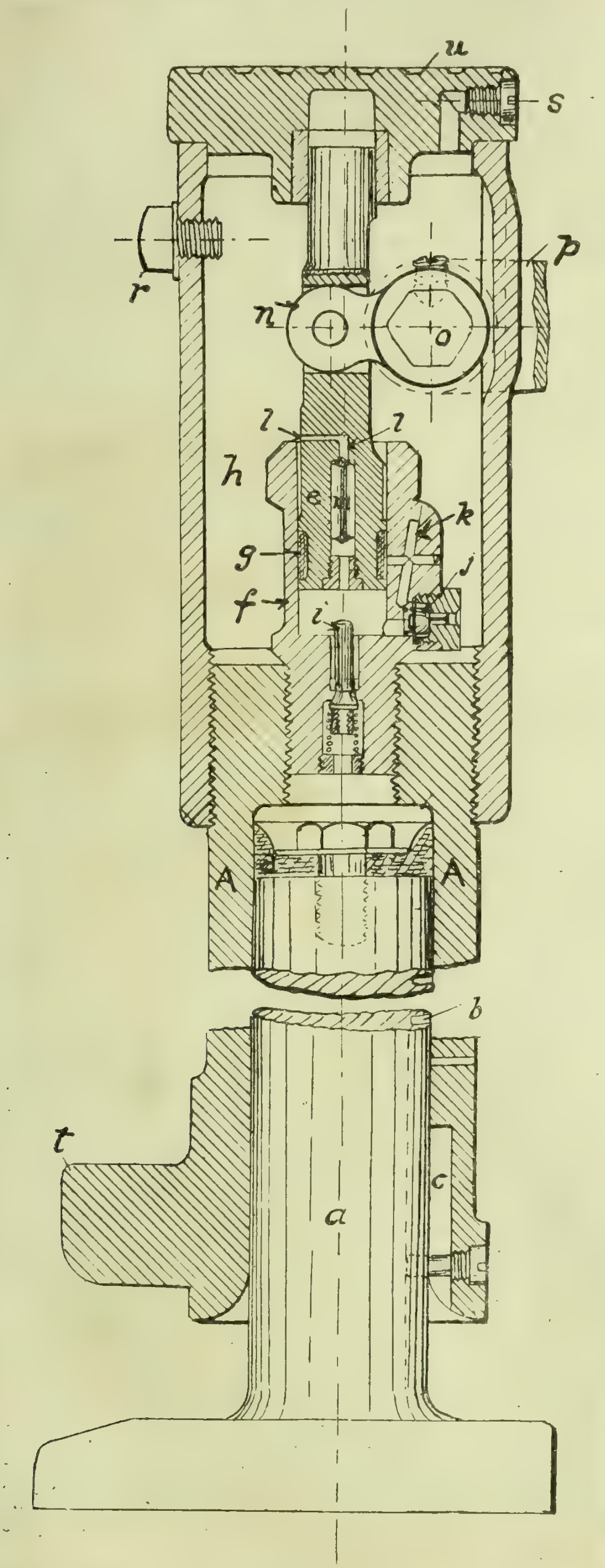


Fig. 40.

The jack is used with advantage either by employing the cover or head *u* of the cistern, which is roughened to act against the load to be raised; or, in cases where the load is low down, the projecting foot *t*, standing off from the bottom of the cylinder, is caused to engage with the load, and thereby to raise it. The power, then, of any hydraulic jack may be calculated as follows, where we assume the efficiency to be as determined above, viz., 77 per cent.

$$\frac{\text{Area of ram}}{\text{Area of pump}} \times \frac{\text{length of hand lever}}{\text{length of pump lever}} \times \text{power on handle} \times {}^{\cdot}77$$
$$= \text{load raised in pounds.}$$

The jack can be damaged by three principal strains, viz.: 1. The load to be raised by the head may crush the walls of the cistern attached to the jack cylinder. 2. The load to be raised may shear off the lifting foot at the base of the jack cylinder. 3. The load may be such that the pressure within the cylinder necessary to raise it may burst the walls of the cylinder. Now, the crushing strength of the metal usually employed—viz., malleable iron or cast steel—is so high that the limits of casting actually ensure that the walls will be strong enough to carry the load. We employ, say, cast steel, which will have an ultimate crushing strength of 40 tons per square inch, or malleable iron, which will have an ultimate strength of 35 tons per square inch; and wishing to make the cistern as light as possible for convenience in handling, we find we cannot get walls to be depended upon in castings which are less than $\frac{5}{16}$ of an inch in thickness. Thus, in the 4-ton jack, our cistern is 3½in. diameter, which gives us an area of $3{\cdot}5 \times 3{\cdot}1416 \times \frac{5}{16} = 3{\cdot}4$in., to carry the load of four tons. Other considerations, of course, come in with respect to the arrangement of the metal; but even then the limit of casting ensures us ample margin for safety in working. Similarly, too, the projecting foot, which may be sheared off, is subjected to such a light load in proportion to its ultimate strength, that we require to consider chiefly the rough usage which may be given to this projection, and arrange a substantial foot for this, rather than for the actual load to be legitimately lifted by it. The bursting strain in the cylinder, however, we estimate with more care, seeing that the strain is one of tension, instead of compression, and that our metal employed may not be equally strong in each case of straining. The diameter of the cylinder being 2in., we have a strain of $2 \times x$ pounds per square inch acting to burst the cylinder, while the metal resisting this bursting tendency is the thickness of the wall on each side; the value of x being that produced by the pump and lever. The load of 8,960lb. has to be raised by the pressure given to the 2in. ram. This amount we have calculated to be 11,636lb., and as the area of 2in. = 3·14in., the pressure per square inch becomes 11,636 ÷ 3·14 = 3,705lb. per square inch in cylinder; 3,705 × 2 = total bursting pressure within cylinder = 3·3 tons.

Assuming the metal to be of steel, moderately good, and with an ultimate tensile strength of 38 tons per square inch, with a factor of safety of 5, we may put 5½ tons per square inch upon the metal; so that the combined thickness of the walls of the cylinder should equal $\frac{3{\cdot}3}{5{\cdot}5} = {\cdot}6$ of an inch. This would make each wall ⅜in. thick, a dimension which might give trouble in casting in the event of the core shifting slightly, so that ½in. is allowed instead.

The ordinary hydraulic jack in common use is not fitted with this ingenious lowering device we have described, but a special passage connecting the ram cylinder with the cistern is closed by means of a screw-down stop valve or simple mitred screw, which seats itself upon the chamfer of the hole from the cylinder, so that the pressure is always beneath the mitred screw. The illustration, fig. 40, represents the standard pattern of four-ton hydraulic jack as used by the British Government, and all the details are correct to scale half full size.

Railways in China.—Huang-Pen-Sien, acting governor, as a correspondent says, of Shanghai, is a native of the province of Kuie-Chow, an interior province, where foreigners are rarely seen. He took his metropolitan degree in 1847, but he received no office of importance until 1883, when he was appointed judicial commissioner in Hupeh, where he might possibly come into contact with foreigners. This gentleman has determined to introduce railways into China. He does not wonder that Peking is opposed to railways, for when he himself was an official at the capital, foreign statements left no impression on him. It is only since he went to Soochow, and saw with his own eyes what a different world it was when Western ideas supervened, that he appreciated the value of railways at all.

DR. JOULE, THE DISCOVERER OF THE MECHANICAL EQUIVALENT OF HEAT.

(Concluded from page 733.)

Valuable as are Dr. Joule's labours in other departments of inquiry, it is on his researches on the dynamics of heat, and especially on his great experimental contribution to the establishment of the law of the conservation of energy—one of the grandest generalisations of modern times—that his fame will chiefly rest. Besides the papers in which he had a conjoint authorship, his own independent contributions to scientific literature, and to the publication of the learned societies are numerous and profound. Many of them relate to original and prolonged investigations extending over several years, and bear witness to the incessant and persevering labours of his life. The Physical Society of London have recently published an extremely interesting volume of his collected scientific papers, and in a prefatory "advertisement" the council of the society "desire to put on record their cordial appreciation of the kindness with which Dr. Joule not only agreed to their request to allow them to publish a collected edition of his scientific papers, but undertook personally the labour of getting together and editing the collection;" and also thanked the Council of the Philosophical Society of Manchester and others for the use of woodcuts for the purpose of illustration. A preface written by Dr. Joule himself states that the society requested to be allowed to publish the papers which have appeared in his own name, and also those in which he has been associated with the Rev. Dr. Scoresby, Sir Lyon Playfair, and Sir William Thomson. The latter has been published by the Physical Society in a second volume.

Though the results of his investigations are for all men and for all time, Dr. Joule was himself in no sense a public man. He undertook his studies with the determination of one who worked not for reward of position or fame, but for the love of the work itself; and unlike many of his eminent scientific contemporaries he has neither written popular treatises nor published any separate works on the subject of his various inquiries. He did, it is true, in addition to his papers read before various societies of learned men, occasionally deliver lectures in connection with one or other branches of his studies, in Manchester, but these rich scientific treats were of very infrequent occurrence. Though he sought neither honour nor reward for himself, honours were showered upon him in profusion, and that which was probably the greatest gratification to him was one in June, 1878, when her Majesty the Queen was pleased, in recognition of his services to the cause of science, to grant him a pension of £200 per annum. It was not for itself that he valued the pension, information of the granting of which was conveyed to him in a letter from the late Earl of Beaconsfield, but as a national recognition of his labours. We have already spoken of his receiving the Royal and Copley medals of the Royal Society, in themselves distinctions of the highest order. In 1880 he received at the hands of the Prince of Wales, the Albert medal of the Society of Arts, instituted in 1862 as a memorial to the late Prince Consort, to be bestowed annually for "distinguished merit in promoting arts, manufactures, or commerce." The medal was awarded to Dr. Joule "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science to industrial pursuits." The list of distinctions conferred upon Dr. Joule is a long and remarkable one.

Dr. Joule was a conscientious member of the Church of England. His views were moderate, the only point upon which he expressed himself strongly being when advocating free and open churches. He was a steady Conservative, and when he heard that Dr. Tyndall had joined the Unionists, he wrote a letter to the professor congratulating him upon the step he had taken, to which he received a reply which pleased him greatly.

In 1872 he was elected president of the British Association, which in that year held its meeting at Bradford, but before the meeting his health broke down and he was unable to attend and deliver the customary inaugural address. Since that date he has been almost entirely an invalid, quietly pursuing his studies as far as his health permitted at his residence at Sale. His wife died in 1854, after only seven years of married life, and leaving behind her a son and a daughter, both of whom are still living. Of Dr. Joule it may be truly said that he has passed away full of years and of honour, and that he has left behind him not only a legacy in the results of his labours, but a noble example to every one who comes after him to do with his might whatsoever his hand findeth to do.

THE BÜRGIN HIGH-SPEED ENGINE.

This is an interesting example of the single-acting type of high-speed engine, which presents some peculiarities special to itself. It is exhibited in the Swiss section of the Paris Exhibition, and is intended to solve the difficult problem of attaining perfect balancing in a high-speed reciprocating engine. The novel departure consists in the use of two pistons, working in a common cylinder, and so connected to the driving cranks that in all positions equal weights of pistons and rods are moving in opposite directions. There have been several attempts to balance by a somewhat similar construction, but this is the first arrangement of a single-acting engine with pistons moving in opposite directions of which we are aware. If we remember aright, Messrs. Lamberton, of Glasgow, exhibited an engine of the double-acting type, in which this desirable feature was ingeniously accomplished. Referring to our illustrations, fig. 1 is a vertical section through the length of the crank shaft, fig. 2 is a similar transverse section, and fig. 3 is a separate illustration of the piston valve and eccentric. The lower piston A, and the upper piston B, work in a long open cylinder C, common to both; and the lower piston connects to the centre crank pin G by the connecting rod D, while the upper piston is attached to a crosshead R, by a rod shown, which crosshead connects in turn to a sliding ring FF, fitting nicely on the machined exterior of the lower end of the long cylinder C. Connecting rods E, E^1 link this sliding ring to two crank pins, G^1, G^1, which are formed by bending, so that their centres fairly oppose the pin G, that is, the pins are separated on the crank circle by 180 deg., or half a circle. The construction of such a crank shaft requires care, to ensure the two pins G^1, G^1 being truly in line; and as space is highly important, the arrangement is somewhat unusual. However, we shall describe that point directly. Steam is admitted between the pistons by the port I, controlled by the piston valve H. In the position shown in fig. 1, the exhaust stroke has just been completed, and the steam is about to be admitted; the two pistons are thereby pushed apart, and the position at about half stroke is shown at fig. 2. When the stroke is completed, the exhaust is opened, and the pistons return to meet in the middle, as shown in fig. 1. By arranging the weights of the two pistons and their connections to be equal to each other, a most perfect balance is secured, and high speeds can be readily run with the greatest smoothness.

We are informed that this engine runs at 500 revolutions per minute without the smallest vibration. The piston valve H is actuated from the eccentric rod M, through the sleeve or hollow rod O, in which works the rod N, through a stuffing-gland driving the internal expansion valve P. The piston valve is therefore double, and consists of an internal and an external piston. The external serves as the ordinary main steam valve, while the internal serves as the expansion or cut-off valve. They are driven by separate eccentrics. The live steam is admitted by the pipe K, and passes through the interior of the piston valve by ports shown more clearly in fig. 3. The valve is single-acting, of course, as the engine is single-acting. The exhaust escapes at the proper time by the annular passage shown in the exterior of the main piston valve, and by the pipe L. The governor is of the throttle type, and is part of the inlet steam valve. The governor is driven by belt from the main shaft by the pulleys and intermediate shaft seen in fig. 1. The cranks G, G^1, G^1 are formed by bending, and are connected to the crank shaft by discs, made in halves and bolted together, as may be seen from figs. 1 and 2. The connecting rods are of special construction, and have springs, arranged as shown in fig. 1, to keep the brasses tight and prevent knock on the up-stroke. It is a common belief that pressure is always upon the crank pins of single-acting engines, because there is no driving effort from steam upon the idle stroke; but this is a mistake. During the first half of the idle stroke there is always pressure upon the crank pin, because the pin is doing work upon the piston and connecting rod, by causing their motion to be accelerated; but during the latter half of the stroke the piston is pulling on the crank pin, as the speed is slowing down. Unless the cushioning is very early and great, this cannot be avoided. By using springs, Mr. Bürgin insures that all slack shall be taken up, and this avoids shock when nearing the end of the stroke.

Mr. Bürgin's engine is constructed by the Société de Constructions Méchaniques, Bâle, and is well worth careful study as a most ingenious piece of mechanism, which possesses many good points. The whole design is neat and substantial, and quite worthy of the high reputation of the Swiss makers.

The possible maximum temperatures produced by the combustion of various fuels is often much overstated, and the usual method of calculating calorific intensity is rendered erroneous by omitting to consider dissociation and other causes of limit to temperature.

THE BÜRGIN HIGH-SPEED ENGINE.

(For description see page 746.)

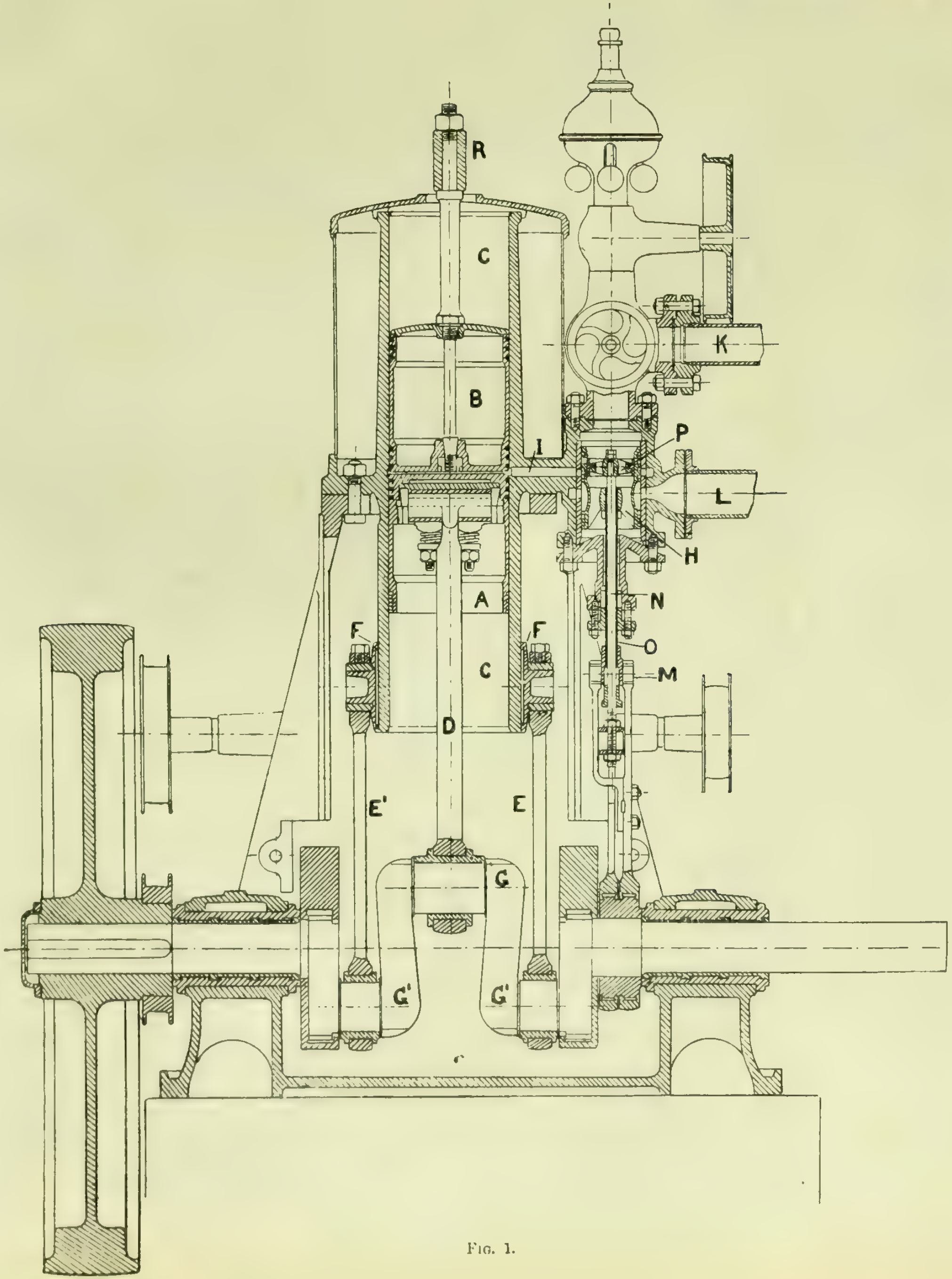


Fig. 1.

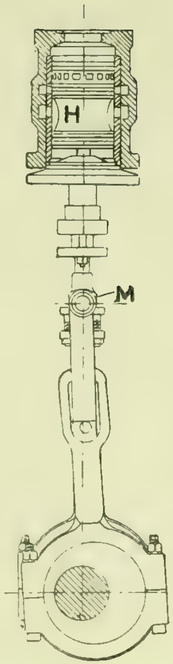


Fig. 3.

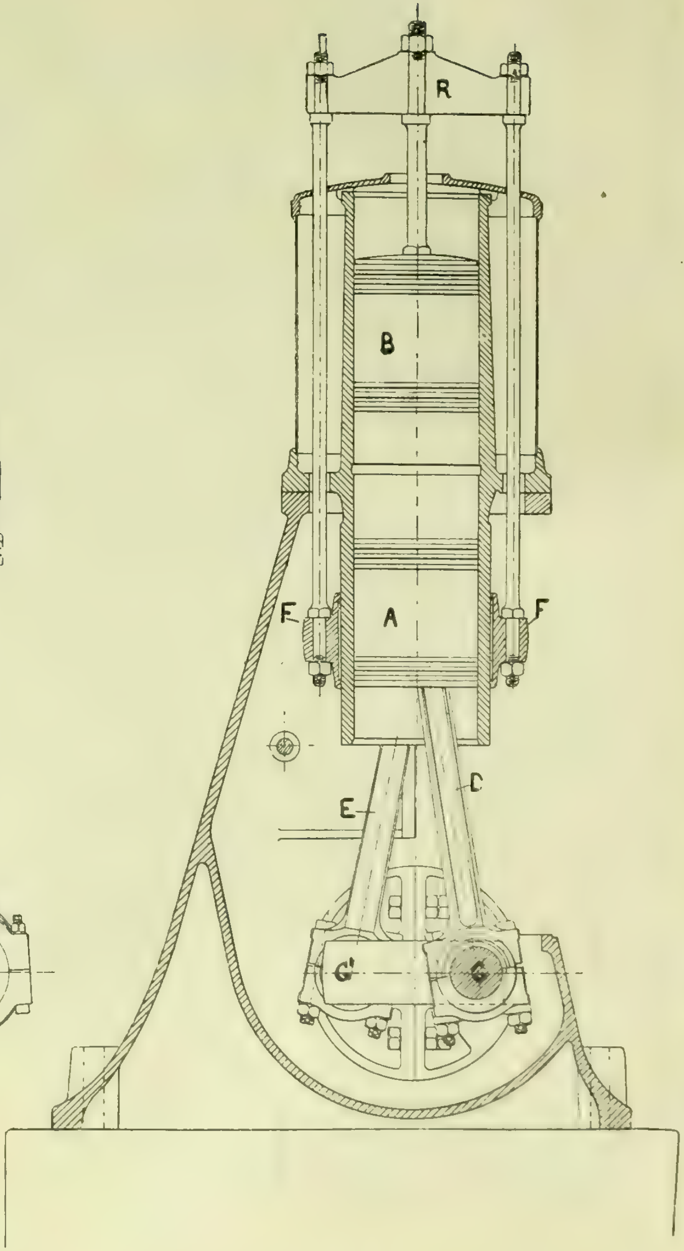
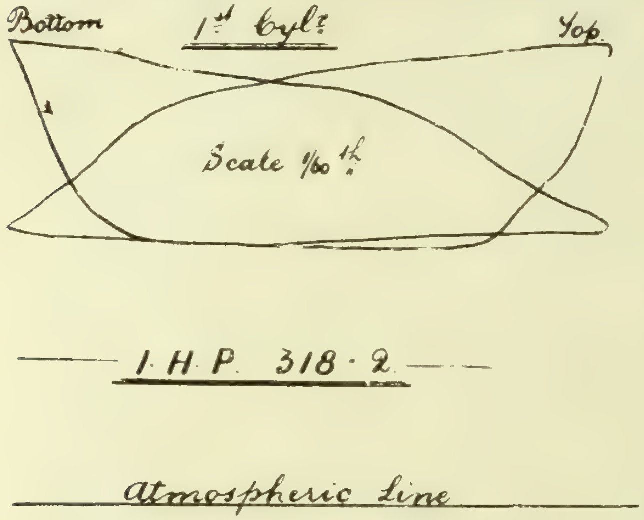
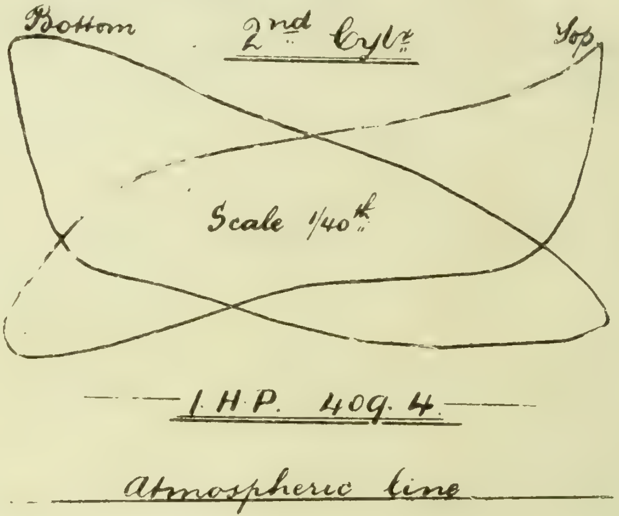


Fig. 2.

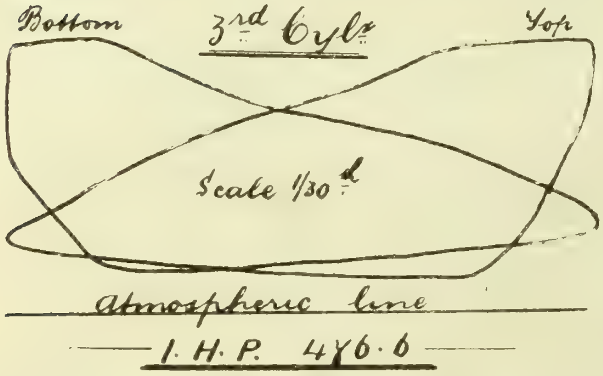
QUADRUPLE EXPANSION ENGINES OF THE STEAMSHIP SINGAPORE.

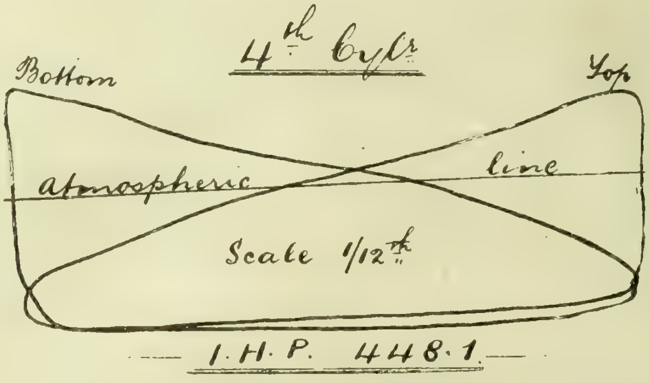
The great success of the triple-expansion over the compound engine for marine work has naturally caused engineers to endeavour to carry the principle further, and use quadruple expansion in order to obtain a still greater economy. The triple-expansion engine has been found by experience to give the best results in practice when the three cylinders drive three cranks side by side on the crank shaft, the greatly-increased uniformity of effort round the whole circle compensating for the slightly greater fore and aft length of the engine-room. The addition of another cylinder and crank in line on the crank shaft, however, would add too much to the space occupied by the engines, and the application of tandem cylinders implies serious inconveniences in ease of access to the various pistons and parts. The problem of getting a quadruple-expansion engine into a small space, and allowing a free access to the cylinders and pistons by simply removing the cylinder covers, without crowding together the other parts, has been most ingeniously solved by Messrs. Fleming and Ferguson, engineers, Paisley, in their design and construction of the engines of the steamship Singapore, which we illustrate on the opposite page.





Cylinders 24", 30", 40" & 60"



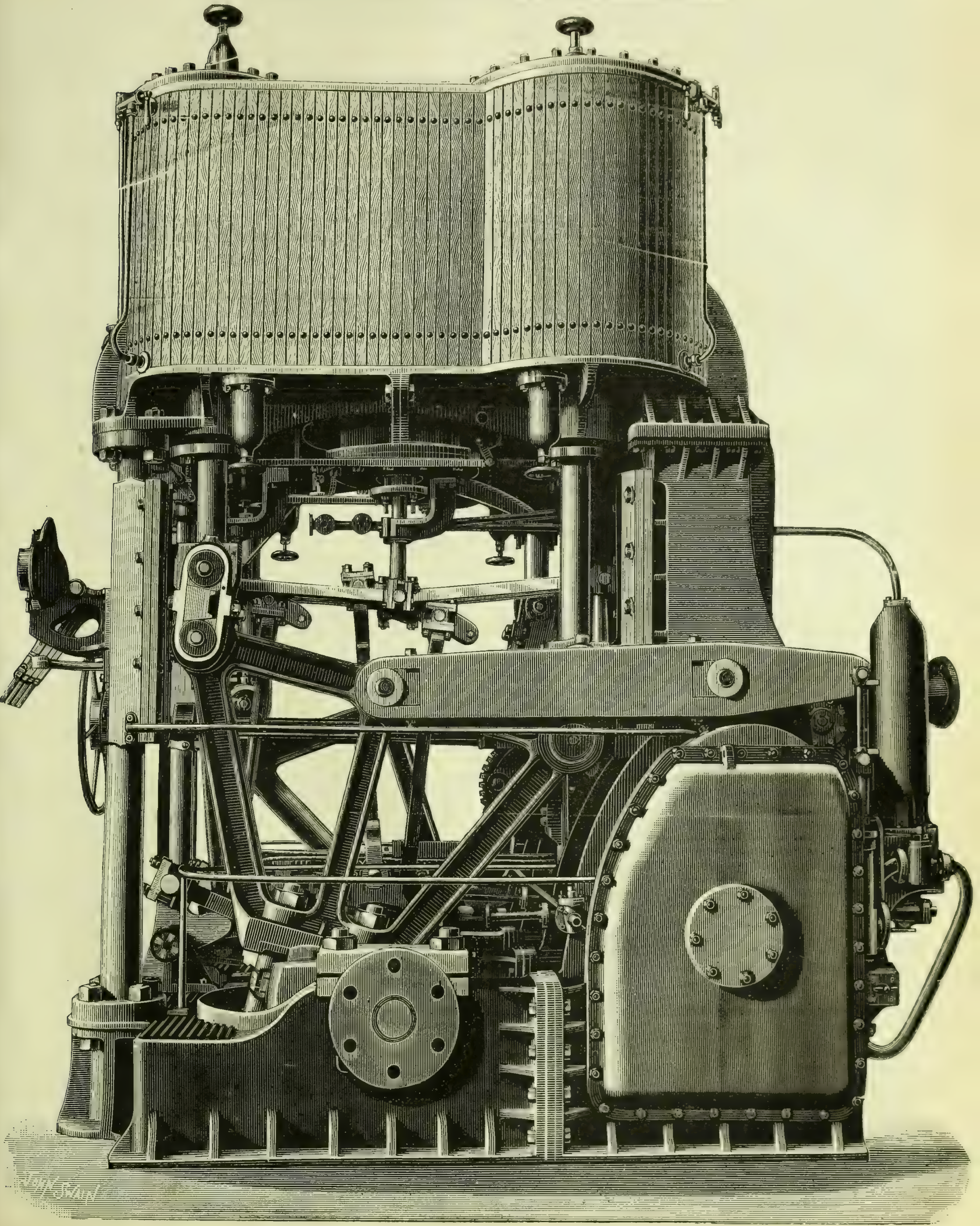


The engine, as will be seen, differs greatly from all usual types of steam-engine construction, and the departure recalls the Z crank engine of the late Sir C. W. Siemens, as well as that of Mr. Edmund Hunt. It does not in reality resemble these engines, but simply recalls them to our minds by the daring with which the designers brush aside all the preconceived notions regarding the connecting rods, which are almost sacred in the minds of the ordinary engineer. The four cylinders are all on the same level, and are grouped together, as shown in our illustration, above two cranks, being bolted to strong cast-iron columns on the condenser side, and by wrought-iron pillars to the bed plate on the other side. Each pair of cylinders actuate one crank, and the piston rods connect to the crank pin by a peculiar triangular connecting rod, which is formed of a strong steel casting. The upper-side of the triangular rod, or rather connecting frame, is sufficiently wide to pass from centre to centre of the cylinders across the vessel, and each upper corner connects to the piston rods by means of short strong links. As the piston rod is constrained to follow a straight path by the crosshead and slide, it is evident that the triangular connecting frame must have its path constrained in some other way, as otherwise there is nothing to prevent the ends being brought in contact with guiding surfaces on either side, depending on the direction of side thrust at the moment. To give the necessary constrained path a side lever is applied, as shown, and its end is connected to the middle point of the connecting frame or rod, so that, at that point, the frame must vibrate in the arc formed by the movement of the end of the lever, above the centre of the crank shaft. As the lever is relatively long, the versed sine of this arc is not great, and the central point of the upper side of the triangular connecting frame moves in a line which deviates but slightly from a straight line.

At the first glance one takes at this system of connections, it would appear that the crossheads are exposed to severe side thrusts, but a little consideration shows that this is not so. Notwithstanding the very short connecting rod, and the great distance from the piston-rod centre to the crank-shaft centre, there is little or no side thrust on the guides. All, or nearly all, side thrust is taken by the fulcrum upon which the lever vibrates, and, as the motion is slight, the friction is reduced to a minimum. The tail ends of these levers are used to drive the air, circulating, main bilge, and feed pumps. From the peculiar arrangement of the connecting rod the stroke of the piston is 42in., while the crank stroke is only 36in. Each pair of cylinders, too, acts upon each crank, as in a coupled engine, with cranks at right angles, so that eight impulses are given, equally divided round the circle, and the turning effort upon the crank shaft is exceedingly uniform. At the same time, there is no position of the engine in which it will not readily start. Between each pair of cylinders there is a cylindrical valve casing, carrying a piston valve, so that the whole operations of the engine are controlled by these two piston valves. Each valve is driven by an eccentric, and a simple linkage admits of reversing by driving from reversing eccentrics. This linkage

QUADRUPLE EXPANSION ENGINE TO S.S. SINGAPORE.

CONSTRUCTED BY MESSRS. FLEMING AND FERGUSON, ENGINEERS, PAISLEY.



we shall describe more fully at another time. The cylinders are 24in., 30in., 40in., and 60in. respectively, and the stroke of all is 42in.

The steam consumption, both in regular work and at the special test during the trial trip, is most satisfactorily low. On the steam trial of the Singapore, conducted under the supervision of Mr. James Mollison, chief engineer surveyor to Lloyd's Register, Glasgow, the consumption of coal was found to be only 1·12lb. per I.H.P. per hour, the engines making 80 revolutions and developing 1,600 H.P. The Singapore attained a speed of 12¾ knots per hour on the measured mile at Wemyss Bay, and carries 1,500 tons dead weight on 13ft. draft of water.

In another engine of similar type, at work on a vessel which sailed to Buenos Ayres, we are informed that 112lb. of coal was consumed per 100 indicated horse power per hour, a result identical with the special test of the Singapore's engines. On page 748 we give a set of indicator diagrams taken from the Singapore's engines, from which will be seen all details of steam pressure and cut-off in the various cylinders.

The leading advantages of these engines are undoubtedly great compactness, yet easy accessibility, uniform driving effort all round the circle, and weights of entire engine kept very low. Notwithstanding the relatively long stroke, the shortness of the connecting rods brings the position of the cylinders very low down in the ship, while the breadth makes them extremely steady and free from vibration. We are informed that Messrs. Fleming and Ferguson have fitted a considerable number of these engines already, and have good orders in hand as well. The extreme compactness and great power in a small space render the engines very suitable for war vessels.

INSTITUTE OF MARINE ENGINEERS.

A MEETING of the Institute of Marine Engineers was held on Saturday evening, 19th October, in the Langthorne Rooms, 17, Broadway, Stratford, presided over by Mr. James Adamson (honorary secretary), when Mr. Joseph Williams read a very exhaustive and carefully prepared paper on the subject of "Forced Draught."

The Chairman introduced Mr. Williams as a member of the institute, who had come from Birmingham in order to read the paper he had prepared, a proof of the interest he had in the institute.

Mr. Williams began his paper by commenting briefly on the several systems of "forced draught" which have been tried—the steam jet and induced draught, cold blast, hot blast, and the closed stokehold.

The first of these was not further referred to, as being inapplicable to marine boilers, considered in relation to the various questions necessarily involved, especially in these days of high pressure. At the same time, it may be held that other appliances besides the steam jet are available for induced draught, as by an exhaust fan, or other appliance; it may be worth further investigation, as this system has much to recommend it.

The Ferrando system is in use in many steamers in America, and in several which have been built for the Italian Government; in it the air is supplied under pressure to the ashpits. Of this system there are many modifications and claimants for various minor improvements.

The objections to the cold blast and the closed stokehold are many and grave. Some of these are capable of removal by arrangements to counteract them; but taking into consideration the "human factor," the closed stokehold system is not the best. The introduction of cold air into the fire-boxes through the furnaces when cleaning fires has been partly overcome in the City of Paris by having dampers fitted in the smoke-boxes, but here it comes to be almost a necessity—to ensure the firemen attending to the use of the dampers—to have an engineer standing by to see that the dampers are closed, and thus minimise the amount of cold air admitted to the back ends of the furnaces when the fires are being cleaned.

The heating of the air before being introduced to the furnaces was considered by the author of the paper to be the best of the many he had seen applied in various parts of the world. With forced draught applied, in some cases with perverted ingenuity, the amount of coal was increased, and at the same time the vessel was driven at a less rate of speed than with natural draught. In his experiences he had found that the system introduced by Mr. James Howden had given excellent results where attention had been paid to the details of working.

Some very interesting and valuable data were given from personal observations, indicative not only of the excellent results which have been gained from the use of forced draught, but of the care and attention bestowed upon the apparent trifles which go to make, when summed up, the success or non-success of any system. A table, showing the gain in space by the adoption of forced draught and new engines, was given by Mr. Williams, taken from actual measurement, as follows:—

Name of Steamers.	Dimensions.	Machinery and Boiler Space.		Per cent Reduction of Boiler room.	H.P. Before Refit.	H.P. After Refit.
		After Refit.	Reducn. After Refit.			
City of Venice......	379×38×29	68ft.	12f .	28	1350	1700
Ohio	343×43×34·6	70ft.	16ft.	26	1850	2150
Austrian	319×38·5×32·5	45ft.	28ft.6in.	54	1150	1400
City of Canterbury..	379×38×29	64ft.	16ft.	37	1350	1700
Illinois	343×43×34·6	64ft.	22ft.	38	1850	2200
Sarmatian..........	370×42×35·6	49ft.	75ft.	63	2000	2200
Indiana	343×43×34·6	44ft.	42ft.	67	1850	1200
Clan Gordon	305·6×34·9×24	—	—	28	750	1050

The animated discussion which ensued was sustained by Messrs. J. W. Richardson, J. R. Ruthven, J. Mc. F. Gray, Sage, R. Bruce, Smith, Conbro, Hawthorn, and others, in the course of which the advantages of forced draught were considered, and the objections to its introduction were brought forward.

The New York City and City of Venice were frequently referred to as examples of Mr. Howden's system, where a considerable saving of fuel had been effected, without any bad results to the boiler on account of the blast. Several cases were cited where, by want of attention to details, faulty design of boilers, or defective arrangement of forced draught, bad results ensued.

In summing up, the Chairman, after commenting on the results obtained and condition of the boilers of the New York City and City of Venice, which he had carefully inspected on two occasions, expressed his opinion that Mr. Howden was working on the right lines, and with some improvements, and boilers constructed to meet the conditions of forced draught, its introduction generally would be accepted without question. Improvements were required in driving the fan. The style of fan and the whole arrangement, both as regards position and delivery of air, were referred to by several members in the course of the discussion.

The meeting closed with the usual votes of thanks to the author of the paper and the chairman, moved and seconded by Messrs. J. Mc.Farlane Gray and J. R. Ruthven, and L. P. Conbro and W. J. Craig.

The next paper will be read by Mr. A. Beldam, on Friday, 1st November, on the "Progress and Development of the Marine Engine."

THE MANUFACTURE OF DYNAMITE GUNS IN BIRMINGHAM.

In order to give the War Office an opportunity of judging of the comparative merits of the Graydon and Zalinski systems of torpedo warfare, a trial will take place sometime next year at Portsmouth, not—as in America—with dummy shells, but with charged ones. With a view to this trial, the syndicate formed for working the Graydon patents—numbering now 38—have contracted with Taunton, Delmard, Lane, and Company Limited, of Birmingham, for the manufacture of a 15in. torpedo projector. This will be 30ft. long, as compared with a length of 55ft., which is necessary for throwing the same sized projectile containing 600lb. of dynamite from a Zalinski gun. And whereas the range of the Zalinski is a little over a mile, the Graydon projector will land its torpedo in a fort or on a ship three miles distant. Messrs. Taunton, Delmard, Lane, and Co. have obtained the contract on account of their unique success in making tubes to resist these heavy pressures, compressed air work being one of their specialties. At present only the 15in. gun has actually been ordered, but negotiations are proceeding, as the result of which it is hoped the order will come to Birmingham for a 6in. siege gun, throwing a torpedo charged with 70lb. of dynamite. The whole of the equipment of the guns, including carriages, compressors, and boilers, will be made by the same contractors. The larger gun, with its complete outfit, costs about £10,000, and though the full complement of compressors will not be furnished with the experimental weapon, the present order is obviously an important one as affecting local trade. The first gun will take till Christmas to complete.

THE IRON AND STEEL INSTITUTE.

A New Form of Siemens Furnace.

Mr. John Head (of London) and M. Pouff (Nevers) introduced to the meeting a new form of Siemens furnace, arranged to recover waste gases as well as waste heat. They said that Messrs. Siemens were the first to heat the gas as well as the air supplied to a furnace, utilising its waste heat for that purpose, and to provide for reversing the direction of the flame in the furnace chamber, whereby uniformity of heat and the highest temperatures were attained. In the new Siemens furnace, the gaseous products of combustion from the heating chamber of the furnace are delivered under the grate of the producer, these gases consisting of intensely hot carbonic acid water in the gaseous state, and nitrogen. It had to be ascertained whether the products of combustion from the heating chamber would contain a sufficient amount of heat for insuring their conversion into combustible gases. This has been found to be the case in practice with furnaces working regularly for the past six months. In the new Siemens furnace the waste gases are directed partly through an air regenerator, and partly under the grate of the producer, there to be reconverted into combustible gases, and to do the work of distilling by hydro-carbons from the coal; in fact, the gas producer in this case absorbs or utilises the heat formerly deposited in the gas regenerators of furnaces, and in doing this transforms spent gases into combustible gases. The new form of regenerative gas furnace has been applied in this country to both heating and welding of iron, to which uses its application is being extended in England and abroad, whilst furnaces are in course of construction to apply it for puddling iron, and for copper and steel melting. Altogether, ten furnaces for these purposes are in course of construction, in addition to two furnaces already at work for heating iron. The results of working during the past six months have shown an average saving of 5 per cent in waste on the weight of the iron heated, and a saving of upwards of two-thirds of the weight of coal used, and a greater money-saving owing to the inferior quality of the fuel employed, as compared with that used in their other furnaces fired with solid fuel. From the total saving thus realised should, however, be deducted the cost of raising steam, for which purpose the waste heat of the old furnaces is utilised. Allowing for separate boilers, the saving effected by the use of the new system in a furnace heating eight tons of iron per shift is nearly 18 tons of coal per week, and the money-saving in iron and coal exceeds £1,000 per annum. This new furnace has also been recently applied for heating billets by the United Horseshoe Company, of London, and in this case the results are quite as satisfactory as those just given.

The Robert-Bessemer Steel Process.

Mr. F. L. Harrison (Philadelphia) read a paper on this modification of the ordinary Bessemer process, which first came into notice in 1884. The converter at the Blaenatron Works, and also at the Stenay Works in France, is used with either an acid or a basic lining. It is claimed by the inventor that, by the acid process, steel of any desired quality can be produced, and especially for making castings of the highest quality of soundness and finish, and that by the basic process a peculiarly soft, ductile metal is produced, equal in all respects to irons of the highest class manufactured in South Yorkshire and Staffordshire. It was now very difficult to see upon what foundation any claim of novelty in the Robert converter can be based, except as a patent of combination, and this he was informed constituted the claim of the inventor. If they admitted that the rotation and decarbonisation of the bath could be effected, it was difficult to believe that a pressure of 4lb. of blast would be sufficient to produce the required inclination of the surface of the bath, no matter in what manner the tuyeres were placed.

Votes of thanks were then passed to the French societies, the French railways, and others who had helped to make the meeting a complete success.

THE PETROLEUM TRADE IN LIVERPOOL.

An important question came before the Mersey Docks and Harbour Board, at one of their recent weekly meetings, in the form of a recommendation of the Works Committee that the board should erect on the Parkhill estate, at the south end of the dock system, six large petroleum depots with all the requisite conveniences, including pipes to connect the depots with the Herculaneum Branch Dock. The estimated cost of the work is £30,000. Mr. Brancker, the chairman of the committee, referred to the enormous increase which had taken place in the petroleum trade in Liverpool during the past few years, and said that as greater facilities were urgently required for the conveyance of the oil from the bulk steamers to the tanks on shore, the committee had come forward with a comprehensive scheme. Mr. Bowring, on behalf of the Petroleum Association, said the scheme would be of immense assistance to the working of the trade, and he hoped it would be proceeded with at once. In accordance with the standing orders of the board the recommendation was formally postponed until next week, when it will be again submitted, and in all probability adopted.

THE MANUFACTURE OF THE ALLOYS OF ALUMINIUM IN THE ELECTRIC FURNACE (COWLES' PROCESS).*

Although aluminium is one of the most widely distributed of the elements, entering into the composition of nearly two hundred minerals, its oxide alumina was regarded as identical with lime until, in 1754, Margraff proved it to be a distinct substance.

In 1807, Davy, so successful with the oxides of the metals of the alkalies and alkaline earths, attempted to decompose alumina by the battery, but failed; and it was not until the year 1828 that Wöhler, by heating the chloride with metallic potassium, first obtained aluminium as a grey lustrous metallic powder, and eighteen years later in globules not larger than pin heads. From these, with extreme ingenuity, he determined the principal properties of the metal. In 1854, Deville (at that time Professor of Chemistry in the Ecole Normale, Paris), in course of some researches on the chloride, obtained a button of pure aluminium by the decomposition of the chloride with sodium, and on the 4th February in that year read a paper, describing his discovery, before the Academy of Science. As a result, a committee was formed to carry on experiments, 2,000f. being granted to meet expenses. On August 14th he read a second paper before the academy, exhibiting several bars of aluminium, and caused a medal of the metal to be struck and presented to the Emperor. In March of the next year, experiments on a large scale, at the imperial cost, were instituted at Javel; and on June 18th Deville presented to the academy, through M. Dumas, large bars of pure aluminium. These experiments are said to have cost the Emperor 35,000f. (£1,458).

Deville's method, modified in details, is still the chief of the chemical methods of preparing aluminium on a commercial scale, and is dependent on the cost of the metallic sodium and the double chloride of aluminium and sodium, which is the compound used in the most important of the present-day processes.

Pure aluminium is a highly lustrous metal, white, with a faint tinge of blue in colour. It resists the action of air and moisture, even at high temperatures; is not blackened by exposure to the action of sulphuretted hydrogen or the alkaline sulphides; and is not attacked by fused nitre nitric, or dilute sulphuric acid. It dissolves readily in hydrochloric acid, or in solutions of the alkalies.

Its density is but two and one half times that of water. In a paper read by Mr. W. H. Barlow before the British Association, 1882, its tenacity is given at twelve tons to the square inch; but weight for weight, it would equal high-class steel. Its elasticity is almost equal to that of silver; is ductile, can be drawn into very fine wire, and is almost as malleable as gold. Its thermal conductivity is about two-thirds of that of copper. Its electrical conductivity is given as eight times that of iron. Its specific heat is ·22; it melts at 1,300 deg. Fah., but exhibits no tendency to volatilise, even though heated in a carbon crucible in a blast furnace to high temperatures. The extreme lightness of aluminium, its power of resisting the action of air moisture and sulphuretted hydrogen, give it an advantage over silver, which it equals in tenacity and elasticity, as a material for jewellery and for scientific and astronomical instruments.

The greatest value of aluminium is, as yet, in its alloys, and it is with their production in the electric furnace I propose to deal to-day; and I may remark that the successful application of the intense heat of the electric arc to the production of metals on a commercial scale marks a new departure in electro-metallurgy, of which we cannot overestimate the importance, rendering it possible to produce rich alloys of aluminium at half the cost of any other process, and so widening the field of their application to an extent hitherto unknown.

Messrs. Cowles' first experiment was with a very refractory zinc ore, containing silver, which they had failed to reduce in an ordinary furnace. A fireclay tube was taken filled with a mixture of the crushed ore and charcoal powder, a bundle of electric light carbons inserted in each end, and a current from a small dynamo sent through the mass. In a short time the ore was reduced, but the fireclay tube was partly melted, showing the necessity for a lining that would protect the furnace walls from the intense heat. Powdered charcoal, a very feeble conductor of heat and electricity, was tried, but it was found that after a time it became converted into graphite, thus becoming a conductor; as the smelting proceeded changing gradually from the inside to the outside, and as the hot zone expanded causing loss of energy and eventually destroying the furnace. Mr. Alfred H. Cowles then suggested soaking the charcoal powder in milk of lime and drying before use; this proved successful, each particle of charcoal being coated with a film of lime, which insulates it and prevents electrical conduction between neighbouring particles even after the charcoal is converted into graphite. Messrs. Cowles now found that they had a furnace that would enable them to conduct metallurgical operations at a temperature hitherto unknown outside the laboratory; and after some experiments with corundum, they, acting in conjunction with Professor Mabery set up the first plant for the production of aluminium bronze, ferro aluminium, and silicon bronze, at the works of the Brush Electric Co., Cleveland, Ohio, U.S.A. The results obtained at Cleveland were so satisfactory, though using only a dynamo of 300 ampéres with E.M.F. of 60 volts., that in 1886 the Cowles Company commenced the works at Lockport, N.Y., U.S.A. The works at Lockport commenced operations with a Brush dynamo giving a current of 1,600 ampéres, with an E.M.F. of 45-50 volts.; to this has been added two dynamos each capable of supplying a current of 3,000 to 3,200 ampéres, with an E.M.F. of 55 to 60 volts. A fourth dynamo is now building of 3,000 ampéres. One striking feature of the Lockport works is the use of water power, the dynamos being actuated by two powerful turbines 30in. diameter = 500 horse power. The number of furnaces in operation are 14, producing about 300lb. of aluminium contained in alloys per 24 hours. Four additional furnaces are now building.

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* Abstract of paper read before the Chemical Science Section, British Association September 13th, 1889, by Mr. John H. J. Dagger, F.I.C., F.C.S.

(To be continued.)

MANCHESTER ASSOCIATION OF ENGINEERS.

THIS association met on Saturday, the 26th inst., at the Grand Hotel, Manchester, when Mr. Geo. Richards, M.I.M.E., read an interesting paper on the "Pneumatic Method of Moulding." The pneumatic moulding machine is an American invention, but is now in use at the works of Messrs. Marshall, Sons, and Co. Limited, Gainsborough, and samples of its work were shown, both from American foundries and Gainsborough. Three working models of the machines were shown, as well as specimens of circular "gates" used in American foundries, and castings fettled by the sand blast. The programme of the association for this season is an excellent one, and includes the following papers: Nov. 23, "Automatic Expansion Gear," by Mr. J. J. Harper; Jan. 25, 1890, "Evaporation of Lancashire Boilers," Mr. M. Longridge, M.A., M.Inst.C.E.; Feb. 22, "Continuous Brakes: their recent development," Mr. G. Kiernan; March 8, "Feed Water: its effect on boilers, and its treatment," Mr. E. G. Constantine; March 22, "The Friction and Lubrication of Cylinder Journals," by Mr. J. Goodman, Assoc.M.Inst.C.E.; and April 12, "Graphic Tabulation, and some Relations of Art with Engineering," Mr. H. Guthrie, C.E. This excellent list, together with an inaugural address by the President (S. Dixon, Esq., M.I.M.E.), which is sure to be thoughtful and interesting, goes far to ensure a highly successful session.

HEAT ENGINES OTHER THAN STEAM.—III.

(Continued from page 736.)

THE engine was of the usual "Crossley" type, having a working cylinder 9½ inches diameter, with a stroke of 18 inches. The indicated horse power at full load was 17·12, the brake horse power was 14·74, and the ratio between brake horse power and indicated horse power was 86 to 100. The gas consumed per indicated horse power per hour in the cylinder was 20·55 cubic feet, that required for ignition being ·21, or about 1-5th of a cubic foot per hour extra. In the Crossley engines the ignition of the gaseous mixture has, until recently, been performed by direct flame ignition, in a manner somewhat similar to that which I have described as being in use in the Otto and Langen free-piston engine; but Messrs. Crossley have now introduced a modification of a form of tube igniter, which needs some little description.

In this (see the three views of fig. 18) there is a closed igniting tube, which is kept hot by a "Bunsen" flame burning externally to it. There is a valve which is opened and closed by means of a lever worked by an engine, and this valve opens communication between the igniting tube and the cylinder at the right moment, allowing a portion of the charge from the cylinder to pass into the red-hot tube, thus igniting the charge and causing the power stroke. The use of this mode of ignition does away with that constant source of trouble in the earlier engines, the slide valve.

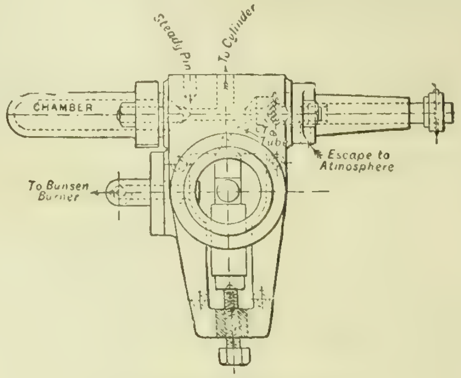


FIG. 18.—Crossley's Patent Igniting Block.

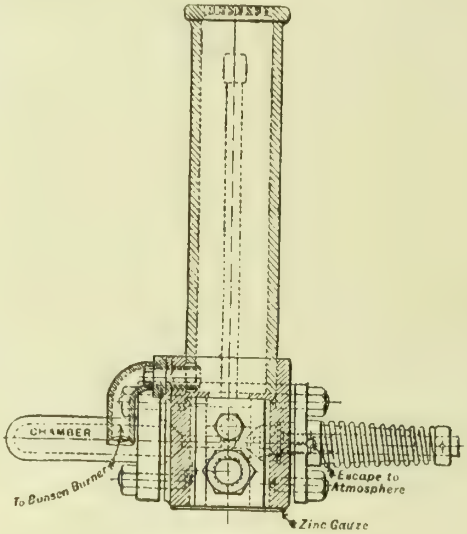


FIG. 18.—Front Elevation.

I have here a model showing, in a similar manner to that of the model of the Crossley engine, the cycle of operations in the Clerk engine, which was at one time largely in use. You will see that in this case there is at the back of the cylinder a space of a conical shape to contain the compressed charge and the unexpelled products of combustion, and that the gaseous mixture is compressed in a separate vessel or pump.

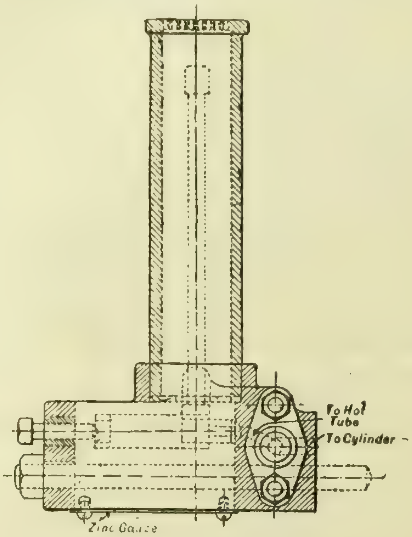


FIG. 18.—Side Elevation.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

FIRE BRIDGES.

To the Editor of "The Practical Engineer."

SIR,—Your correspondent "Azim" mentions that it is a good approximate rule to make the area over the fire bridge about one-sixth the area of the fire-grate, and that the distance from the top of the bridge to the furnace crown in a 2ft. 9in. furnace tube should not be less than 9in. I have calculated the areas of the passage over the bridge (assuming the top of the bridge to be built flat, and not curved to the shape of the furnace tube) by the following formula, for finding the area of segment of a circle :—

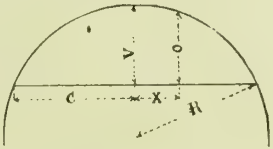
$$C^2 = V\,(2R - V)$$

$$\text{area of segment} = \frac{4V}{3}\sqrt{(0{\cdot}626V)^2 + C^2}$$

where R = radius of circle
V = versed sine
C = semichord

and I find the area of the segment of a circle above the fire bridge, in a tube 2ft. 9in. diameter, with versed sine 9in., is, as nearly as may be, 190 square inches. Taking the fire-grate of a 2ft. 9in. tube as 6ft. long—a length of grate very generally adopted in Lancashire boilers—the area of grate will be 16½ square feet, or 2,376 square inches. The ratio of the passage over the bridge, with the bridge wall 9in. from the crown of furnace, therefore, would be $\frac{2376}{190} = 12{\cdot}5$, or less than one-twelfth the fire-grate area.

The area of a 2ft. 9in. tube is 855·3 square inches, half of which is 427·65 square inches, and one-sixth the fire-grate area is $\frac{2376}{6} = 396$, a difference of only 31·65 square inches if there were no bridge at all above the grate bars. If the versine of the segment of circle be taken as 15½in.—that is, the distance in centre between top of bridge wall and top of tube—we should get the passage over the bridge one-sixth of the fire-grate area, but this would be *one inch only*, about the grate-bar level. Surely this is too low. It certainly does not represent ordinary practice. The rule given by your correspondent "L," to make the height of the bridge two-thirds the diameter of the flue tube, would make the depth over the bridge in centre 11in., or 5½in. above the level, which certainly appears more in accordance with the general practice in this district. Your correspondent "W. H. Booth's" rule, to allow about 12 square inches area over the bridge for each square foot of fire-grate area, would give 198 square inches, which also appears to accord well with what is usually done. This would give the depth over the bridge as only a little more than 9in. in an ordinary 2ft. 9in. furnace tube.—Yours, &c., ENGINEER.



MR. WORSDELL'S COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

SIR,—"Fairplay," in his letter on Mr. Worsdell's compound engines, which appeared in your issue of October 18th, attempts to prove by figures and comparison with another railway company that compounding of locomotives is altogether a failure. I do not think it worth while to test the accuracy of his figures, but think I shall be able to convince any unbiassed mind that "Fairplay" is unconsciously advocating the very thing he is trying to condemn.

He says: As it is a question of economy, and economy only, perhaps "Loco." can explain the following figures of the North-Eastern Railway Company, compared with a line not using compound engines—giving the number of engines on the North-Eastern Railway (1506) and the Midland (1822); the cost of coal per train mile—for the former, at 1·78d., against 1·56d. for the latter. Repairs and renewals per engine at £155 9s. 5d., against £102 14s. I will take the question of the cost of coal per train mile—a difference in favour of the Midland Railway of ·22d. Now, I would not put this down altogether to the engines, for everyone knows who has travelled that the North-Eastern engines have to draw more dead stock about than any other railway in the kingdom, the Midland included; and it is my opinion that if the traffic department of this line were as careful not to have so many empty coaches running on their trains as the Midland are, the result would be just the opposite. But put that on one side for a moment, and suppose this loss was altogether due to the extravagant engines on the North-Eastern. They have altogether 1,506. Out of this number there are 80 of Mr. Worsdell's compounds, and 1,426 non-compounds. Would any sensible man put this extra consumption of fuel down to these 80 new compounds? No, I am sure he would not. It is more likely he would put it down to the 1,426 non-compounds, knowing that a great many of these must be very old and wasteful. And more than this, if the 80 compounds were using more fuel than the non-compounds did, I have no doubt we should hear of it. The fact is, they use less. Consequently, the compounds have actually brought the average consumption lower than it would have been without them. I think the explanation on this point quite sufficient for anyone.

With regard to the cost of repairs and renewals, I will take the matter of repairs next. "Fairplay" couples them together; but I consider renewals are altogether out of the question, as I shall explain further on. Will "Fairplay" be surprised when I tell him that none of the compounds had been into the works for repairs on December 31st, 1888, at the time he makes the comparison so nicely in favour of non-compounds? A few of Mr. Worsdell's compounds have been into the works for repairs since the above date that had been at work 2½ years, and the cost, I am told, is only about one-half the amount for non-compounds. "Fairplay" must acknowledge, when he comes to think of it, that the cost of renewals cannot be put down to the failure of compounds, but to the contrary reason, as I will endeavour to point out.

When the present locomotive superintendent took charge, in 1885, he found many old and worn-out locomotives at work on the North-Eastern system. Some of them were actually dangerous to the public, as will be evident when we are told that out of thirteen locomotive boiler explosions in the kingdom, nine of the engines belonged to the North-Eastern, and occurred during the time Mr. Fletcher was in charge. The present locomotive superintendent was accordingly compelled to replace them, as, in fact, the cost to repair them would be nearly as much as building new engines; not only that, but these obsolete engines were not fit to run on any line. These were the kind of engines that "Fairplay" might safely condemn, which would, undoubtedly, contribute to the high consumption of fuel that his figures show. I think sufficient has now been written to prove that "Fairplay's" figures are more favourable to compounding than otherwise.

"Fairplay" says that he has been a reader of *The Practical Engineer* from its commencement almost, and considers it very valuable to a mechanic. I quite agree with him, and I have no doubt he will have all the back copies stored up side by side with the *Newcastle Chronicle* referred to in his letter. Now, I will ask "Fairplay" to look up your issue of April 20th, 1888, and read a contribution on Compound Locomotives, by a practical man who has had 25 years' experience amongst them, and he will find a statement there, which I think cannot be disputed, showing a saving of 4·4lb. fuel per mile by Mr. Worsdell's compounds over non-compounds doing the same work, and in another case a saving of 10·6lb. per mile by his compound goods engine over non compound goods doing exactly the same work, in the same link, at the same time. This I consider is the proper way to test them. I do not wish to encroach on your valuable space too much, Mr. Editor, but I should just like to refer to some of the remarks made by "Fairplay" in other parts of his letter, which are worth noting. I quite agree with him when he says "I consider the greatest advantages to be attained in locomotives are simplicity of construction, durability, high steam pressure, and economy in repairs." Now, if "Fairplay" is a practical man, and will examine Mr. Worsdell's compounds, as I have done, he cannot but admit that the workmanship is not to be excelled. Although compounded, they are far more simple than many non-compounds I have seen, and will cost less to keep in repair. Again, he says if non-compound boilers were made to carry 175lb. to 180lb. pressure, better results would be got; if so, how is it that so many locomotive superintendents in the kingdom are so foolish as not to do it? I fear "Fairplay" will say anything which he thinks calculated to crush the compounds and the enterprising man who has had the pluck to come out of the old groove and try other methods, which methods have proved successful. I feel sure the directors of the North-Eastern Railway are quite capable of looking after the interests of the shareholders without consulting "Fairplay," or any other. And I would advise your correspondent to look more thoroughly into the matter of compounding locomotives before he rushes into print again. He will perhaps give the compound locomotive fairplay in the future.—Yours truly, LOCO.

TEAL'S PORTABLE HOIST.

To the Editor of "The Practical Engineer."

SIR,—In your issue of October 25th you illustrate a modification of the ordinary Weston differential pulley block under the head of "Teal's Portable Hoist." The advantages claimed are tabulated in a comparative table of tests, but there are some items which are required to make the list valuable or otherwise, viz., the power required to lower a certain load, the weight of the blocks, and the distance between the extreme ends of the two hooks when they are brought into the closest working space. If you can publish these particulars, we shall be able to compare them with English-made blocks, of which I have records in every respect equal to those set out in the report of "Teal's hoist."—Yours, &c., M. I. M. E.

QUERIES AND REPLIES.

100. **Pulsometer.**—What is the reason for giving the upper portions of the condensing chambers their peculiar tapered form?—S. B.

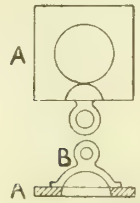
Answer.—While the steam opening is necessarily small, it is also necessary to have a considerable surface of water for the steam to press on, so as to give good volume of delivery. An entrance of steam through a small hole, direct upon a wide surface of water, would cause the steam to be blown into the water, and prematurely condensed. A tapering chamber allows it to fill the space with the smallest possible disturbance to the surface of the water. While this is the reason of the taper, its peculiar pear-shaped form is determined also by the desire to secure compactness in the pulsometer as a whole.—C.

Answer.—A condensing chamber at the commencement of a cycle of operations is filled with water. Steam flows in at the top of this chamber, and meets a surface of water. Some of the water has to be displaced. It is evident that, to prevent large condensation of steam, the area of water which it meets must be small.—P. R. J.

104. **Brass Furnace.**—Will some experienced correspondent oblige querist with a rough dimensioned sketch of the most modern double-brass furnace suitable for say two 46lb. pots?—Mechanicus.

Answer.—In the adjoining figures C, C are the furnaces, which, if made from 13in. to 14in. square, will take pots up to about 60lb. very well. The dimensions given throughout are approximate, because the difference of an inch or two anywhere does not appear to be of any moment, as affecting results. These dimensions are averaged from those of three furnaces, of different sizes, in constant use. The whole of the structure is built of fire bricks, set in thin strata of fire-clay. Plates of sheet iron of about ⅜in. or ½in. in thickness should be built in, as shown at *d d d d*, to support the bricks and fire bars. The latter *e* consist simply of pieces of bar iron, about 1⅜in. or 1¼in. square, thrust through the bottom of the furnace from front to back. When the melting is over these are drawn out, allowing the fire to fall down into the ashpit below. The ashpit D is extended well in front, to give room for a man to get down and clear it out, and this is covered over at all other times with a light cast-iron grating, level with the floor. This grating is seen in section in fig. 1 at E, but is not shown in the other figures—only the recess which receives it is seen at *f*. The draught passes down through this grating and through the openings F to the furnaces, and is drawn upwards by the tall chimney G, which may be from 9in. to 10in. square, and of a good length—about 18ft. to 20ft., which will ensure a sufficient draught, the damper H regulating its intensity. The fire is made, and the crucibles lifted in and out through the top; and the sinking of the furnace below the floor level permits the workman to stand well above the furnace mouth, enabling him to handle the tongs and crucibles, and see the progress of the melting. When the melting is proceeding the openings of the furnaces are covered with a square plate, fig. 4 A, perforated with a circular sight hole, and this last is covered with a circular "tile" B of cast iron.—J. H.

Fig. 4.



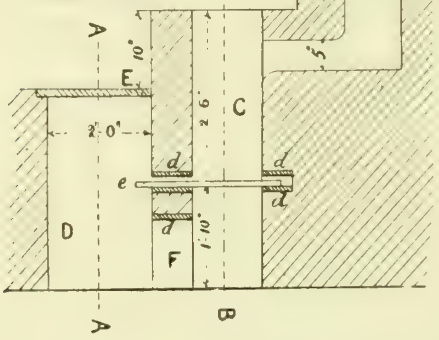


Fig. 1.

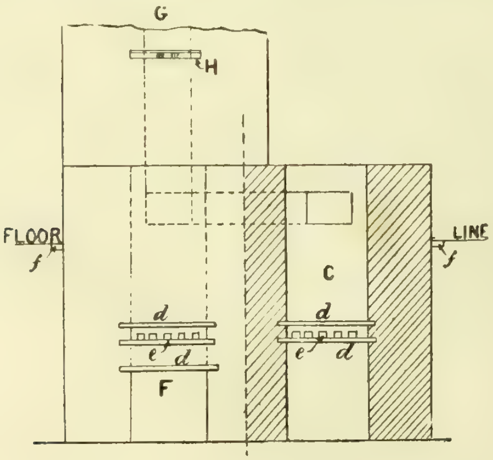


Fig. 2.

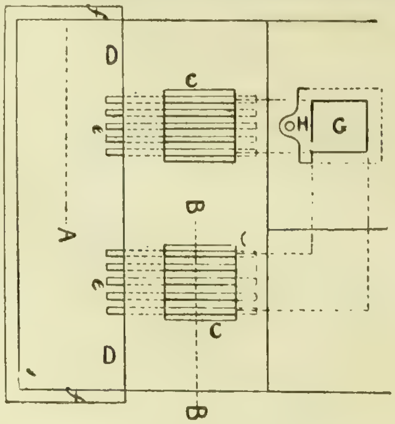


Fig. 3.

106. **Anti-calcaire.**—Will you kindly inform me as to what this is composed of, and what action it has on hard water? Would it be suitable for use with feed water?—Marine.

Answer.—Anti-calcaire is a finely divided powder, composed of powdered lime, powdered alum, or sulphate of aluminium, and calcined and ground soda or soda-ash. The proportions of these ingredients vary according to the quality of the water to be purified, which is first tested or analysed. The anti-calcaire may also contain permanganate of potash (of which Condy's disinfecting fluid is a solution), to precipitate some of the matters to be eliminated from the water. It is patented by P. H. Maignen in connection with his softening process for hard water, and is protected by four patents. It has been largely used for domestic purposes, softening water for drinking, washing, &c., and would, of course, also be suitable for softening water for steam boilers if not too expensive. Where sea water is to be treated, the further constituent of pyrosulite is used. When used in the house for softening drinking water, the quantity required is about one grain for each degree of hardness shown by the water, or 16 grains per gallon of water such as London drinking water, which has about 16 deg. of hardness (or 1oz. for 28 gallons), and 20 grains per gallon, equal to about 1oz. for 22 gallons of water, when used for washing. Anti-calcaire is sold in tins at from 2d. to 7s. each, the price being about 6d. per lb., but it may be obtained in large quantities at about 28s. per cwt. A 2d. tin will last about six weeks for one person, with London water; and a 6d. tin is estimated to be sufficient to soften 300 gallons of water of 16 deg. of hardness. About as much anti-calcaire as will lie on a halfpenny, added to a wash-hand jug full of water, when going to bed overnight, will cause the precipitation of the lime, magnesia, &c., causing the hardness, by the time the water is required for ablution in the morning, when the impurities will be found to have settled as a sediment at the bottom of the jug, and the water will be quite soft and clear. If "Marine" desires any further information, he may obtain it from the patents, which were taken out as under: February 7, 1884, No. 3,038; June 9, 1884, No. 8,743; 1885, No. 7,446; and 1886, No. 6,072. The 1885 patent includes a process for re-utilising the precipitate of carbonate of lime, and preparing it for further use, by driving off the carbonic acid by ignition, leaving strong caustic lime, which may be used itself as in Clark's process, or in combination with silicate of soda, for sulphate waters; and, when water is salt or brackish, the dioxide of manganese, saturated with sulphuric acid, all dried and powdered, is added.

114. **Friction in Water Mains.**—What methods are used for lessening any tendency to increase of surface friction in water mains?—F. J. J.

Answer.—A very efficient method is to subject the pipes to Dr. Angus Smith's process, by means of which they are coated all over during the act of casting with a black enamel, which prevents rust, and thereby reduces friction and increases the discharging power of the mains. This process costs about five shillings per ton for medium-sized pipes, and is largely adopted. In some cases a scraper, worked by the pressure of the water, has been passed through a whole line of pipes, with good results.—Hydra.

116. **Seating Hydraulic Pump Valves.**—I should be very glad to know what is the best method of seating valves in a hydraulic pump, the valve being 3in. or 4in. diameter and the pressure two tons per square inch. I am afraid, if seated in the ordinary way, they would leak and get loose. Pump Valves.

Answer.—Considerable difficulty would be experienced in getting a valve 3in. or 4in. diameter to stand a pressure of two tons per square inch. It would be far better, instead of having one large valve, to employ a number of smaller ones, when ordinary valves would doubtless give every satisfaction. I very much doubt, however, whether you actually require so large a valve for water of so high a pressure.—Hydra.

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109. **Balloon Motor.**—Will some reader kindly give me particulars of the motor employed by the French officer who recently constructed a very large and elaborate balloon? Perhaps some reference to the description, if it has been published, can be given.—F. B.

119. **Machine for Washing Mill and Furnace Ashes.**—Can any reader refer me to makers and description of machinery for washing and cleaning the ashes from mill and puddling furnaces. Information will much oblige.—R. T. C.

127. **Distilled Water.**—I require 20 gallons of distilled water in 10 hours. I propose to obtain this by means of a coil in a cylinder 1ft. 6in. diameter, and 4ft. high. Please show how I can find the size and length of coil to be used, and how much cold water must be admitted in cylinder. Pressure of steam in coil to be condensed, 40lb. Assistance with above will be greatly esteemed.—Doubtful.

128. **Compression and Release in Engines.**—How is the required amount of compression in a steam engine determined, and at what part of the stroke should release commence? An answer will much oblige.—A Beginner.

129. Loss of Power by Hot Condensing Water.—Will any of your readers inform me as to the disadvantage under which an engine will labour with the water in lodge or dam at 110 deg. F., instead of at 70 deg., and what will be the difference in I.H.P. to the engine, taking in infection water at 110 deg. instead of 70 deg? The engine is of the compound Tandem type, H.P. cylinder 20in. diameter, L.P. cylinder 38in. diameter, with 4ft. stroke, revolutions 60 per minute, boiler pressure 75lb. per square inch.—Young Engineer.

130. Expansion of Rails by Heat.—I have heard it stated that the average expansion and contraction of the railway metals, between the hottest day in summer and the coldest in winter, between London and Edinburgh, is only 3ft. Is this correct? if not, can you say what the difference is?—Inquirer.

131. Changing Pulleys on Crank Shaft.—I have a steam engine with a 4ft. 6in. driving pulley, running to a 3ft. 6in. pulley on the main shaft, and the engine making 150 revolutions per minute. Would it be any advantage to replace the 4ft. 6in. driving pulley by a 6ft. pulley, and reduce the speed of engine to 110 revolutions per minute? What difference would the above alteration make in the economy of engine? Information will oblige.—Vulcan.

132. Pressure on Journals.—Will some practical reader show me how to calculate the pressure on the guide bars, crank pin, crank shaft, and other journals of a train of gear wheels: Cylinder 18in. diameter, 42in. stroke, revolutions 40 per minute, conecting rod 8ft. 10in. long, driving pinion on end of crank shaft, radius 9in., the centre of pinion to journal 14in. This gears into a wheel of 30in radius, the centre of wheel to centre of journal 14in. On the same shaft is a pinion of 12in. radius, the centre of pinion to centre of journal 16in. This gears into a wheel of 60in. radius; the centre of wheel to the centre of journals is 16in. and 32in. respectively. The end of this shaft is coupled on to a three-roller sugar-cane mill, by Merrilees, Watson, and Co., Glasgow, with three equal pinions of 15in radius. Rollers same radius as pinions; the distance between centre of journals supporting rollers is 78in. A graphic or arithmetical solution would greatly oblige?—Engineman, North Queensland.

133. Small Engine Castings.—Could any of your readers kindly inform me of the best and cheapest form of engine for driving a 5in. centre lathe, and where I could buy castings?—F. J. H.

134. Liquid Fuel.—I am told the Great Eastern Railway runs some of their trains with locomotives burning tar and oil, &c., for fuel. Can any of your correspondents give me particulars of the burner or sprayer used, and say if it is applicable to ordinary vertical boilers? How do you start the fire, and what about standing? does the fire go out, as I presume, if the burner keeps at work, too much steam would be made? What do they do about draught? Any particulars would be very acceptable.—W. E. D.

135. Rapid Wear of Marine Engine Eccentric.—Would any reader kindly enlighten me with regard to the following?—The wear on the go-ahead eccentric strap for the high-pressure valve of a marine engine is so great that it has to be renewed every trip, and when abroad the go-astern strap has to be placed on the go-ahead block to bring her home. Now, I attribute this to the weight of the valve and the surface on the back of it being exposed to the steam pressure, thus causing a great amount of friction to be overcome. I intend fitting a small cylinder, with a balance piston on the end of the valve spindle, to try and overcome this wear, and I should be very glad if some reader would give me an idea for determining the proper diameter of the piston. The weight of valve is 4cwt. 3qr. 5lb.; weight of eccentric rods' motion and valve spindle about 3·5cwt. The valve spindle is continued through the valve and top of casing; the diameter of part continued is 2⅜in.; size of back of valve exposed to steam is 2ft. 9in. by 2ft. 5½in., with a ring to be deducted from this, 18in. diameter, which takes part of the pressure of the valve; pressure of steam, 95lb. per square inch; travel of valves, 6in.—Marine Engineer.

PATENTS AND INVENTORS' QUERIES.

21. Sale of Invention under Provisional Protection.—Having provisionally protected an invention, can I legally sell all rights in the said invention, and which party would file the final specification and pay Patent Office fees?—C. J., Penrhyn.

Answer.—You can agree to sell your patent now provisionally protected, but until your own final specification is accepted you have nothing you can legally sell. No one can file the final specification except you, but it is of course entirely a matter of arrangement between the purchaser and yourself as to who pays the fees. Patents are often disposed of in the provisional stage, and arrangements made for the purchaser to complete, but always under agreement to sell or assign when the patent is completed.

22. Rights of Manufacture under License.—If I allow a maker to manufacture under license, can I at any future date sell my rights to the same or any other person?—C. J., Penrhyn.

Answer.—If the license is an exclusive one, as such licenses often are, then you cannot sell your rights to the patent to any other, but you can sell your rights to the royalty payable by your licensee. If you have granted licenses which are not exclusive, you can appoint other licensees, but you cannot do anything to interfere with the conditions expressed in the various licenses. If your sole licensee wishes to purchase your rights outright, of course you can sell them.

23. Assignment Fees.—Are there any Patent Office fees for selling right out, or granting licenses, and which party generally pays them?—C. J., Penrhyn.

Answer.—There are no Patent Office fees for granting licenses, but such licenses or assignments should be registered at the Patent Office. The assignee, as licensee, generally pays those fees.

24. Dimensions of Patent Drawings.—What are the dimensions of patent specification drawings, and can plan, elevation, and details be shown upon one sheet?—J. P., Coventry.

Answer.—Under the patent rules, patent drawings must be made upon sheets of white, smooth paper, of 13in. by 8in., or, if the drawing is too large, 13in. by 16in. You can use either sizes, as you prefer, but in both cases a margin line must be drawn ½in. from the edge all round. All views may be on one sheet, if you can get them in.

TO CORRESPONDENTS.

T. G. C., West Ham.—The best appliances for heating a bath by gas are manufactured by Messrs. Fletcher, of Warrington, whose gas burners and heaters are to be had through every ironmonger

J. D., London, N.—Unwin's "Elements of Machine Design," published by Messrs. Longmans, in the Science Series, is the best book at a moderate price upon the subject of machine construction. Your best way to get to a plantation abroad is to apply for employment in some engineering firm, whose business is in sugar mill and sugar plant, such as Merrilees, Tait, and Watson, Glasgow. Such firms often send workmen abroad in charge of machinery made by them.

J. H. C., Motherwell.—Your query is too general; please repeat it in more definite form, stating clearly the circumstances of the design upon which you wish information.

Valve Gear, Cheltenham.—We shall endeavour to procure details of the piston valve referred to.

Old Reader, near Aberdare.—You can get copies of all Board of Trade rules, when published, from Messrs. Eyre and Spottiswoode, East Harding Street, Fleet Street, E.C. As the Weights and Measures Act does not come into force till 1st January, 1890, the rules for examination will not be published till very shortly before that time. You will therefore require to wait until the nature of the examination is settled before getting the information you require.

MISCELLANEA.

Fatal Explosion.—On Thursday, October 17th, a youth named George Goddard, working at Messrs. Hall's bleachworks, Whaley Bridge, was unscrewing the top of a kier of boiling cotton, when it exploded, and he was hurled across the room. He was removed home very much scalded, and died during the afternoon from his injuries.

The American Elevator Co.'s and Worthington Co.'s Awards at Paris.—The American Elevator Co. has been awarded a gold medal by the jury at the Paris Exhibition for the standard hydraulic elevator at the Globe Terrestre. The Worthington Pumping Engine Co. have received one of the grand prizes of the exhibition for their magnificent pumping station.

Further Gold Discoveries in Wales.—The Welsh newspapers announce an important discovery of gold reefs in the parish of Breche, Carmarthenshire. The reefs are traced for a considerable distance along the surface of the earth, and the results of the quartz-crushing average rather more than two ounces of gold per ton. The dressing of old workings believed to be Roman have also been unearthed.

Shaw's Gas Governor.—We are pleased to observe that Mr. Joseph Shaw, of the Albert Brassworks, Huddersfield, has been awarded a gold medal at the International Exhibition, Cologne, for the Shaw Gas Governor, and that he has received the "James Watt" silver medal of the Royal Cornwall Polytechnic Society for the same invention, the highest award, we are informed, ever given by this society for a gas governor.

The Linotype Company.—We are informed that the Linotype Company are now prepared to receive applications for the manufacture and supply, on royalty, of the linotype composing machine. Applications to be addressed to their head offices, 52, New Bond Street, London, E.C. Machines are now to be seen at work daily in London, Manchester, Glasgow, and Paris, and intending hirers are invited to apply to the company for information as to terms of use.

Messrs. S. W. Partridge and Co. will issue in a few days, under the title of "One and All," an autobiography of Richard Tangye, F.R.G.S., of "Tangyes," showing the rise of the vast industry centred in the Cornwall Works, Birmingham. The book will be illustrated by original drawings by Frank Hewett; and as a record of early struggles and final success of one of the great "captains of industry," it will be a most valuable addition to contemporary biographical literature.

On Friday, the 4th ult., a visit was paid to Bristol by the visitation committee of Lloyd's Register of British and Foreign Shipping. The works of Messrs. Newhall and Company were first inspected, and the committee there saw in the course of construction two steel steamers—one intended for the River Plate and the other for Russia. The machinery was also inspected, and a set of engines for a boat being built for Messrs. Howley and Cole, Hayle. From here the committee proceeded to the Albion Dockyard, and were there shown a steel barque of 1,300 tons gross. The opinion was here expressed by the members that they had never seen better work, although they had visited all the ports in the kingdom.

Terrible Explosion in a Foundry near Manchester. A man named John M'Neill was instantaneously killed, and a number of others were seriously injured, by an explosion which occurred on Monday last at the Hope Ironworks, Droylsden, owned by the Clayton Foundry Co. Limited. Forty to fifty men were engaged in the foundry, and some were making a large casting. Fifteen tons of metal had just been poured into the mould on the floor, when the sand was observed to lift a little and fall again. This was succeeded by a tremendous explosion, which projected the molten metal in great volume to the roof and all around, seriously burning many men, especially on the crane above the casting. One of them lost his hold, and fell among the molten metal, and was at once killed. The shop was set on fire, but was extinguished after a time. The cause seems to have been undue dampness of the sand. Fifteen men now lie at the infirmary, seriously injured.

One point of much interest which has been examined by American railroad officers who have visited England this year is the great Edgehill yard of the London and North-Western, near Liverpool. This is a yard for sorting and "marshalling" freight cars by gravity. It comprises over 57 miles of tracks, and is said to have cost £2,000,000. This yard is described by Mr. W. M. Ackworth in his recent book, "The Railways of England." A much better description was given in the *Railroad Gazette*, April 15, 1887. Through this yard all the outward and inward freight traffic of the London and North-Western passes. About 3,000 cars are handled in 24 hours as a maximum, not as an average, but the yards have a capacity of 5,000 or 6,000 cars per day. Some 54 trains are made up and sent out between the hours of 12 p.m. and 6 a.m. All cars arriving from Liverpool to be tested and made up are hauled to the summit of an incline and deposited on the reception lines. From these they are dropped by gravity through the sorting and "gridiron" tracks, and come out made up in trains, the cars arranged in the order of stations at which they are to be left. From 80 to 83 men are employed. We have no estimate or statement of the relative economy by which the great expenditure of this yard is justified, but Mr. Ackworth states that the work done there in 1887 "implied the employment of the whole time of nearly 400 engines, which collectively performed about 2,000,000 hours' work at a total cost of precisely £497,437."

Electric Brakes.—There are various forms of so-called electric brakes which are practicable, and even efficient, in working. In none of them, however, does electricity furnish the power by which the brakes are applied; it merely puts in operation some other power. In one type of electric brake the active breaking force is taken from an axle of each car. A small friction drum is made fast to the axle. Another friction drum, hung from the body of the car, swings near the axle. If, when the car is in motion, these drums are brought in contact, that one which hangs from the car takes motion from the other, and may be made to wind a chain on its shaft. Winding in this chain pulls on the brake levers precisely as if it had been wound on the shaft of the hand brake. The sole function of electricity in this form of brake is to bring the friction drums together. In a French brake which has been used experimentally for some years with much success, an electric current, controlled by the engine-driver, energises an electro-magnet which forms part of the swinging frame in which the loose friction pulley is carried. This electro-magnet, being vitalised, is attracted towards the axle, thus bringing the friction drums in contact. In an American brake lately exhibited on a long freight train, a smaller electro-magnet is used, but the same end is accomplished by multiplying the power by the intervention of a lever and wheel. The other type of so-called electric brake is that in which the motive power is compressed air, and the function of the electric device is simply to manipulate the valves under each car, by which the air is let into the brake cylinder or allowed to escape, thus putting on or releasing the brakes. All of these devices have this advantage, that, whatever the length of the train, the application of the brakes is simultaneous on all the wheels, and stops can be made from high speed with little shock.—*Iron.*

Electricity Applied to Works and Mills.—On Wednesday, 2nd October, the first meeting of the session of the South Staffordshire Institute of Iron and Steel Works Managers was held in the Mechanics' Institute, Dudley. Mr. Tucker (president) was in the chair, and there was a large attendance of members.—Mr. T. Vaughan Hughes, an electrical engineer, read a paper on "The Application of Electricity to Works and Mills." The reader said he believed that works and mills would soon be run by the electric current, and the long lines of shafting, the innumerable pulleys on belts, and the clatter, wear, and tear of trains of wheels would be done away with. By electric working the dangerous overhead pulleys and long belts would be done away with. It would not be difficult to transmit the power, and the mills might be many miles from the source of power. Steam or water power could be utilised, and there were systems in existence which did not stop if one portion broke down, and when the power was not wanted in portions of the works there was no loss of energy, because of the ease with which it could be turned off, and there was no loose pulley or strap to wear out. There was everything to recommend an electrical transmission plant. Waste heat from blast furnaces could be used miles away; steam boilers could be placed near the colliery to save haulage of coal; the power of a stream or river could be used; and hundreds of horse power could be conveyed along small copper wires; whilst the places could be lighted up by electricity. All this could be done well and cheaply.—The paper was favourably received; and after a brief discussion a hearty vote of thanks was accorded the author.

The Iron and Steel Institute and M. Schneider.—The *Times* Paris correspondent states that sixty members of the Iron and Steel Institute paid a visit on Friday, Sept. 27th, to Creuzot, to present M. Henri Schneider with the Bessemer gold medal, awarded for the first time to a Frenchman. The institute considered M. Schneider entitled to this honour by the importance of his ironworks, now employing 15,000 men, the steam hammer, moreover, having been first adopted there. Sir Lowthian Bell, in the absence of Sir J. Kitson, made the presentation. He commented on the progress of the Creuzot Works, which he had known since 1839, and complimented M. Schneider on having been the first Continental manufacturer to adopt the Bessemer steel process. M. Schneider, in acknowledging the honour, referred to the Channel bridge scheme, which he had been anxious to submit to English engineers, and he thanked the institute for its favourable reception of his paper on that subject. M. Périsse, vice-president of the French engineers, remarked that the inspection of Creuzot by the visitors had fully justified its reputation, and M. Barbe, chief engineer at Creuzot, spoke of the friendliness experienced by French engineers in England. The presentation took place at a lunch given by M. Schneider, who also provided a dinner for the visitors at Dijon on their way back to Paris. Several speeches were there made, and Mr. J. S. Jeans was warmly thanked for his successful management of the excursions made by the institute during its Paris congress. Mr. Jeans, in reply, attributed the chief merit to Mr. Henry Chapman. Mr. Whitwell described the Creuzot excursion as one of the most instructive and agreeable ever made by the institute.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

October 4th.

15573 Valves, A. W. Whieldon, Chelmsford
15578 Valves, C. Scott and H. Hodgson, Manchester
15579 Tube Expanders, C. Wicksteed, Kettering, Northamptonshire
15584 Steam Washing Machine, J. M. Martin, Edinburgh
15586 Opening Bridges, F. Hudleston, London
15599 Gas Furnaces, C. Thompson, London
15601 Bronzing Machines, C. Landolt, London*
15608 Steam Engine, C. Wells, London
15619 Regulator, G. Webb, London
15532 Cylindrical Printing Apparatus, R. Cresswell and B. Bloom, London*

October 5th.

15642 Paddle Wheels, W. O. Horsnaill, Birmingham
15648 Welding Pipes, W. P. Thompson, Liverpool. (C. W. Smith, United States)
15653 Hydraudic Engines, W. Wadsworth, London
15670 Break, J. Bovey and E. Sanders, London
15676 Motor, C. Barnett, Surrey
15677 Valves, J. Leclaire, London

October 7th.

15680 Adjustable Bearings, T. H. Thwaites, Huddersfield.*
15681 Portable Forges, T. H. Thwaites, Huddersfield.*
15692 Key Way Cutter, J. Walker, Leeds.
15699 Water Indicator, H. B. Beeny, Surrey.
15702 Injectors, J. A. Fletcher, S. Fletcher, and J. Fletcher, Ashton-under-Lyne.
15710 Packing, W. Armstrong, West Hartlepool.
15715 Hydraulic Apparatus, L. Sénaux, Manchester.
15717 Nails, J. J. Macky and J. Mitchell, London.
15720 Sawing Machinery, H. J. Haddan, London.
15721 Motors, H. Groswith, Glasgow.*
15722 Rotary Engines, H. H. Leigh, London. (P. E. Dou and M. J. A. Dou, France.)*

October 8th.

15753 Pressure Gauge, J. Reed, Isle of Wight.
15761 Elevators, W. P. Gibson, London.*
15762 Apparatus for Operating Elevators, W. P. Gibson, London.*
15770 Vapour Burners, H. H. Lake, London. (J. A. Cawles, United States.)
15781 Furnaces, W. A. Perry, D. de Kremen, and J. U. Shorter, London.
15790 Circular Saws, H. J. Haddan, London. (J. Vassaux, Belgium.)
15791 Band Saws, H. J. Haddan, London. (J. Vassaux, Belgium.)
15798 Pipe-making Machines, H. H. Lake, London. (G. V. Wagenen and J. Graves, United States.)*
15806 Air-compressing Apparatus, A. B. W. Kennedy, London.
15814 Metallic Packing, W. Cordts and J. C. A. Plett, London.
15824 Iron and Steel, G. Archbald, London.*
15829 Type-setting Machines, L. Dow, London.*
15833 Air Compressors, H. H. Lake, London. (U. Cummings and A. Gerry, United States.)*

October 9th.

15845 Lubricator, J. Scott, Bristol.
15865 Steam Generators, J. Jackson, London.
15867 Furnaces, C. Thompson, London.
15883 Explosives, H. J. Haddan, London. (L. Azémar, France.)
15885 Fluid Meters, S. Clayton, Bradford, Yorkshire.
15887 Brazing Metals, P. P. Craven, London.*
15889 Power Hammers, E. Gartze, London.*
15897 Steam Engines, G. F. Redfern, London. (B. C. A. de Landsée, France.)*
15905 Stop Valves, J. A. Hopkinson and J. Hopkinson, London.
15907 Connecting Gas, E. Nunan, London.

October 10th.

15921 Lifting Machines, J. Harrison, Stamford, Lincolnshire.
15924 Indicators, E. Hall-Brown, Hartlepool.
15930 Lathe, W. Barraclough and A. Rhodes, Glasgow.
15935 Valves, J. Bartlett, Bridport, Dorsetshire.
15942 Propeller Blades, J. Scott, Greenock.
15954 Hydraulic Power, F. Hamer, London.
15961 Pipe Joint, C. I. C. Bailey and F. Fitch, London.
15966 Fluid-tight Joints, J. A. Hopkinson and J. Hopkinson, London.
15972 Multiplying Gear, John Laidlaw, London.
15979 Lock Nut, H. A. Cutler, London.
15985 Rolling Mills, H. H. Lake, London. (G. Brisker, Germany.)*

October 11th.

15995 Packing, F. W. Durham, New Barnet, Hertfordshire, and E. S. Hough London.
16009 Oil Gas Apparatus, J. Lawson, Barnsley.
16012 Cycle Gearing, D. Jones, C. Wade, F. Kerby, and F. J. Underwood, Coventry.
16017 Counters, W. T. Shaw and A. Sydenham, London.*
16032 Propellers, A. Malta-Müller, London.
16038 Gas Governor, J. J. Purnell, London.
16039 Carbonate of Lead, J. H. Noad, London.
16040 Furnaces, J. Quinton, Glasgow.

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THE PRACTICAL ENGINEER,

NOVEMBER 8TH, 1889.

MR. LONGRIDGE AND AIR PUMPS.

IN a recent impression we published most interesting and suggestive remarks on "Horizontal Air Pumps" by Mr. Michael Longridge, extracted from the last Annual Report of the Engine, Boiler, and Employers' Liability Insurance Company, dealing with the principles involved in the successful design of such pumps, or, indeed, of any pumps required to produce efficient vacuum, which, from the circumstances of their arrangement, must move at the full piston speed of the engine itself. Mr. Longridge at once admits that the prejudice entertained by millowners against horizontal air pumps is justified too often by the inferior vacuum which they attain. He proves, however, that the weak point lies, not in the fact of their horizontal position, but in their necessarily high piston speed when attached direct to the tail ends of the piston rods of the engines. This mode of connection allows of great mechanical simplicity, and of course supplies the main reason for adopting the form. In nearly all horizontal air pumps the valves are acted upon vertically, and the real pumping action is performed by the water surfaces, which are caused to rise and fall by the displacement of the air pump plunger, and so act as vertical liquid pistons. The air pump bucket or plunger remains at all times immersed in water, which is supposed to follow its movement closely, and the horizontal water surface performs all the pumping action by its alternate rise and fall in a vertical direction. This arrangement is necessary in order to ensure smooth action without shock, which would otherwise be caused by forcing a confused mass of water and air through valves working in a horizontal direction. In a common form of horizontal air pump the piston moves to and fro in a cylinder, and the effectiveness depends absolutely upon the water following that piston closely without leaving a vapour space, which would virtually diminish the volume swept by the piston, and at the same time cause noise by concussion due to water-hammer action. In order to make this clear, consider the action of an ordinary pump of this type, with the piston or plunger running at say 600ft. per minute. The speed at the middle of the stroke will be about 942ft. per minute, and the water must follow the plunger at this rate, as it has all to enter at the end of the cylinder's diameter. The pressure required to give this velocity must exist in the condenser, and is caused by the combined action of the pressure of air within the condenser and the head of water above the plunger. From the laws regulating the discharge of liquids from or into circular orifices with sharp edges, the effective area of a cylinder which is not expanded is only 66 per cent of the apparent measured area, and therefore the velocity of water at the entrance to the cylinder in this case must be 1,412ft. per minute if it is to follow up the piston. Now, the pressure required to produce this velocity expressed in head of water is 8·6ft., so that if this velocity is to be attained the water must stand in the condenser at middle stroke at 8·6ft. above the centre line of the plunger. This is an impracticable height, which does not exist in actual pumps, and so the force necessary to supply the motion adjusts itself by a reduced vacuum. When the pump starts and discharges air and water from the condenser in sufficient quantity to produce such vacuum that the difference in pressure between the air and water vapour in the condenser and the column above the piston is 8·6ft. of water, or about 4lb. per square inch or 8in. vacuum, then no further reduction of pressure is possible, because the piston at once runs away from its following column of water. At the ordinary atmospheric pressure the best vacuum which such a pump could give would be under 20in., assuming the temperature of ejection at 100 deg. Fah. Immediately the difference between the condenser and the piston reaches 8in., then the water would cease to follow the piston, and so less air and water would enter through the foot valves, and the volume swept by piston would not be all effective; the vacuum would be the same as given by a pump of much smaller capacity.

To remedy this defect, Mr. Longridge suggests the use of expanded or flared entrances to such cylinders, and the reduction of piston speeds by driving from levers or bell cranks. He considers 400ft. piston speed the highest at which plungers should be coupled direct to the tail ends of piston rods, but even at this speed he considers it better to provide a reducing motion. No doubt Mr. Longridge's proposals are perfectly reliable and safe, but it seems to us that he has omitted to consider another way out of the difficulty, which has been used with great success many years ago, and is now used in horizontal pumps. We refer to that type of horizontal pump in which the plunger is not a piston working in a cylinder, but is a solid plunger working through a stuffing gland into the mass of solid water contained in valve chamber. The water has, in this arrangement, no occasion to acquire the velocity of the plunger in order to maintain complete contact with it, as it does not require to flow into a cylinder at all. It merely falls in as the plunger moves, and all round the circumference, as well as the end, no particle of water need attain a velocity at all approaching that of the engine piston. In the Allen engine condenser* this plunger terminated in a conoidal pointed end, and the water was displaced very smoothly, even at very high piston speeds. Indeed, considering the smoothness with which our high-speed steamships move through water at much higher speeds than 900ft. per minute, while the contact with the stern portion is kept up as it leaves the water behind it, by flow in from the sides, it seems very evident that properly-shaped plungers could move in water at very high velocities without loss. A steamer, for example, moving at 20 miles per hour through the water—and there are many of this speed now—is moving at the rate of 1,760ft. per minute. In looking over the counter of such a vessel at the water closing in at the stern, it is wonderful how little is the disturbance and difference of level required to make it close in. In the same way with a plunger moving in solid water, and designed with proper lines, if we may use the term, there can be no difficulty in keeping the water in contact at very much higher velocities than Mr. Longridge fixes as the limit. The plunger would require to be pointed, however, and not square-ended, or considerable eddy resistance would be occasioned.

The Worthington pumping engines have their pump plungers, even of the double-acting kind, moving in solid water, although the piston speeds are too low to require the ends to be pointed; and if double-acting air pumps of this class were constructed with pointed plungers, we do not doubt but that the horizontal pumps could be made to give thoroughly good results, coupled to the tail ends of the piston rods of engines running at the highest speeds now used. The only difficulty seems to lie in the increased length of air pumps required in order to allow room for a double-acting plunger to work through a long sleeve or collar in the middle of the condenser. This greater length, however, would be compensated for by the absence of connecting reducing gear, and the simplicity of the direct connection. In the Allen engine a stuffing-box was required, but that would be quite unnecessary for a double-acting plunger, as the Worthington engines pump against the highest pressures with such plungers without packing of any kind. The rise and fall of the column of water could be confined within very narrow limits, and the valvers would act as in an ordinary air pump. In high-speed engines with frequent rotations, in our opinion, the air pump foot valves should be arranged to be actuated mechanically, and the vacuum would be much improved, as, where rapid action is required, automatic valves working in water are by no means suitable. There is little doubt that even with vertical air pumps the vacuum could be improved upon by the use of positive mechanically driven valves.

OVERHEATING OF FURNACE PLATES.

Experiments have recently been made by M. Hirsch on the causes which lead to the burning out of boiler furnace plates, and as a result he corroborates the fact, long known to boiler experts, that under some circumstances oil in the interior of a boiler is highly dangerous. The interior of a boiler to be examined, was painted with the oil before filling and firing up in the usual way, and it was found that some oils so diminished the efficiency of contact between the water and the plates that in one instance the furnace plates rose to a temperature above the melting point of zinc when only evaporating 35lbs. of water per square foot of grate area. Further experiments were made with a tinplate vessel painted with different oils, and when filled with water it was found that the tinplate could be raised to a red heat by quite a small flame.

Valvoline does not give trouble except at very high rates of evaporation, and naphtha does not give rise to burning unless it is decomposed. It decomposes readily, however, if rapidly heated.

Linseed and colza oils occasion the worst results; vegetable or animal oils, which are readily decomposed, proved most dangerous; and mineral oils, which are not so decomposed, proved the safest.

THE POOR ENGINE-DRIVER.

In a letter to our esteemed contemporary, *Engineering*, a writer under the above signature makes an appeal to engineers in power on railways which, in our opinion, is most just and important. The writer is an engine-driver of many years' experience, and he complains of the liability to pass signals at danger, especially in foggy weather. He suggests that drivers should be assisted in their duty by the sense of hearing as well as sight, and gives as the result of his experience, that the noise of an engine at full speed is so great that nothing but a signal upon the engine itself can be really effective. He says: "The driver has also to keep his eye on the brake, steam and water gauges, and even the fireman, for although he does the firing and other work, the driver is answerable for all; but, sir, the driver's greatest enemy is the fog. It is during a fog, when a driver can see nothing, that he is put upon his mettle. Then the sense of hearing has to be brought into use, although it is the sight which is relied upon mainly. Unless the driver knew the different sounds of the various bridges that he passes under or over, he frequently would not know where he was. Some comical things have been put to work with distant signals to help the drivers—trumpets, bells, horns, rattles, and nobody knows what else besides, but they are quite useless unless they are attached to the engine, as the noise from the steam and the rattle of the engine prevent their being heard. The best and most effective way of calling the driver's attention to a signal is by means of the engine whistle. This could easily be done with a rod on the engine attached to the whistle, and a plate near rail attached to distant signal by wire, so that when a signal was at danger the whistle would be opened and the driver's attention would thereby be called, should his mind be on something else about his engine or train."

Now, this seems very true, and it is easy to see what an advantage would follow the use of hearing as well as sight to aid the driving of our fast trains, even in clear weather. The signalling by means of lever on the rails and the engine is not quite so easy a matter as this engine-driver believes. It is vitally important to increase safety and ease the great strain upon the engineers engaged in such severe and responsible work, and we hope, with the poor engine-driver, that some ingenious inventor may be able to solve the difficulty.

TRIAL OF AN ELECTRIC TRAMCAR IN BIRMINGHAM.

On Wednesday, last week, a public trial took place of an electrical car, which is described as the production of the combined experience of the Julien, the Sprague, and the Electric Power Storage systems. The car has been built by the Midland Carriage Co., and is stated to be capable of running 70 miles with one charge of the accumulators. The trial was made on the Sparkbrook line of the Birmingham Central Tramways Co. The motor is mounted on the front bogie of the car, and the accumulator cells are placed under the seats entirely out of sight. The gearing is of the helical kind, and is ingeniously adapted to allow the car to travel smoothly round the sharpest curves. The route taken

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*See *Practical Engineer*, vol. iii., p. 233.

was a severe test, as it included several very steep inclines, which the car easily ascended, loaded with passengers. The worst gradient was 1 in 17. The trip was considered very successful.

We trust that the difficulties of electric traction are now sufficiently overcome to permit of public use. We have heard of so many completely successful trips of accumulator cars, which so far have not reached practical use, that we hope against hope that this may be a success at last.

FIRE-BRICK LINED FIRE-BOXES FOR LOCOMOTIVES.

Our esteemed American contemporary, the *Railroad Engineering Journal*, in its October issue, contains an interesting article on this subject, from which we condense the following details and reproduce the illustrations.

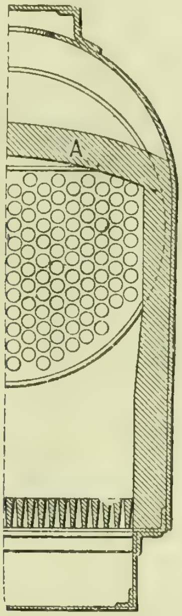


Fig. 1.

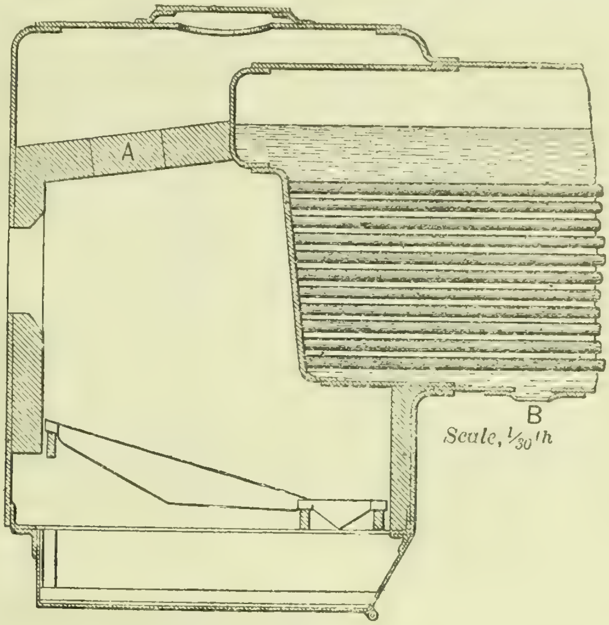


Fig. 2.

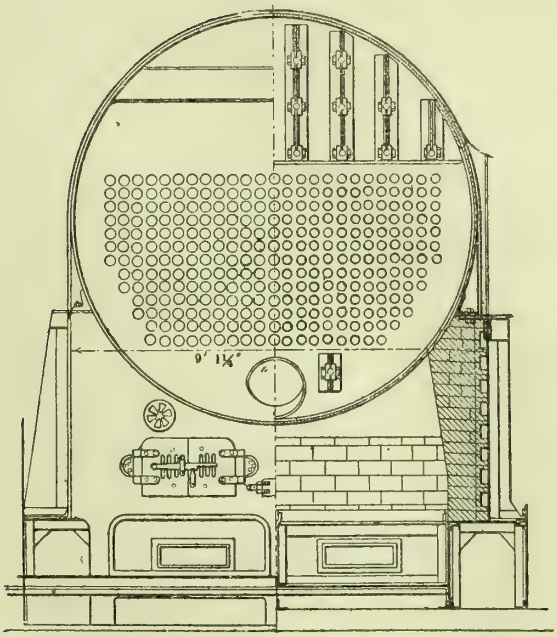


Fig. 3.

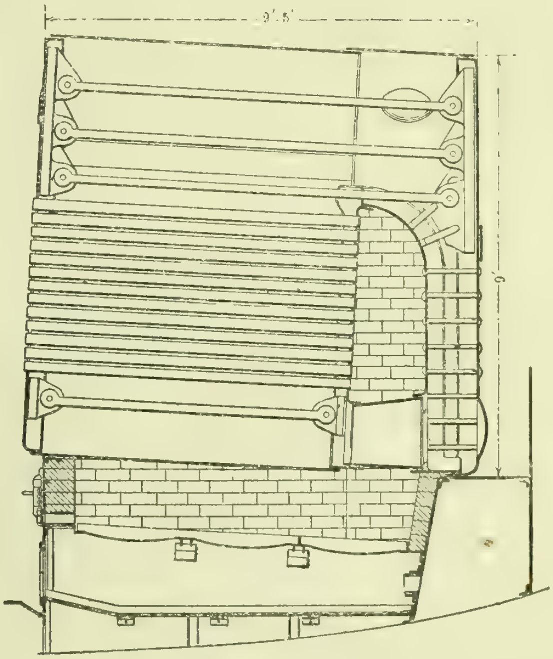


Fig. 4.

The most costly and the most troublesome part of a locomotive to make and to maintain is the fire-box. The inside plates are liable to crack, to corrode, and to burn out, and the riveted seams often leak. If we could dispense with all of these, we should certainly get rid of the most troublesome and expensive parts of a locomotive. A method of doing this has been proposed and experimented with by Mr. Stefan Verderber, inspector-in-chief of Hungarian State Railroads, who, so long ago as 1878, took this subject up, and after many experiments came to the conclusion that the fire-box as a steam generating part of the boiler was superfluous. This latter conclusion of Mr. Verderber has been received by locomotive men with the greatest incredulity. They say, what was admitted by him—that about half of the steam produced by a boiler is generated by a fire-box, and therefore, if you take that away, you dispense with the best part of your heating surface. It reply to this, it may be said that the fire-box is the hottest part of the boiler, and therefore, quite naturally, the surfaces immediately around the fire absorb more heat than is communicated to the water through the heating surface in the tubes. If one-half of the heat is communicated to the water around the fire-box, it is absurd to expect that there will then be as much left to be conducted by the tubes; but if the heat is not extracted from the fire in the fire-box, it will enter the tubes, and as Mr. Verderber remarked, "there is no reason at all why tubes should—at equal temperature and density of the burning gases—

evaporate less water per square foot of surface than the fire-box."

Having satisfied himself that the tubes would absorb the heat if it was not first extracted in the fire-box, he took an ordinary locomotive, with water spaces around the firebox, and lined it with plates covered with fire-clay, leaving an air space of about 2½in. from the fire-box plates, so that no heat could be conducted to them. It was found, with this arrangement, that a given weight of coal evaporated as much water as was evaporated before the change was made.

He then took an old boiler, the fire-box of which required renewal, and removed the inside plates, stay bolts, &c., and put a new tube plate in the back end, and lined the outside shell of the fire-box with plates covered with fire-clay, leaving a space between these plates and the outer shell as before, which was filled with mineral wool. This engine gave as good evaporate results after the change was made as it did before, but some trouble was experienced in keeping the tubes, which were of brass, tight in the copper tube plate.

Engineers, he says that, having occasion to renew some worn-out copper fire-boxes, he adopted a modification of the Verderber furnace for two locomotives, goods and passenger, fired with petroleum refuse, which have now been running over two years. One of these boilers is represented by figs. 5 and 6. He says further, that "from his own observations with these two locomotives he would have no hesitation in using the plan for all his boilers, as there is much about it which, in his opinion, recommends it for firing with liquid fuel." The modification which he refers to consists in replacing the brick arch, which forms the roof A A, figs. 1 and 2, of the Verderber furnace by a crown sheet A A, figs. 5 and 6.

This arrangement he found extremely satisfactory, and in the discussion which followed the paper, Mr. Urquhart said that the cost of maintenance was less, and the loss of time from the engine standing in the shops for repair was less, than half what it would be in the case of an ordinary fire-box.

The fear has been expressed that the outside of a fire-box lined with fire-brick would be much hotter than one surrounded with water. With reference to this, Mr. Verderber reported that he cased the fire-box with plate, and the space of about 2in. was stuffed with slag wool; consequently the temperature of the casing plate is much lower than that of a common locomotive. He reported that "one may safely put one's hand upon the casing plate of the locomotive while working, which one certainly could not do on other locomotives." He said further: "My apprehension that the brickwork would suffer by the shaking of the engine has proved unfounded, and the fire-brick lining of the combustion chamber stands perfectly well against the shaking of the locomotive as well as the temperature of the fire-box."

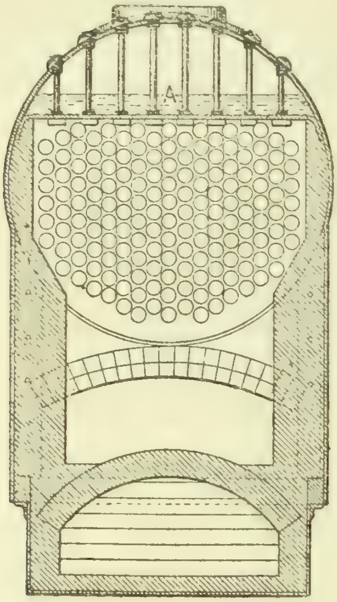


FIG. 5.

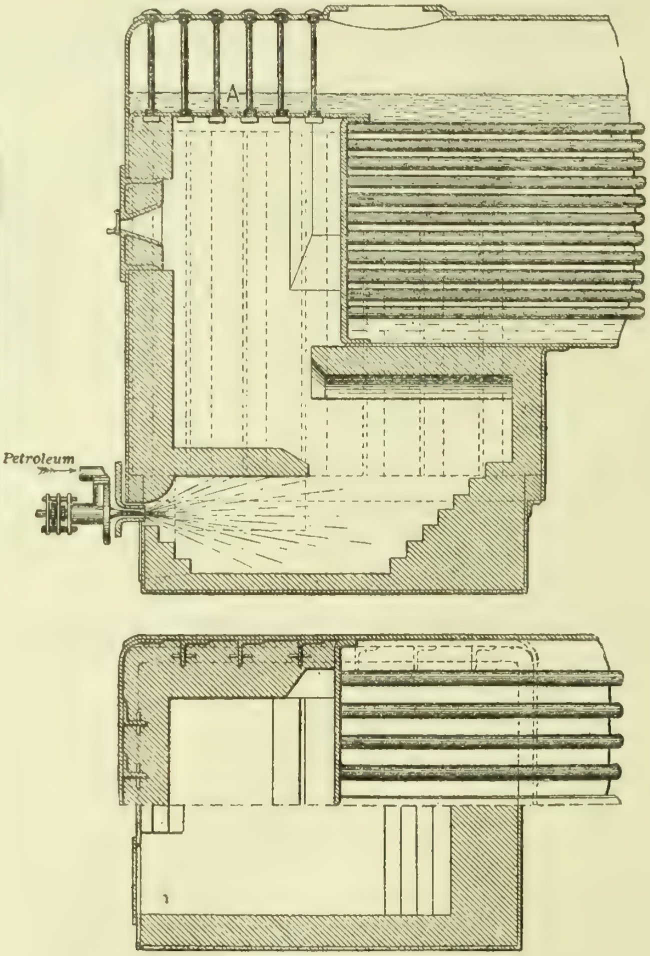


FIG. 6.

Being satisfied of the evaporative capabilities of such a boiler, Mr. Verderer then had a boiler (shown in figs. 1 and 2) constructed. In this arrangement, he says, "the cylindrical part of the tubular boiler reaches into the fire-room, as shown in fig. 2. The tube plate is composed of two parts, and has a play for expansion both in the vertical and horizontal direction." This fire-box, at first, was lined with the plate casing, covered with fire-clay, but afterwards a common fire-brick lining, with arched roof, was made, as shown in figs. 1 and 2, of which it was said that, at the time of writing, it had worked about five months, and had worn well. A careful set of experiments were made, which showed that this boiler gave practically as good evaporative results as boilers of the ordinary type, and there are now several steamboats and steamships which have fire-brick lined fire-boxes, and have been in regular use for a number of years. The United States twin-screw steam cruiser Chicago also has boilers of this kind, as seen at figs. 3 and 4.

In a paper on "The Use of Petroleum Refuse as Fuel in Locomotive Engines," by Mr. Thomas Urquhart (see *Practical Engineer*, Feb. 22, 1889), read before the Institute of Mechanical

With this evidence before us, it seems quite safe to conclude: (1) That with a slight increase in the tube-heating surface, a locomotive boiler with a fire-brick lined fire-box, and without water-spaces around the fire, will generate as much steam, and do it as economically, as an ordinary boiler will. (2) That such lining can be made to stand a reasonable length of service, and by lagging the outside the exterior is not as hot as the ordinary boiler. (3) That the first cost, and cost of maintenance of a firebox of this kind, is materially less than that of one of the ordinary kind with water spaces; that it is safer, will give better combustion, and that much less time is lost in making repairs than is required by the boilers now in use.

The advantage which would result from the use of such fire-boxes would be very great. It would reduce the locomotive boiler to a simple cylinder with tubes in it, and without any other bracing than that required for the upper part of the tube plates. This would be the simplest and cheapest form of boiler to make. There would be no flanging of plates, except for the edges of the tube plates and the base of the dome. Stay bolts would become a thing of the past, cracked and leaky fire-boxes would cease to worry boiler-makers, expensive plates for them would no longer be needed, and crown bars and their braces could be abolished.

INFLUENCE OF TEMPERATURE ON THE MECHANICAL PROPERTIES OF IRON AND STEEL.

The following article, by M. André le Chatelier, is translated from the *Comptes Rendus*:—

In studying the influence of temperature on the mechanical properties of iron and steel, I have only tested samples of cast metals. Puddled iron, tried in the state of fine wire, gives very irregular results, due to the impurities contained. The cast steel and iron used in these experiments were very pure; they contained from 0·35 to 0·40 per cent of manganese, with variable traces of carbon, from 0·05 (cast iron) to 0·80 per cent (steel of medium hardness). The experiments were made by applying the load at a uniform rate of 2,130lb. per square inch in a minute. The extensions were measured on a length of 5·9in.

The results obtained show that steel and iron act differently from all other metals. In the variations of their mechanical properties with the temperature there are three phases to be noted.

First phase, from 59 *to* 196 *deg. Fah.*—The resistance to rupture decreases from 52,200lb. to 47,360lb. per square inch for the cast iron, and from 97,700 to 91,880 for the steel. The specimens break with considerable reduction of area. The elongation was 30 per cent for the cast iron and 20 per cent for the steel. Between these temperatures iron and steel obey the same laws as other metals.

Second phase, from 212 *to about* 464 *deg.*—In this phase iron and steel have peculiarities not shown by any other metal. The breaking load remains sensibly constant, about 49,780lb. per square inch (cast iron) and 92,450 (steel). The extension is much reduced. It ranges between 7 and 9 per cent for the cast iron, and between 3 and 7 per cent for steel. The most noticeable fact in this period is the following: The extension, instead of being continuous, as with other metals, takes place by jerks, so to speak, varying considerably in amount, which are separated by periods during which the slightest stretch cannot be perceived. These abrupt extensions are accompanied by cracking, the sound of which is quite loud at 302 deg. The slightest jar produces this cracking sound. I have noticed these extensions by jerks in more than 200 tests, and I have found them at the same temperature in all the alloys of iron, even those containing only 2 or 3 per cent. The amount of carbon has a great influence upon the maximum elongations, which rarely exceed 2 per cent for the cast iron, and for the steel can attain 6 per cent, or 0·35in., for a wire 5·9in. long. I have proved that the abrupt elongations of the steel are not local, but occur simultaneously over the whole length of the wire submitted to test.

Third phase, above 464 *deg.*—At the commencement of this period the breaking load increases considerably; its value for cast iron is 62,870lb. per square inch, from 482 to 527 deg., and for steel 103,540lb. per square inch at 302 deg. and 107,950 at 572 deg. The elongation increases and becomes about 20 per cent at 572 deg. for both metals; rupture occurs with a slight reduction of section. The metal again obeys the laws of other metals; the elongation is continuous; the breaking loads increase above 572 deg.; the elongation by re-heating begins to manifest itself at 662 deg.

The periods of transition between the three phases are very short for the conditions under which the experiments were made, the passage from the first to the second phase being between 176 and 212 deg.; as to the third phase, at its commencement the elongations are at first discontinuous—a character of the second phase—and then become constant, indicating the passage to the third phase. But the initial temperatures of these phases are sensibly increased if the load is applied more rapidly. Thus, when the specimen is strained at the rate of 17,780lb. per square inch in a minute, the commencement of the second phase occurs at 248 deg.

Producing the rupture by a series of blows, the second phase for cast iron does not commence below 392 deg., with a zone of transition extending from 176 to 392 deg.; the third phase commences about 662 deg. This explains the popular belief that iron and steel have a maximum tensile strength and brittleness at 572 deg. They really are most brittle under blows at this temperature, but they also have the maximum tensile strength and ductility under loads gradually applied.

To conclude, two modifications are produced in the mechanical properties of cast iron and steel; one may be noted about 176 deg., and the second at 464 deg. These modifications depend both upon the temperature and the rate of applying the load—that is to say, upon the time of applying the strain and its amount. They must be due to the transformations caused by the simultaneous influence of the load and the temperature, being made pronounced as the temperature is raised and the metal subjected for a longer time to the action of the influencing causes.

These transformations are permanent, and are shown, after cooling, by a considerable increase of the elastic limit and breaking load, and by a noticeable diminution of elongation.

Among the many experiments of this kind which I have made, I will cite the following: Three wires of cast iron, 7·9in. long, were loaded with 42,670lb. per square inch, at a temperature of 59 deg., which caused an elongation of 9 per cent. In this condition they were heated, No. 1 to 165 deg., No. 2 to 201 deg., and No. 3 to 374 deg., each for a period of ten minutes. After cooling they gave the following results:—

Specimen.	Temperature.	Load, lbs. per square in. Elastic Limit.	Load, lbs. per square in. Breaking Load.	Elongation, per cent.
1	165	47,650	54,330	21
2	201	52,060	53,190	2
3	374	56,890	59,170	4

CALMING THE SEA WITH OIL.

A competition, the result of which will prove of great interest to the shipping community at large, has been instituted this year by the Dunkirk Chamber of Commerce, who had in view a practical trial of the utility of oil in aiding a ship to weather a storm. The first prize (£4) has been awarded to Captain Bruxelles, of the schooner Perle, who reports as follows: "On April 21, while off Portland, we encountered an east-south-easterly gale. We endeavoured to stand out to sea with closely-reefed sails, but were unable to clear the Westman Isles. We then resolved to attempt to pass between these isles and the mainland. The tempest was then at its height, the sea was making a clean breach over the ship, and we were in great danger of foundering. I directed two bags containing tow saturated with oil to be placed astern on port and starboard quarters. Almost instantaneously the sea moderated, and, although the swell was still heavy, no waves broke over the ship. I am in a position to state that a pint and a half of oil per bag is sufficient to calm the sea for about two hours."

MINING STATISTICS.

A Blue-book has just been issued containing summaries of the statistical information furnished in the reports of Her Majesty's Inspectors of Mines for 1888. During the year the number of persons employed in and about all mines in the United Kingdom of Great Britain and Ireland, together with the Isle of Man, amounted to 592,656, of whom 5,680 were women above ground. The number, exclusive of those employed on private branch railways and tramways and in washing and coking coal, was 578,417, of whom 5,357 were women, the aggregate increase being 10,391. The number of fatal accidents was 885, and the total number of deaths occasioned thereby 960, being an increase of four in the number of fatal accidents, and a decrease of 91 in the number of lives lost, compared with the totals of the preceding year, the ratio of fatal accidents and deaths to persons employed being 1·660 per 1,000, as compared with the higher ratio of 1·850 of the year 1887. This death rate is more favourable than in any preceding year. The number of persons employed in and about mines under the Coal Mines Regulation Act was 534,935, of whom 3,935 were women working above ground. In these mines there were 821 fatal accidents and 888 deaths, the number of accidents being nine less than in the preceding year, and the number of deaths 107 less. There was one fatal accident for every 652 persons employed, and one death for every 602 persons employed. These ratios are more favourable than in any preceding year. The total quantity of material wrought was 182,660,163 tons, of which 169,935,219 was coal and 8,635,032 ironstone, the rest being fireclay, oil shale, and other materials, being a total increase of 9,610,368 tons compared with the preceding year, the increase of coal being 7,815,407, and of ironstone 1,065,114.

SIMPLE AND COMPOUND STATIONARY ENGINES.

Mr. Walter Meunier has recently made some experiments with different types of stationary engines for the Alsatian Society of Steam Users. The results obtained may be of interest and value to steam users in this country. In the table which follows, the figures for each engine are the averages of five tests.

Comparative Table of the Performances of Single and Double Cylinder Engines.

Compound Engines.

Type of engine.	Indicated horse power.	Pounds of water hourly per indicated horse power.	Remarks.
Four slide valves	65	16·42	Cranks at 90 deg.
Wheelock	124	16·16	Single tandem.
Four flat slide valves	251	16·06	Cranks at 90 deg.
Wheelock	304	15·93	Double tandem.
Corliss-Berger	306	16·15	Cranks at 90 deg.
Average	210	16·14	

Single-cylinder Engines.

Type of engine.	Indicated horse power.	Pounds of water hourly per indicated horse power.	Remarks.
Corliss-Creusot	150	17·18	
,, ,, ...	154	17·27	
Corliss-Berger	212	16·99	
Old type Corliss	302	18·26	Double engine.
,, ,, ...	256	17·92	,, ,,
Average	215	17·52	

The difference between average consumption of steam in the two types is 17·52 – 16·14 = 1·38lb., or 8·55 per cent in favour of the compound engines. But the efficiency of the compound engines, as measured by a friction brake, was only 88·15 per cent of the indicated horse power, while that of the simple engines was 91·15 per cent, giving a difference in favour of the latter of 3 per cent; so that the actual economy of the compound engine was 8·55 – 3 = 5·55 per cent.

Comparing the simple Corliss-Creusot engine with the Wheelock compound, the difference in steam consumption is 17·18 – 16·16 = 1·02lb., 6·31 per cent in favour of the compound. Comparing two other engines of recent construction, the simple Corliss-Berger with the compound engine having four flat slide valves, the difference is 16·99 – 16·06 = 0·93lb., or 5·79 per cent in favour of the compound engine. The average economy of the compound engine, in these two cases, when the indicated horse power is compared, is 6·05 per cent, or only 6·05 – 3 = 3·05 per cent, when the effective horse power is made the basis of comparison.

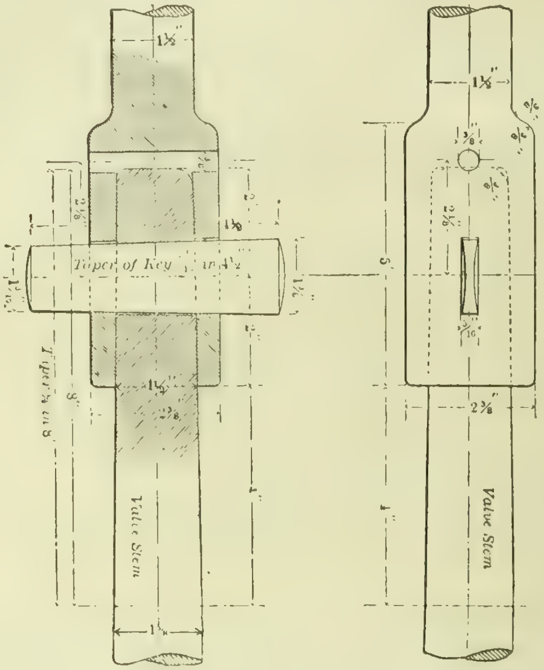
Some conclusions drawn from these experiments by Mr. Meunier are summarised below.

In each special case all the details must be carefully considered before deciding which type of engine is to be adopted. A calculation should first be made to determine whether the interest on the additional cost of the compound engine is greater than its annual saving in fuel. In the second place, the cost of attendance and supplies is larger for a compound engine than for a simple motor of the same power.

For large power the compound engine is preferable, both on the score of economy and smooth working when the load is constant. But if the engine is not to develop more than 250 horse power, Mr. Meunier thinks that the modern simple engine, which has been so much perfected of late, is to be preferred on account of its simplicity.—*Railroad Gazette.*

VALVE ROD AND STEM.

In the accompanying illustration we show the form of connection between valve rod and stem which is used on the Chicago, St. Louis, and Pittsburgh Railway. We do not reproduce this as something entirely new, but because we believe it a much better form than the one generally used. It will be seen that the stem has no shoulder, but that it "bottoms" in the socket on the valve rod. When the stem of the yoke is worn by the packing, and it becomes necessary to turn it down, such an operation does not make any change in the fit, whereas in the common form it reduces the small shoulder which prevents the stem from working in too tight. In the stem shown it simply turns off a portion of the taper which extends beyond the socket. The hole through which a key is inserted to drive out the stem saves much valuable time when the parts are being disconnected, and is of special value when the stem is broken or when the engine must be quickly disconnected.—*The Master Mechanic.*



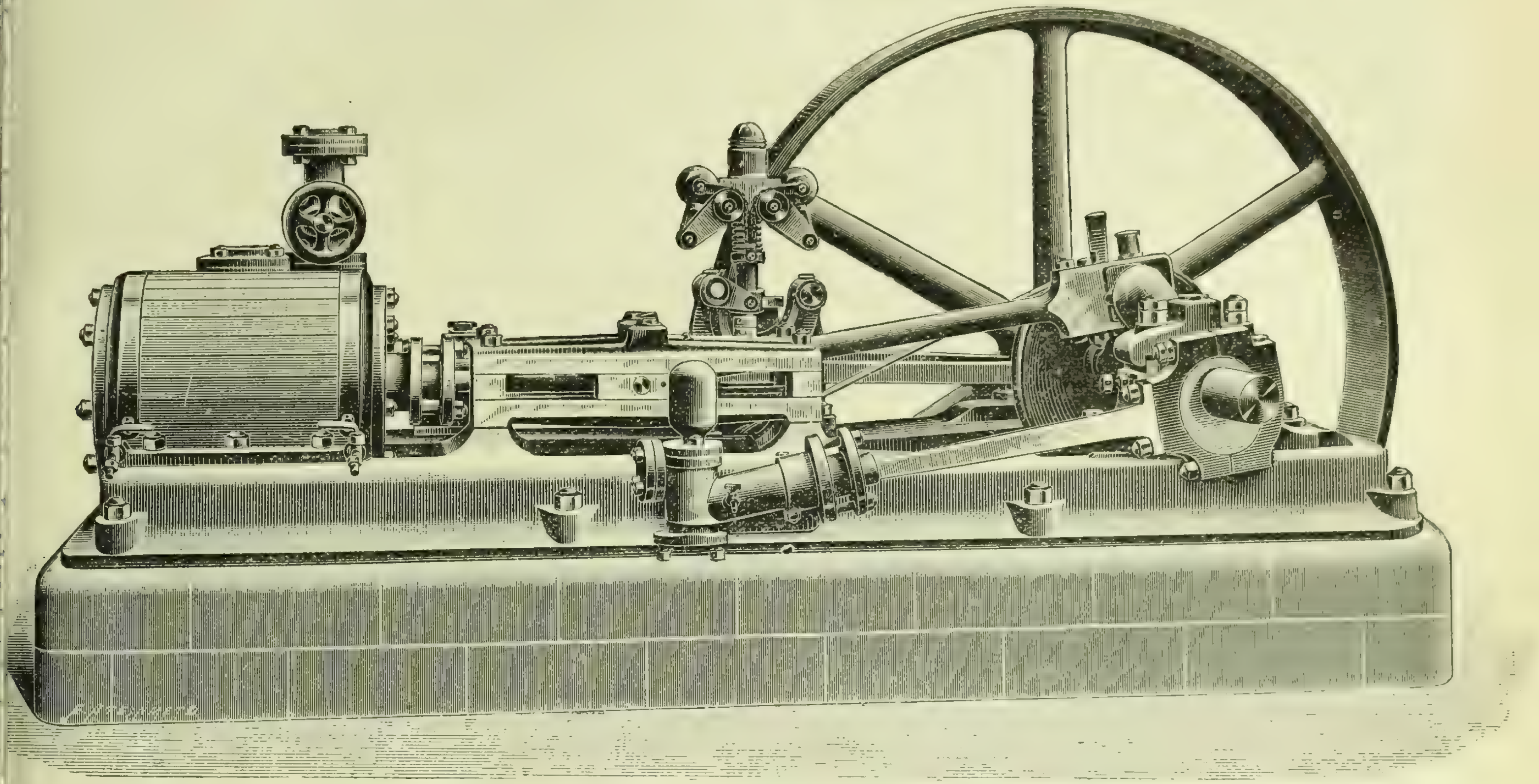
A STEAMER FOR THE MANCHESTER SHIP CANAL.

On Saturday, October 26th, Messrs. Wigham, Richardson, and Co. launched from their Neptune Works, on the Tyne, a steel screw steamer, built for the Manchester and District Shipping Company, to the order of Messrs. George Tweedy and Co., for which firm the builders have already constructed seven vessels. The vessel is named the "Fonar," and is classed 100 A 1 special survey at Lloyd's on the spar deck rule, with poop, bridge, and forecastle; and will carry nearly 6,000 tons measurement of cargo, besides nearly 300 tons of bunker coal. She has about 1,000 tons of water ballast in deep tanks available for cargo or bunker and under the tunnel, according to Christie's patent, as well as in the engine-room. She is fitted with all the latest improvements to facilitate both the handling of the ship and the loading and discharging of the cargo, among which may be mentioned a powerful steam windlass, steam steering gear, steam winches, and a complete set of shifting boards for grain. The 'tween decks are fitted throughout with side lights for emigrants. The masts are constructed in such a way as to make the steamer suitable for the Manchester Ship Canal. The engines have also been constructed by the same builders, and are of the quadruple-expansion type (Tweedy's patent), being, we believe, the first set of quadruple engines built on this principle. They have four cranks (not of the tandem type), and are fitted with the most modern appliances for supplying distilled water to the boilers.

As heat engines, the best types of modern gas engine are more efficient than any other motor, converting about 24 per cent of the heat given them into indicated work.

TEN-HORSE POWER HORIZONTAL ENGINE.

CONSTRUCTED BY MESSRS. CHARLES BURREL AND SONS, LIMITED, ENGINEERS, THETFORD.



Messrs. Chas. Burrel and Sons, Limited, engineers, of Thetford, have recently produced a very substantial horizontal steam engine from entirely new patterns, among their other well-known specialties. We here illustrate the 10 H.P. nominal engine, and from the illustration it will be seen that the engine is of massive and simple construction. The 8 and 10 H.P. nominal sizes are made with bent cranks, but disc cranks are used from 12 H.P. upwards. The bed is cast iron, of the box pattern, conveniently arranged to receive the cylinder, &c. The cylinder is fitted at both ends with brass drain cocks, having packed glands. A patent sight-feed lubricator is provided for the thorough lubrication of both valves and cylinder. Felt lagging is used, as a non-conducting material, around the cylinder, which is covered with polished mahogany, secured by brass bands. The crosshead is of steel, with wrought-iron case-hardened pins, and the crank shaft is of mild steel, supported at the outer end by a wall bearing and bracket or pedestal. The engine is fitted with a continuous acting feed pump and Burrels' patent automatic expansion governor, which we hope to describe fully in an early issue. This governor acts upon a second slide valve working on the back of the main slide. The whole engine is most creditable in its details and workmanship, and will, without doubt, be much appreciated by users.

COMPOUND LOCOMOTIVES.

At a meeting of the Western Railway Club, Chicago, U.S.A., October 15th, Mr. D. L. Barnes, of the *Railroad Gazette*, read the following paper :—

It is to be regretted that a subject so important has to be limited to the short time which can be allotted to subjects before this club at any particular meeting, and therefore, realising the great amount of time consumed in even the shortest mathematical discussion of such a subject, and believing that in the locomotive class of compound engines mathematical discussion is neither necessary nor as fruitful of valuable results and conclusions as simpler investigations made with the aid of the actual performance of common locomotives,'this short review of the subject has been arranged in simple form. When this topic is first presented to a railroad man, his impression will often be that it is another "craze" which will soon die out like the Fontaine, Shaw, bicycle, and other schemes to revolutionise locomotive construction. One cause of this is that we have all held till recently the opinion, taught by the engineers now advocating compound locomotives, that no advantage could be obtained by compounding an engine unless a condenser could be attached to the low-pressure cylinder, thus securing the assistance of a vacuum. For years this was the theory of all, and to-day it is still the theory of many. The correction of this error has been the result of the labours of the United States navy, the Massachusetts Institute of Technology, the Stevens Institute, the Sibley School of Arts, the Westinghouse Engine Co., and other experimenters on this side of the ocean, and of many experimenters, particulurly in marine engineering, on the other side.

The simple reasoning which leads to a belief in the economy of using a low-pressure cylinder without a condenser is as follows : We all know that in any simple engine with one cylinder it is more economical to cut off steam at one-quarter than at one-half stroke, also that it is more economical to cut off at one-quarter than at one-eighth stroke. We know this, because—using the most conclusive reason—by actual trial we have found it to be so. Abstract theory is unnecessary to tell us this. By actual trial, then, we well know that there is, in any cylinder, a point at which if the entering steam is cut off the greatest economy will result. If the steam is cut off earlier than this point, or later than this point, then the work done per pound of steam used will be reduced. We also know beyond dispute that the total work which ought to be obtained from the steam used can only be secured by an increase in the amount of the expansion of that steam.

Hence we find ourselves in this predicament: To obtain the greatest amount of work from a given amount of steam, it is necessary to cut off at the earliest point in the stroke which will assure just sufficient pressure at the end of the stroke to blow the fires. But—and therein the difficulty lies—we have found by experiment that the cut off at such an early point results in a loss from various causes. These causes have large names, and, owing to the dispute existing regarding which one of the causes, or sets of causes, is the chief source of the evil, it is best to neither name nor consider them in a simple discussion of the subject. It is enough for all practical purposes connected with the locomotive for us to know that the most economical cut-off in locomotive cylinders is not the one which will result in the reduction of the steam pressure at the end of the stroke to about the atmospheric pressure or anywhere near it.

It is the compound locomotive that is at present offering a solution of the problem, and a means of harmonising the conflicting conditions. With it, the steam can be expanded to that pressure which will just blow the fires without using in either cylinder a cut-off that departs from the economical point to such a considerable amount as it would in the case of the simple engine. For instance, let us suppose that the one-quarter cut-off is found to be the most economical, then during the most economical operation of one cylinder the steam will be expanded four times before being exhausted. If two cylinders be used, it will be expanded four times in the first and four times in the last, or in both eight times. The terminal pressure will then approach nearer to that desired without having in either cylinder reduced the cut-off much below the most economical point. It must not be thought that the economy, when two cylinders are used, is twice as great as before, because it is not so, either from a mathematical calculation or from results of actual trials. The best gain in economy that can be assured in a properly-designed compound locomotive as a result of greater expansion, and from other savings dependent upon such increased expansion, is not far from 15 per cent.

The principal advantage resulting from an arrangement of two locomotive cylinders in series, one after the other using the same steam, is, as has just been stated, the possibility of expanding to a more advantageous degree without departing materially from the most economical cut-off in the cylinder. But there are other advantages resulting simply from the use of two cylinders.

The use of two cylinders permits the cut-off to be longer in either where the speed is high and but little work per revolution is required. This longer cut-off for the same work results in the use of the ordinary link motion at a point where its action is more satisfactory. Moreover, the compression is much reduced. The back pressure in the low-pressure cylinder is more nearly under the control of the designer of the locomotive, and exists more as the result of the use of the exhaust to blow the fires than because of the cramping of the port opening through which the exhaust must pass to reach the nozzles. A favourite way of running compound locomotives at high speeds has been to place the low-pressure valve motion in full gear, and cut off as desired in the high-pressure cylinder. While this is not a method that would be considered scientific from a purely mathematical standpoint, yet it has some advantages, not the least of which is reduction of the amount of compression and back pressure in the low-pressure cylinder, and a tendency to offset some of the bad features of the Stephenson and other link motions when the engine is revolving rapidly.

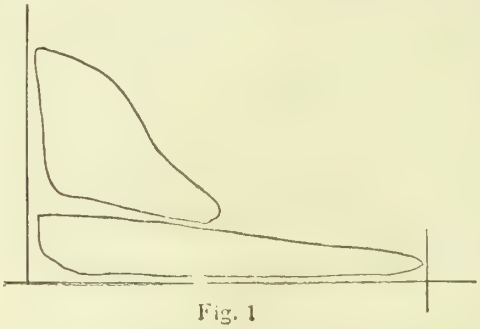


Fig. 1

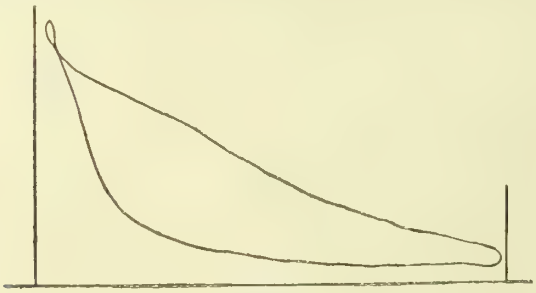


Fig. 2

Two indicator cards shown here, one of which is taken from a compound, the other from an ordinary locomotive, may render this point clearer. Fig. 1 shows a card taken from a compound locomotive at a speed of 50 miles per hour with a high-pressure cut-off of 50 per cent, and low-pressure cut-off of 73 per cent. Fig 2 shows an indicator card taken from an ordinary locomotive at 50 miles per hour at a cut-off of 25 per cent. It will be noticed that the steam line in fig. 1 from the compound locomotive is much superior to that on fig. 2 from the ordinary locomotive. The card is fuller, showing a better valve opening, and the expansion line is more pronounced. The back pressure is less in the case of the compound, but as these cards were taken from different locomotives they are not comparable in this respect, because different amounts of back pressure may have been needed to blow the fires in the different engines, yet the difference shown is about what we may expect from indicator cards taken from the same engine before and after compounding, no other changes being made in its design. An important difference between these indicator cards lies in the compression line. In fig. 2 the valve commences to close the exhaust ports about midway on return stroke, and the resulting compression cuts off a large corner of the card, while in the case of fig. 1 from the compound engine the exhaust port closes suddenly, almost at the return stroke, and the position of the compression line reduces but little the total area of the card. Fig. 1 also illustrates the results of the favourite method of running compound engines at high speed by dropping the reverse lever of the low-pressure cylinder until the cut-off is nearly at a maximum. This condition places the valve gear in the best position for promoting the exit of the exhaust from the cylinders, and removes to a considerable extent one of the worst defects of the ordinary type of engine.

Another advantage, and one of the most practical, resulting from the use of two cylinders in series on a locomotive, is the great efficiency of the boiler as a result of a decrease in demand upon it for steam. This is brought about by the fact that the steam in a compound engine is used to better advantage, and each pound of it does more work than each pound in the case of the common locomotive. Therefore, for the same trainload less steam is used and less demand is made upon the boiler. This is no small advantage, as can be seen when one remembers how hard our locomotive boilers are crowded in comparison with the boilers used in stationary service.

We have now seen what are the three principal improvements which we hope to make by the use of two cylinders connected so that the steam of one enters the other instead of being discharged to the atmosphere. These improvements, as before stated, are, when simply expressed : (1) More economical use of the steam taken from the boiler, because of greater expansion ; (2) use of the steam to greater advantage, for the reason that the link motion is operated under more favourable conditions ; (3) a decreased demand upon the boilers now in use, which, we all believe, will result in an increase of economy in the consumption of fuel.

The question now naturally arises, "To which of these three advantages does the compound locomotive principally owe its usefulness?" Only one answer can be given : "We do not know." It is the combined effect of them all, and experiments have not been made which show wherein is the greatest increase in economy. Of course, mathematicians are ready to show that the advantage is due to the increased expansion ; but, although familiar with their deductions, I am myself unable to say that, in the case of the locomotive, the principal part of the economy lies in that particular improvement. Therefore, being thus in doubt regarding the cause of the increased economy, it would be advisable for those who are contemplating the trial of compound locomotives, while perhaps not avoiding the study of the mathematical, or what might be called the theoretical, side of the subject, yet to incline rather to the more practical and tangible side, and proceed to make all deductions from the actual indicator cards taken from the present engines, and endeavour as much as possible to remove, while making the new designs, the three great evils of high-speed locomotive cylinders and valve gear, viz. : The enormous compression, the high back pressure, and the marked wire drawing of the entering steam.

Other advantages than those mentioned here will present themselves to you as a result of the decrease of the demand for steam from the locomotive boiler in its regular work, not the least of which is the reduction of one of the greatest evils in locomotive boilers as now constructed and operated, viz., the large amount of water accompanying and suspended in the steam furnished the cylinders. All of the water which enters a locomotive boiler is not necessarily evaporated into steam. In some cases as much as 50 per cent can go over to the cylinders in the form of water as a result of a much forced draught and a contracted steam space above the water in the boiler.

It may be interesting to know what is the simplest form of a satisfactory compound locomotive that has been devised. Such is the two-cylinder type, and in any case, where the cylinders are rather large for the work to be done when the engines are worked in the ordinary way, there is no need, in order to produce a compound from the common type, to change both cylinders. One can remain and a larger one be added on the opposite side, leaving all parts of the link motion and valves the same as before. The exhaust of one cylinder must be conducted to the steam passage or steam chest of the other. This had better be done by passing the exhaust from the high pressure around the interior of the smoke arch in such a way as not to interfere with the cleaning of the tubes. This pipe will form a reservoir, which, if made of copper, and of sufficient dimensions to allow the steam to pass from one cylinder to the other without difficulty, will be large enough to act as a satisfactory receiver, and that detail, so perplexing in marine work, will, in this case, require no further consideration ; and, in addition, being made of a good conductor, it will absorb from the hot gases coming through the tubes a large amount of heat which would otherwise be wasted.

The simple changes needed in the cylinders and steam connections to produce the compound from the common type of locomotive are neither difficult to make nor to decide upon, but those required in the valve gear to produce the best results do require, while inexpensive to make, much consideration with reference to the service to be required of the engine. It is true, however, that good results will be obtained if little or no change is made in the valve gear when changing to double expansion ; yet if the maximum saving is desired, the valve gear must be well considered. If the locomotive is for fast express work, then the gear must be arranged to produce cards not unlike the one shown herewith ; if, on the contrary, the engine is intended for switching or for slow freight, then the steam must be differently used to obtain the maximum power and efficiency. A consideration of the subject with reference to obtaining the best results leads almost directly to the conclusion that two reversing levers are necessary, but when the work for a given locomotive is nearly of a constant nature there is probably little or no need for making the valve motions independent, even when the maximum economy is desired.

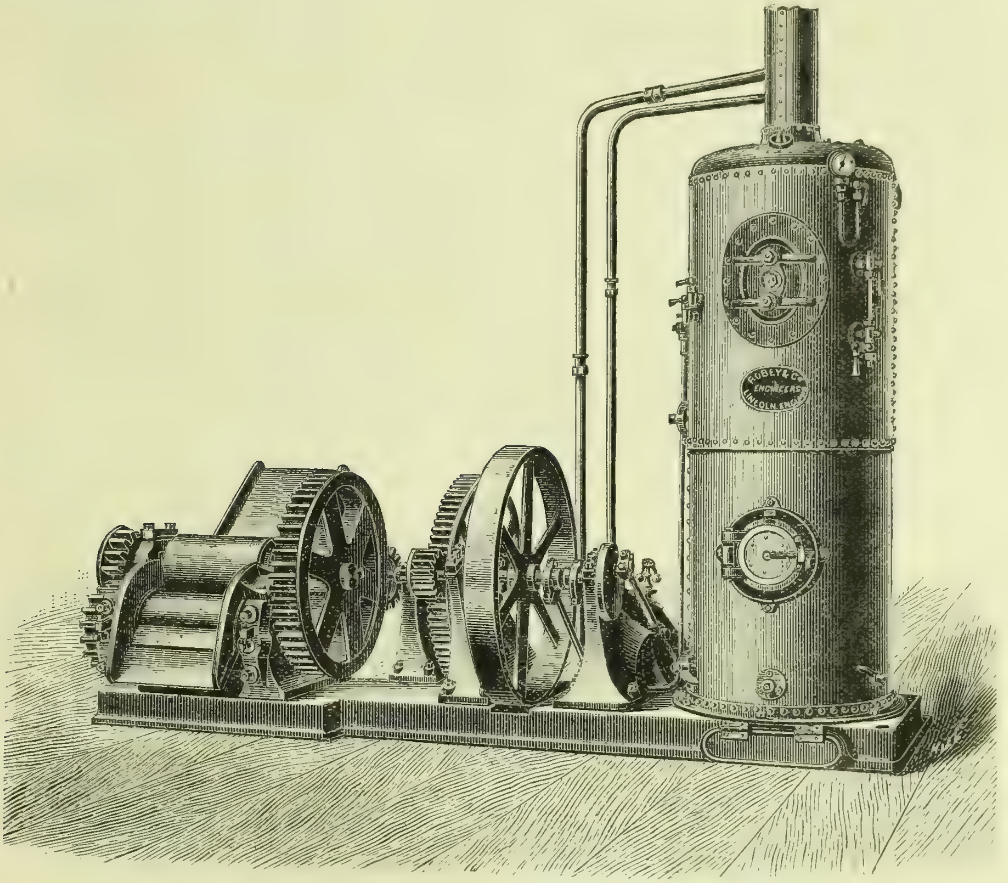
In taking up this question seriously, one will be confronted with a number of starting valves for the admission of high-pressure steam to the low pressure cylinder when starting the trains. But happily this detail has a simple aspect when viewed from the side of the present American practice of starting trains with the throttle lever, the reverse lever being meanwhile in full gear. The problem came up on the German state railroads, where the cost of construction is carefully considered, even more so than in the United States. Labour is cheap there, but all that is possible of the money collected by the Government is needed for the army, and they have none to spare for locomotives. It was settled thus: When trains are to be started the reverse lever is dropped "down in the corner," as it is called here, and in so doing an extension of the reach rod beyond the top arm of the reverse shaft is caused to push the handle of a small valve, and steam is admitted from the boiler direct to the low-pressure cylinder. This valve, having a small opening only, reduces the steam sufficiently in pressure to make the power of the large about the same as that of the small cylinder. As soon as the train is moving off at about three miles per hour, the reverse lever is hooked up about two notches, which closes the small valve just mentioned, and the engines are working compound. Thus, on the German roads the problem of starting trains is solved simply and easily. The engineer notices no difference in the number of motions required, whether he is working a compound or a single engine, and, what is more suggestive of simplicity, no additional handles are placed in the cab.

Having at hand a large amount of data relative to the performance of the compound locomotive, together with indicator cards taken therefrom and drawings of the same, it is to be regretted that more of the many interesting topics in connection with this subject could not be presented; but it may be that the drawings and illustrations which I have brought here to-day for the inspection of the members will offset the omission of further argument from this paper.

In reading over the foregoing, I find that in cutting down the paper I have eliminated a very important point; that is, with respect to the relative capacities of the high and low pressure cylinders. Various ratios of one cylinder to the other have been tried, varying from 2 to 1 to 3 to 1. A short conclusion drawn from the results of the trials may be stated, without departing from the truth, as follows; (1) The capacity of the high-pressure cylinder compared with the low-pressure cylinder should depend upon the character of the service for which the locomotive is intended. (2) In general, unless the low-pressure cylinder is greater than twice that of the high-pressure cylinder, changes will be demanded in the valve motion in order to gain the maximum economy and greatest efficiency. (3) If two reverse levers are used, thus rendering the cut-offs in each cylinder independent of the other, then the action of the locomotive in hauling trains, particularly at high speed, will not be unsatisfactory, even when the cylinder ratios are not such as to allow the maximum economy in service.—*Railway Gazette.*

SUGAR MACHINERY.

Messrs. Robey and Co. have paid much attention to the manufacture of first-class machinery for the extraction of sugar from the cane, and the mills made by them have earned the highest praise from sugar cultivators who have used them. The mill illustrated below is specially designed for small plantations. The rollers are 12in. in diameter, by 18in. long, and are driven by a train of strong gearing actuated by an engine of three horse power nominal, but capable of working up to 16 H.P. The whole is fixed on a strong cast-iron foundation plate, by which means its erection is much facilitated. The foundation plate is made in two parts, for the sake of greater ease in transit. Steam is supplied to the engine by a vertical cross tube boiler, which has an enlarged firebox suitable for burning wood, megass, or other inferior fuel. The whole design and workmanship is completed in Messrs. Robey and Co.'s well-known careful and efficient manner.

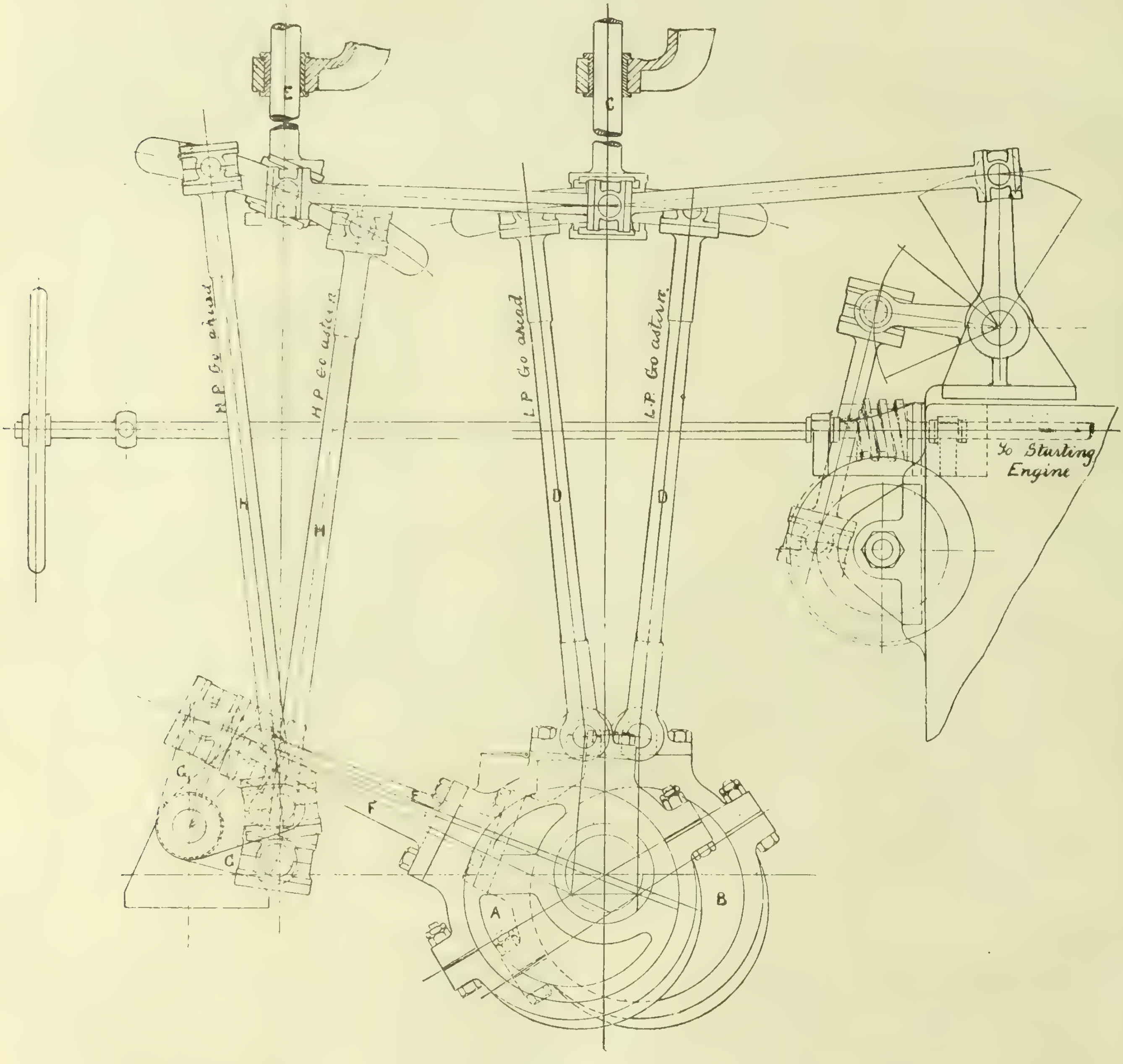


COMBINED ENGINE AND SUGAR MILL.

At a recent meeting of the City of London College Science Society, Mr. Henry Adams, M.Inst.C.E., read a paper on "Apparatus for Weighing." After describing in detail the principles upon which various lever balances depended for their accuracy and sensitiveness, he showed the application of compound levers to an ordinary weighbridge, and of a steelyard to coal weighing cranes. He then described the Duckham and other suspended weighing machines, and closed by a reference to the latest invention for weighing goods while suspended upon a crane, that of Mr. Shapton, of the firm of W. G. Armstrong, Mitchell and Co. The lecturer believed that this invention was based upon sound principles, and contained in itself the elements of success.

QUADRUPLE EXPANSION ENGINES OF THE STEAMSHIP SINGAPORE.

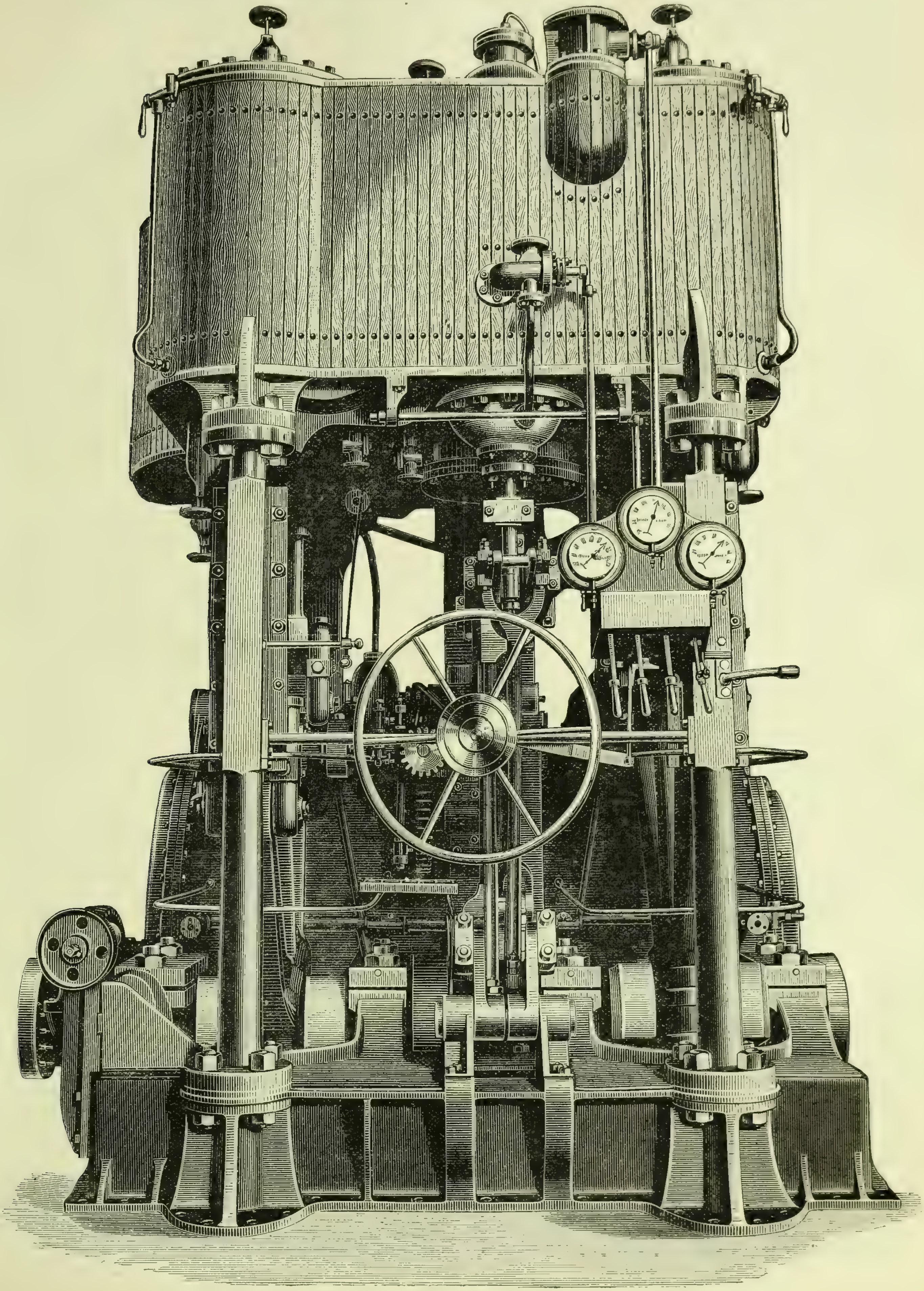
In our last issue we gave a description of the ingenious quadruple expansion engines of this vessel, constructed by Messrs. Fleming and Ferguson, of Paisley, together with a set of indicator diagrams, and an account of the tests for power and fuel consumption. We now give a front view of the engines (see p. 767), and an illustration showing the details of the valve gear. The valve gear is very simple, and consists of two sets of ordinary link motion worked by one go-ahead eccentric A and one go-astern eccentric B. The valve spindle C, which carries the piston valves for the third and fourth cylinders, is worked direct by the quadrant rods D D, jointed to the eccentric straps as shown. The valve spindle E, which carries the piston valves for the first and second cylinders, is worked by eccentric rods FF, fixed to the eccentric straps, the direction of motion being changed by bell cranks G G, and transmitted to the quadrant through quadrant rods H H. Reversing is effected either by steam starting engine or by hand, as shown in the diagram. A few other dimensions of this interesting engine may be given before concluding. The proportions of the side levers are such that the stroke of the air and other pumps is reduced to 1ft. 6in. In the Singapore there is only one set of pumps worked of the after engine; the air pump is 21in. diameter, and the double-acting circulating pump 11½in. diameter. Both feed pumps are 3½in. diameter, and the two bilge pumps 3¾in. diameter, all having 1ft. 6in. stroke. In this vessel the tails of the forward levers are used for working auxiliary pumps. The boiler is of the standard marine multitubular type, 14ft. 6in. diameter by 18ft. long, and contains six furnaces—three at each end. It is constructed of Siemens-Martin steel, and works at 165lb. per square inch, tested by hydraulic pressure to 330lb. per square inch. The whole engine is an admirable example of careful design and good work, and is well worthy of careful study by the practical engineer because of the many novel and successful departures in its details.



VALVE GEAR OF S.S. SINGAPORE.

Chromium Steel Armour-Plating for War Vessels.—A new invention in armour plating has lately received much attention at the hands, not only of our own naval experts, but in France. Long ago wrought iron was found to be too soft to withstand the impact of the modern sharp pointed steel shot, and hard steel was found to be so shattered by repeated blows from the armour-piercing projectiles as to be very quickly destroyed. To keep the steel together wrought iron was then welded to the backs of the plates, and under the name of compound armour it forms the costly defences of our battleships, costing some £80 a ton. The new armour, however, is a new alloy of steel with chromium and an unknown substance, and it is said to have a tenacity equal to wrought iron, combined with the hardness of the best tempered steel. If the invention should justify its existence, it might revive the controversy of guns versus armour, wherein at present the gun is victor.

QUADRUPLE EXPANSION ENGINE OF S.S. SINGAPORE.



THE MANUFACTURE OF THE ALLOYS OF ALUMINIUM IN THE ELECTRIC FURNACE (COWLES' PROCESS).

(*Continued from page 752.*)

I will now describe the English works of the company at Milton, Staffordshire. These, the first electro-metallurgical works established in Europe, are situated near Milton Station on the North Staffordshire Railway, with which system they are connected by a siding, and also abut on a branch of the Trent and Mersey canal—thus affording facilities for cheap transit of raw material, coal, and finished products. The experience at the Lockport works showed conclusively that great economies were to be expected from increasing the size of the furnaces and the strength of the electric currents; but no current of more than 3,000 ampéres had been used up to the time the Milton works were planned. Mr. Cowles then prepared a specification for a dynamo to give a current of 5,000 ampéres at 60 volts., and eventually Messrs. Crompton's designs were accepted. This dynamo is of 500 horse power, and furnishes a current of 5,000 to 6,000 ampéres, with an E.M.F. of 50 to 60 volts. It is said to be the largest machine (at least in regard to quantity of current) in England, and probably in the world. The boilers supplying steam to the works are of the Babcock-Wilcox type, representing 600 horse power, and are fitted with mechanical stokers; by this means one man can easily attend to the generation of steam for the whole works. The main engine, used for driving the dynamo only, is a compound condensing horizontal tandem engine, made by Messrs. Pollitt and Wigzell, of Sowerby Bridge, and is well worth noting for its beautiful workmanship. Its motion is indeed so silent that, with your back to it at the moment of starting, you cannot tell whether it is in motion or not. It is of 600 horse power, and is provided with automatic expansion gear; and the centrifugal governor maintains the speed at 76 revolutions. It is needless to say that work of this kind involves rapid fluctuations of load, and as an additional precaution against racing, the engine is fitted with Tate's electrical stop valve, which stops the engine automatically if the speed exceeds a certain limit. It can also be stopped from various points in the engine and furnace rooms by means of push buttons connected in parallel with the main circuit leading to the Tate's valve. The engine has a 23in. high-pressure and a 43in. low-pressure cylinder, the stroke is 5ft., the average steam pressure being 85lb. The flywheel is 20ft. in diameter, and weighs 20 tons; it is geared to the dynamo by 18 driving ropes, so that the dynamo makes five revolutions for each revolution of the engine.

From the dynamo the current is led by copper bars to an enormous "cut out," calculated to fuse at 8,000 ampéres. This is probably the largest ever designed, and consists of a framework carrying 12 lead plates, each 3½in. broad by $\frac{1}{10}$in. thick. From this it passes into the furnace rooms; a current indicator is inserted in the circuit consisting of a solenoid of nine turns (this was cut out of a cylinder of cast copper by means of a parting tool, in a screw cutting lathe). In the solenoid is an iron core suspended by a spring; the movement of this is communicated to two pointers, one dial being placed in the engine-room, the other in the furnace-room. The range of the indicator is such that the entire circle of 360 deg. equals 8,000 ampéres.

There are two furnace-rooms, each containing six furnaces: the first room contains the bronze furnaces, in which is carried on the manufacture of aluminium copper and silicon copper; the second is devoted to the production of ferro-aluminium. The furnaces are rectangular in form, built of firebrick, the internal dimensions being 60 inches by 20 inches by 36 inches; into each end is built a cast-iron tube through which the carbon-electrodes enter the furnace. Each electrode consists of a bundle of 9 carbons, each 2¼in. diameter, attached to a head of cast iron, for ferro-aluminium, or cast copper when cupro-aluminium is made. Each carbon rod weighs 20lb. Quite recently it has been possible to obtain carbons 3in. diameter, weighing 36lb.; these are employed in bundles of 5. The "head" of the electrode is secured to the copper rods or "leads," which can be readily connected with or disconnected from the flexible cables supplying the current. Each cable is secured to slides running on omnibus bars of copper overhead, so that it can be brought into position opposite the furnace to be used. The electrodes are arranged so that it is possible, by means of a handle and screw, to advance or withdraw them from each other in the furnace. Lining the furnace is the first operation preparatory to smelting. This is done by covering the bottom of the trough with a layer of prepared charcoal. Oak charcoal is used. This is ground under edge runners, treated with milk of lime and dried, first in a steam jacketed revolving drum, and afterwards on a hot iron plate. Each particle of charcoal is thus coated with an insulating film of lime.

The electrodes are now arranged in the furnace, and a "former," consisting of two pieces of sheet iron connected by stirrups, arched so as to fit over the electrodes, forming a box without top or bottom (the size being dependent on the charge used), is dropped over the electrodes. Prepared charcoal is then rammed into the space between the iron sheet and the firebrick walls of the furnace. This done, the charge of ore, mixed with coarse charcoal and the metal to be alloyed with the aluminium, in form of turnings or granules, is placed inside the iron box; after which this is carefully withdrawn. Some broken pieces of carbon are arranged so as to connect the electrodes and start the current. The charge is then covered with coarse charcoal, and the cast-iron cover, having a hole in the centre for the escape of the gases, is lifted into place, and luted so as to prevent the entrance of air. The commencing current is about 3,000 ampéres, gradually increasing to 5,000 ampéres in the first half-hour. The time occupied by a "run" is about one and a half hours. Soon after starting, the gases escaping from the orifice in the cover take fire and burn with a white flame: this gas consists mainly of carbonic oxide, with small quantities of the hydrocarbons and nitrogen. On the conclusion of the run the furnace is allowed to cool, the metal alloy collecting in the bottom of the furnace; the next furnace ready charged is connected, so that the process is a continuous one, the furnaces being successively charged and connected. A form of furnace in which the metal is tapped from the bottom has given very satisfactory results.

(To be continued.)

SURVEYING AND CLASSIFICATION OF SHIPPING.

A PAPER on this subject was read before the North-East Coast Institution of Engineers and Shipbuilders, by Mr. G. E. Macarthy, on October 21st.

The author, after some preliminary historical remarks, in which he stated that of the remote beginning of marine insurance, with which the subject of classification was so closely allied, little was known. The Phœnicians, Greeks, and other ancient peoples, we were told, were in the habit of guarding themselves against risks of maritime enterprise. "Nautical insurance," as Gibbon termed it, was common to the Romans, and in the middle ages it was carried on regularly in the Italian republics, which even went so far as to regulate by law the "load line."

The classification of British shipping appeared to have commenced about the year 1726. An advertisement in the *London Gazette*, of 18th February, 1668, stated that "ship lists" were kept at Lloyd's Coffee-house, owned by a Mr. Edward Lloyd, and these lists contained the germ of the present well-known "Lloyd's Register." "A1 at Lloyd's" has since become a household word.

The register, it was said, was established by underwriters for their sole use. The members were bound under penalties not to communicate the contents, or allow the register to be seen by outsiders. In 1798, the committee for conducting the affairs consisted of eleven gentlemen, who held their meetings at Lloyd's Coffee-house. At this time a new style of classification was introduced, which being scarcely equitable in its operation, ultimately led to the formation of a new register, and it was interesting to notice the low estimation in which vessels built in the northern ports were held, not only at this time but long after. The dissatisfied shipowners failing to obtain satisfaction, several of them started "The New Register Book of Shipping" in 1799, and this became known as the "Red Book" or Shipowners' Register, the old one being known as the "Green Book" or Underwriters' Register.

It was not until 1822 that any record of a steamship was found in the register.—the James Watt, 294 tons, built at Greenock in 1821, and classed A1. The distinction, however, of possessing the first practical steamboat was reserved to Lord Dundas, who in 1801 had a vessel constructed which towed two loaded vessels 16½ miles in six hours. The idea was now fairly started, and in 1811 the well-known Comet was built. Indeed, to such importance had the subject grown in 1817, that a committee of the House of Commons sat in that year. As a result of their investigations, all steamboats were required to be registered, and their boilers to be of wrought-iron or copper.

In 1834 there was a fusion of the two registers, and the rules then underwent considerable alterations. The permanent committee was composed of eight merchants, eight shipowners, and eight underwriters, together with the chairman of Lloyd's and the chairman of the General Shipowners' Society. These gentlemen were drawn from the shipping community of London alone, the outports having no direct voice in their choice. To conduct the surveys prescribed by the rules of the new committee, a staff of surveyors was appointed, numbering sixty-three in all, of whom thirteen were exclusively the servants of the society, and these latter were distributed in the different ports of the United Kingdom.

In 1838 "The Liverpool Register of Shipping" was started, but in 1844 "Lloyd's" amalgamated with it, giving Liverpool a "branch" committee, consisting of twelve members elected by the Liverpool Underwriters' and Shipowners' Associations in equal proportions, which "branch" exists to this day.

The first iron steamer entered in Lloyd's Register appeared to have been the Sirius, 180 tons, built in London in 1837, but it was not until 1854 that the committee decided to class iron steamers, and in 1855 the shell plating for vessels of 3,000 tons was required to be 1in. thick and the frames to be spaced not more than 16in. apart.

The "Liverpool Underwriters' Registry for Iron Vessels" was next established, as a result of dissatisfaction as to the classification and surveying of iron vessels. This registry attained considerable success, but has since been absorbed by its older rival, viz., Lloyd's.

The author then gave a list of the officers of "Lloyd's Register" of the present time, and also the following list, taken from "Lloyd's Register" of 1888-9 :—

	BRITISH.		COLONIAL.		FOREIGN.		TOTAL.	
	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
Iron Steamers	2,905	3,845,361	98	79,581	703	985,450	3,706	4,900,392
Steel ,,	496	984,369	58	63,399	149	217,144	703	1,264,912
Iron Sailing Vessels ..	1,485	1,781,152	48	43,037	156	141,482	1,689	1,965,671
Steel Sailing Vessels ..	88	135,413	..	..	9	10,515	97	145,928
Wood Vessels.	1,468	330,199	132	63,550	255	140,562	1,855	534,311
Total......	6,442	7,076,494	336	249,567	1,272	1,495,153	8,050	8,821,124

Next in importance to Lloyd's Register was the Bureau Veritas, which was established at Antwerp, in the year 1828. This society closely resembled Lloyd's, and issued at first a monthly list, but the following year it assumed its present form of an annual—"Veritas Register." In 1837 the society was removed to Paris, where it still holds its sittings.

The early London method of classification, and which existed for a long time, had the grave defect of being based solely on the age of the vessels, an absolutely false principle, and the Bureau Veritas claimed the merit of discovering and remedying this defect by the adoption of a system of classification based upon the actual condition and value of the hull and equipment, and it was said that the alterations in Lloyd's Register which were adopted after the fusion of 1834 were inspired by the rules of the Bureau Veritas.

About the year 1867 the Bureau Veritas began to lay down rules for the construction of iron vessels and machinery, and later on the conditions relating to mild steel used in marine work, and about 1884 those relating to the triple and quadruple expansion engines. The surveyors on the staff numbered 250, and were men of experience, and quite up to the latest novelties in shipbuilding, engines, &c.

The "Veritas Register" for 1889 gave the following entries of classed vessels, viz. :—

	STEAMERS.		SAILING VESSELS.		TOTAL.	
	No.	Tons.	No.	Tons.	No.	Tons.
British................	110	176,873	903	726,771	1,013	903,644
German	386	469,877	1,546	567,985	1,932	1,037,852
French................	265	379.520	1,347	230,309	1,612	609,829
American	69	140,241	690	664,707	759	700,948
Various	543	491,268	3,859	1,432,539	4,402	1,923,835
Totals........	1,373	1,657,779	8,345	3,022,311	9,718	5,716,118

The nationalities represented numbered over thirty-three. British tonnage headed the list with sailing vessels, and stood third in steam. Germany was first in steam, and third in sailing vessels.

The object of the author in bringing the subject before the institution was a desire to elicit its opinion as to the practicability of establishing a North-East Coast Register of Shipping, and, if practicable, whether such a register would benefit the shipping interest of that district.

In summing up these remarks, the author wished it to be understood, in the first place, that he distrusted monopolies. Lloyd's monopoly was in many respects objectionable. It was slow, uncertain, and very costly in its working. Its surveyors, no doubt, were men of ability and intelligence, but in matters of any importance they had no power; reference must be to a committee sitting in London (many said it was a one-man committee). Take, for instance, the petroleum tank steamer question. How difficult must have been the task of the shipowner, shipbuilder, and engineer before they worked the oracle at White Lion Court. Or the well-deck steamer question; and if they note at what cost of time and labour, journeying to and fro, and petitioning, these scientists were instructed as to what was a safe load-line, they could then imagine the simplicity of dealing with a registry located at their shipyard doors. He would now mention a much smaller matter. A steamer known to be thoroughly staunch and extra strong (she was proved so in the sequel) required a periodical survey. The surveyor, acting honestly on the letter of his instructions, ordered every stick of wood ceiling, &c., out of her; vessel to be cleared of everything to the bare iron; holes to be drilled until the entire hull would have been riddled like a sieve; then these holes were to be gauged; plans submitted to the committee, who would examine same and state what next would be required. Aghast, the owner asked how long they would detain the steamer, and was informed that five or six weeks might end the business. In desperation, the owner withdrew her and classed her in Veritas Register, obtaining her original highest A1 class, and completing the work in seven days. Had a committee been sitting in Newcastle, this matter would have been settled in twenty-four hours or less.

Taking the tonnage built during the last twenty-five years in the ports of the Tyne, Wear, and Tees, calculated by the excellent statistical diagram prepared by the council of our institution in May, 1888, it would far exceed six million tons. The value insured in the same area by local mutual and other insurance bodies, having under their orders an excellent staff of surveyors, amounted to more than twelve millions sterling per annum. Might we not, therefore, put the question, were there not there the elements of a successful North-East Coast Shipping Registry?

THE INSTITUTION OF MECHANICAL ENGINEERS.

THIS Institution held its last meeting for the year at the Institution of Civil Engineers, London, on the evenings of Wednesday and Thursday of last week. The first paper read was contributed by the president, Mr. Charles Cochrane, on "The Results of Blast Furnace Practice with Lime, instead of Limestone, as a Flux." After referring to the experiments of Sir I. Lowthian Bell, the author enumerated the leading features of the various chemical and thermal actions occurring in the blast furnace. He then stated that one great difficulty in blast furnace economy was due to the reduction of carbonic acid to carbonic oxide, by the action of the incandescent carbon with which it came into contact. This caused a great waste of fuel. The main object of using lime instead of carbonate of lime as a flux, was to eliminate one of the sources of carbonic acid, and so reduce the tendency to loss from its excessive reduction to carbonic oxide. Some of the results were disappointing, but the consumption of coke per ton of pig produced was reduced from 23·28cwt. used with limestone to 19·49cwt. with lime. Sir I. Lowthian Bell, in discussing the paper, differed from Mr. Cochrane on many points—which was to be expected—for when did experts ever agree on the phenomena of the blast furnace? He considered the economy effected as admittedly trifling, and in the main due to the expulsion of the carbonic acid in the limestone by the use of fuel in a separate kiln. Mr. Richards, Mr Martin, and Mr. David Evans took part in the discussion, and seemed to disagree with the conclusions of the author.

A paper by Mr. Job Deurden, of Burnley, "A Description of a Rotary Machine for making Block-bottomed Paper Bags," and one by Major English, entitled, "Further Experiments on Condensation and Re-evaporation of Steam in a Jacketed Cylinder," were also upon the agenda. We shall shortly give abstracts of those papers. We are informed that the council has determined to present Mr. Henry Chapman with a recording barometer, as a means of recognising Mr. Chapman's services in connection with the organisation of the arrangements for the Institution's Paris meeting. This we are very pleased to hear. M Eiffel has also been made an honorary member of the Institution, in connection with the Paris trip.

PRODUCTION OF COAL, IRON, AND STEEL IN FRANCE IN THE FIRST HALF OF 1889.

THE *Journal Officiel* for the 7th September last publishes statistics prepared by the Ministry of Public Works of the production of coal, iron, and steel in France during the first six months of the present year. According to these statistics the total production of coal was 11,906,974 tons, being an increase of 829,253 tons over the corresponding six months last year. The largest share is furnished by the Departments of Pas de Calais, Nord, and Loire. The iron production amounted to 387,465 tons this year, as against 428,076 last, a diminution of 40,611 tons. Steel, such as rails, plate, &c., was produced to the amount of 246,088 tons, compared with 239,624 tons in 1888.

THE COAL SUPPLIES OF THE WORLD.

In view of the question which has suggested itself on more than one occasion as to how long it would be before the Old World coal deposits would become exhausted, the *Deutsche Handels-Museum* supplies some interesting figures relating to the world's coalfields outside of the North American continent. According to these, the Low Countries, Switzerland, Denmark, Germany, and Bohemia, possess coalmines of a surface area of about 59,000 square miles. Russia alone has 22,000 square miles. The deposits of the island of Formosa amount to something like 10,000 square miles, some of the coal veins ranging up to 96 feet in thickness. The coalfields of Austria, Spain, Portugal, Italy, Greece, Turkey, and Persia cover about 39,000 square miles, those of India 35,000, and those of Japan 6,000 square miles, while those of China are estimated at the enormous figure of 400,000 square miles. But these are not all. The Falkland Islands, Patagonia, and Peru are very rich in coal, while the southern part of Chili is one immense deposit. In Brazil, veins varying in thickness from 17ft. to 25ft. are found in numbers, and in the United States of Columbia there is an abundance of the mineral. Mexico and the Vancouver Islands are also well supplied, there being probably not far from 20,000 square miles, while the deposits thus far discovered in Tasmania, New Caledonia, and Natal are estimated to cover 100,000 square miles, the larger number of these deposits not yet having been worked. The above figures are without reckoning the immense stores of coal in the United States.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

POWER AND VALVE SETTING OF COUPLED HORIZONTAL ENGINES.

To the Editor of "The Practical Engineer."

Sir,—I work a coupled horizontal engine, 12in. cylinder, 24in. stroke, and non-condensing, having a belt flywheel 6ft. diameter on the centre of the shaft between the engines, with two 6in. broad belts driven from it. There is an ordinary Watt governor on the shaft, and a steam stop valve for each cylinder.

If anything goes wrong with one engine, could I uncouple the connecting rod of that engine and work the other engine safely?

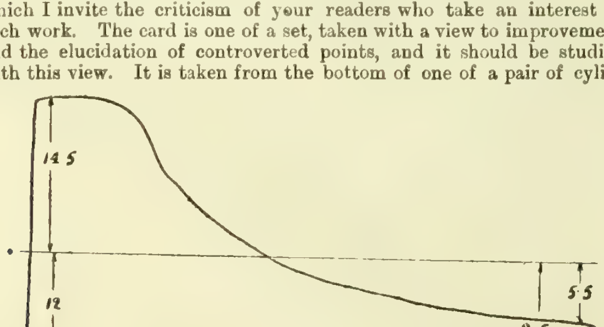
Will some of your readers be so kind as to let me know the horse power of the engines? Steam pressure at the boiler 40lb.; the boiler is nearly below the engine, and the cut-off is at $\frac{3}{8}$in. stroke? The slide valves are of the ordinary D kind, driven by eccentric, and no cut-off valves. When the engine is on the dead centre the lead is so small that I cannot put in the edge of a piece of tin. The foreman of the shop where the engine was made says that is quite right; but the inspector, and I myself, think it too little. The engine will not start well unless one crank is at half-stroke. Any information will much oblige yours, &c.,

Glasgow. J. D.

INDICATOR DIAGRAM PRACTICE.

To the Editor of "The Practical Engineer."

Sir,—Availing myself of your courtesy, I enclose a diagram upon which I invite the criticism of your readers who take an interest in such work. The card is one of a set, taken with a view to improvement and the elucidation of controverted points, and it should be studied with this view. It is taken from the bottom of one of a pair of cylinders of 20in. diameter by 2ft. stroke, and of the type known as "crank-overhead"; cranks at right angles, crank shaft supported on the top of A framing, flywheel near one end of shaft. This flywheel is more correctly a bevel mortice wheel of about 10ft. diameter, and not more than two tons weight, driving a pinion on the turbine or pump shaft, which is vertical and underneath the engines. The revolutions are about 50, and cannot be increased. The boiler pressure is about 25lb; it also is fixed. The working parts were not in first-class order when this card was taken. The connecting rod is only 4ft. long, and the air pump is 14in. diameter and 12in. stroke, and is driven from a part of the parallel motion which takes the place of guides, and as a result brings the added weight of its moving parts to resist the up-stroke of the piston, together with the piston and its weight, the whole weight on the up-stroke thus becoming 6cwt. for the weights alone, not including the resistance or load on the air pump. The next cards will show the altered valves and results.—Yours, &c., Cast Iron.



COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—In the discussion on this subject, I think there is one point which has not received due emphasis, and that is, the way in which all our most famous engineers have set themselves against compounding. The names of Johnson, Strondley, Drummond, the Stirlings, and others whose locomotives are famous all over the world, are to be found amongst the opponents of compounding, in whatever form; and it is not a little remarkable that the most ardent advocates of compounding are gentlemen whose earlier "simple" engines made no very great reputations.

It looks as if these engineers were determined that posterity should hear of them in connection with something or other, and had chosen compounding as the simplest method of obtaining that result.

Mr. Webb, some years ago, announced with triumph that "Experiment," after a period of some months, spent mostly on the Irish mail, not a heavy and not a very fast train, averaged only 26lb. of coal per mile, compared with, I think it was, 34lb., the consumption of his "Precedents." But he omitted to give the consumption of the Brighton engine, "Gladstone," for a good reason. And what compound, of whosoever's "system" or "patent," would work the Midland trains on less than 20lb., as the new singles are doing?—Yours, &c,

W. B. Thompson.

GROVES' & THORP'S CHEMICAL TECHNOLOGY.

To the Editor of "The Practical Engineer."

Sir,—The writers of the part of this work referring to coal gas have made use of my name pretty freely, but apparently the bulk of their quotations are from old trade lists, which are not usually the sources from which theory and calculations are likely to be obtained for a work on chemical technology, and this is probably the reason why the article in question is so very deficient in necessary information. On page 431 it is stated, "There exists no information as to the influence exerted by the shape and dimensions of the gas nozzle, and of the delivery tube for the mixture of gas and air"—"there is no rule to guide in fixing the proportions." Anyone who is at all conversant with the subject is fully aware that this matter was worked out by myself, and that the full details of the theoretical construction of burners are given in the Transactions of the Gas Institute for 1883. Another serious error is the analogy the writer attempts to draw between light and heat from coal and gas, the conditions as regards pressures and other matters being in many cases the reverse of each other.

It is well known that the practice of heating by gas is in a state of rapid transition and evolution. This is too much for the writer of the article, who specifies a pattern four years old, and quite superseded, as the "newest." On page 401 I am made to say that gas fires cost from 1d. to 4d. per hour; this might have been true years ago, but it is very far, indeed, from the truth now. Out of sixty modern gas fires, tested by myself, the maximum consumption of the largest was 40 cubic feet per hour, at $\frac{8}{10}$ pressure, which at 2s. 1d. per 1,000 cubic feet is exactly 1d. per hour; the minimum consumption of the smallest is 7ft. per hour, being about 1d. for six hours.

The writer makes several remarks about absence of proof and figures for certain statements made in trade lists, whilst his own statements as to the relative radiation of coal fires and gas fires are not only vague, but are on the face of them absolutely incorrect and incapable of proof, and states that he does not know why I call a gas stove a gas fire. As I never did such a thing, I should be curious to know where he got his information from.

It is not at all necessary to evolve a new theory as to the general antipathy to stove or convected heat being "prejudice or rays of less refrangibility." Even "old trade lists" would have explained that with convected heat the lower part of the room is always the coldest, and cold feet and heated upper extremities are not conducive to comfort. If the writer had copied the American habit of lifting his feet out of the colder air near the floor level, he would have understood that no new theory was required, and that the cause is very well known.—Yours, &c., Thos. Fletcher, F.C.S.

A New Explosive.—There is a new one announced somewhere almost every new moon. The latest invention of the kind is in Austria. It is to be called "ecrasite," is to be used for military purposes exclusively, and its explosive force is said to be to that of dynamite as 100 is to 70. We may be sure that, like dynamite itself and all the other recently-invented explosives, "ecrasite" is also a nitro-glycerine preparation.

QUERIES AND REPLIES.

109. Balloon Motor.—Will some reader kindly give me particulars of the motor employed by the French officer who recently constructed a very large and elaborate balloon? Perhaps some reference to the description, if it has been published, can be given.—F. B.

Answer.—If "F. B." refers to the balloon constructed by Captain Renard, in France, he will find a description of it in the supplement to the *Scientific American* of October 18th, 1884, also November 29th of the same year, and again more recently in the supplement to the *Scientific American* of March 13th, 1886.—Balloon.

117. Driving Ropes for Engines.—Would some of your readers be good enough to inform me what size of ropes, and how many, would be required for an engine 500 horse power? also what would be about the price of such an engine.—Improver.

Answer.—The following will be found a good rule for finding the indicated horse power that may be transmitted by ropes. Multiply eight times the square of the circumference of one rope by the number of ropes, and by the circumferential velocity of the driving pulley in feet per minute; and divide the product by 33,000. By this rule it will be found that ten ropes, each 6½in. circumference, will be required for transmitting 500 horse power, assuming a circumferential velocity of 5,000ft. per minute. A 500 horse power engine is a size not usually stocked by makers, and its cost price would depend entirely upon the type of engine required.—Hydra.

Answer.—The datum given by "Improver" is insufficient for me to furnish an independent answer. The rule given by Messrs. Pearce Bros., who are large makers of rope belting, is:

Driving force, or diff. of pull on the two sides of the belt $= 7{\cdot}81\, c^2$, where c = circumference of the rope in inches.

$$\therefore \frac{7{\cdot}81 \times c^2 \times \text{vel. of rope (ft. sec.)} \times 60 \times n}{33{,}000} = \text{H.P. transmitted,}$$

n being the number of ropes used.

Assuming the velocity of ropes is 3,000ft. per minute, which it generally is, we have—

$$\frac{7{\cdot}81 \times c^2 \times 3{,}000 \times n}{33{,}000} = \text{H.P.} = 500;$$

$$\therefore c^2 n = 704{\cdot}22.$$

So that ten ropes of girth 8·4in., fifteen ropes of girth 6·8in., or twenty ropes of girth 5·9in., will transmit 500 horse power, if the velocity of the ropes is 3,000ft. per minute. If they move at any other velocity, $c^2 n$ will have a different value from the above, which value can be easily found.—P. R. J.

120. Crank Pin.—I have a crank pin to put in; it is 10½in. diameter by 10⅝in. long in that part which fits the crank eye, and 9½in. diameter by 10in. long for the working part, with 1⅜in. of a collar outside, making it 22in. long. There is no taper on the pin, and it is held in position by a key. I want to know if there is any advantage in having a hollow pin; if so, what the advantage is, and what size of hole you would recommend. Also, if a steel forging can be got with a hole in it.—Crank Pin.

Answer.—In answer to this querist, I beg to inform him that one advantage claimed for a hollow pin is that it will not heat so readily as a solid one, and a better means of lubrication and cooling is afforded. The greatest advantage of hollow shafts is the reduction in weight in marine work—an important item in these days. There should be no difficulty in obtaining a steel forging with a hole in it. The diameter of the hole of a steel pin, to be of equal strength to the present iron one, would be about 2in.—J. R.

Answer.—As the central portions of large shafts have a tendency to become unsound during manufacture, a small hole is often bored through to test them in this respect, the decrease in the strength of the shaft being very slight, owing to the material at the centre offering little resistance to torsion, and it is due to this fact that hollow shafts are employed when great power has to be transmitted; the material being disposed where most effective, a stronger shaft is obtained with the same weight of material. The steel forging must be got solid, and afterwards bored to the size of hole required, generally about one-third of the diameter of shaft.—Orion.

122. Weight Applied by Safety Valve Lever.—Will one of your practical readers kindly give reliable formula for calculating weight applied by unloaded lever in safety valve calculations, as various rules are given by different engineering authorities?—J. W. B.

Answer.—A good practical method of ascertaining the moment of safety-valve levers, and one in which the possibility of error in calculation is eliminated, is as follows: Having the valve ground in, and the lever with pins attached completed, place them in position, and fasten a piece of string or wire, with a loop in it, at the valve pin. On applying a spring balance to the loop, the actual moment of the lever, with attachment, can be read off the balance at the point where the lever commences to rise; to this add the weight of the valve, then the weight w required on the lever can be found, making the necessary deductions for lever and valve.

The following is an example for escape valve on testing machine: Pressure per square inch, 320lb.; lever, 23¾in. long; from fulcrum to valve centre, 1½in.; diameter of valve, 1in.; combined moment of lever and weight of valve, 13½lb.

Now, the effective pressure on valve $= (320 \times {\cdot}7854) - 13\tfrac{1}{2} = 237{\cdot}8$lb.; hence—

$$w \times 23\tfrac{3}{4} = 237{\cdot}8 \times 1{\cdot}5 \quad \therefore \quad w = \frac{237{\cdot}8 \times 1{\cdot}5}{23{\cdot}75} = 15\text{lb.}$$

The weight can be cast approximately to this, and afterwards adjusted by boring a hole and filling with lead to the correct weight.—Orion.

Answer.—Uncouple the lever and find where it balances. This gives, nearly enough, the centre of gravity of lever. The distance of this to the fulcrum, divided by the distance between fulcrum and valve, and multiplied by the weight of lever, gives the effective pressure of lever on valve. To get the total pressure on the valve, add this to the effective pressure due to weight, and also to the weight of valve and spindle. This is the total pressure keeping down the valve. To get pressure per square inch, divide by area of valve in inches.—C.

Answer.—From the above, I presume "J. W. B." wishes to know how to calculate the effort of the lever. The following is the course I have always followed, and found it reliable. Take off the lever and weigh it; then balance the lever on the edge of a chisel, and measure the distance from point where balanced to fulcrum; then calculate as in any ordinary loading. Thus: L equals distance from balancing point to fulcrum, l equals from fulcrum to centre of valve, and W equals weight of lever; then $\frac{\text{L} \times \text{W}}{l}$ equals the load put on the valve by lever alone. If there is a spindle attached to the lever, it must be allowed to remain so during weighing and balancing the same. Weight of lever, say 8lb; L = 12in.; l = 3in.; $\frac{12 \times 8}{3} = 31$lb., the load on valve due to the lever alone, and 31 ÷ area of valve equal the load per square inch of valve.—Chalkline.

123. Compressed Air for Underground Haulage.—What are the advantages and disadvantages of compressed air, as compared with steam, for underground haulage?—Tabor.

Answer.—The principal advantage of compressed air is that when exhausted it supplies fresh air to the workings. If this is not required in any given case, then its greater cost is a disadvantage. Also, if the air be not heated before using, the exhaust pipe must be kept as short as possible, or it gets choked with ice, due to the cold of expansion. If the engine has to be at a considerable distance from the boiler, compressed air may be found to be cheaper than steam, owing to the condensation of the latter in the pipes, but, on the other hand, first cost and maintenance of air pumps have to be considered.—C.

124. Coil Friction.—What is meant by coil friction? If a rope is coiled twice round a fixed cylinder, and a weight of 10cwt. is pulling at one end of the rope, what is the smallest weight pulling at the other end of the rope which will prevent it from slipping on the cylinder?—Tabor.

Answer.—If a flexible band of any material (say a rope) be wound round a fixed drum, and have suspended from its ends, A and B, two equal weights, a considerable addition must be made to A before the rope commences to slip, and so lift B, the difference between the two weights A and B being a measure of the friction between the coiled rope and the drum. This friction increases almost directly with the weight B, provided the length of rope in contact with the drum (l) is constant; if, however, l be increased, while the weight remains the same, the friction rises very rapidly. Professor Perry gives the result of experiments made with varying values of l, from which he deduced the following formula:—

$$\log \frac{\text{W}}{w} = 0{\cdot}4343\, k\, \frac{l}{r}.$$

Where w = the weight suspended at one end of band (A);
W = the weight (B) required to overcome the friction, and slowly raise w;
l = length, as given above in inches;
r = the radius of drum in inches;
k = the coefficient of friction, which will vary for different substancs, and from the experiments was found to be 0·166.

The value of the ratio $\frac{l}{r}$ in the case given $= 2 \times \frac{2 \times 3{\cdot}1416}{1} = 12{\cdot}5664$;

and $\log \frac{\text{W}}{w} = {\cdot}4343 \times {\cdot}166 \times 12{\cdot}5664 = {\cdot}90617$;

$\therefore \frac{\text{W}}{w} = 8{\cdot}05$; and from the equation $w \times 8{\cdot}05 = 10 \times 112$ we have—

$w = \frac{10 \times 112}{8{\cdot}05} = 139$lb., the pull required to prevent slipping under the conditions considered.

It is this feature which is utilised in testing engines with a rope friction brake, termed an absorption dynamometer, the power absorbed being the product of the difference in pull at the two ends, and the velocity of the rim in feet per minute; this result, divided by 33,000, giving the horse power.—Orion.

Answer.—"Coil friction," applied to a rope alone, means the internal friction in the rope, due to alternate bending and straightening when passing round a cylinder, or pulley applied to the cylinder. It means, in addition, the friction between cylinder and rope. The weight that would balance any load, such as that given, depends on the diameter of cylinder, on the quality of rope, whether tarred or untarred, &c.; also upon what the cylinder is made of, such as wood or iron, and upon the greasiness, or otherwise, of its surface. On the usual hollowed-out winch-end, with friction strips cast on, a few pounds would balance 10cwt. On a smooth cylinder of the same diameter, about 5cwt. would be required. Round a similar wooden cylinder the balancing load would be considerably less, but it depends in this case on the hardness of the wood, and of the size of rope, a small rope cutting deeper into the wood, and thus increasing friction.—C.

Answer.—Coil friction is the resistance to motion which is exerted when one end of a rope, coiled round a cylinder, is pulled.

We have the easily derived mathematical formula—

$$\text{N} = \text{M}\, \epsilon^{\mu\theta},$$

Where N = the pull to be just balanced;
M = pull to be exerted on one end of rope, just to balance W;
ϵ = base of Napierian logarithms;
μ = coefficient of friction between rope and cylinder; and
θ = angle of lapping of the rope round the cylinder in radians.

In the question:—
N = 10cwt. = 1120lb.
$\epsilon = 2{\cdot}71828$.
$\mu = {\cdot}7$ (if hemp rope and wooden cylinder).
$\theta = 4\pi = 4 \times 3{\cdot}1416$, since the number of radians in 360 deg. is $2\pi = 2 \times 3{\cdot}1416$.

$$\text{N} = \text{M}\, \epsilon^{\mu\theta}$$

$$\therefore 1120 = \text{M}\,(271828)^{{\cdot}7 \times 4\pi}$$

$$\therefore \text{by logs. } 1120 = \text{M}\ 6766$$

$$\therefore \text{M} = \frac{1120}{6766} = {\cdot}17\text{lb.}$$

If now we take an iron cylinder—

$$\text{N} = \text{M}\, \epsilon^{\mu\theta}$$

$$\therefore 1120 = \text{M}\,(2{\cdot}71828)^{4\pi \times \mu^1}$$

Where μ^1 is different from μ, since friction occurs between hemp and iron—

$$\mu^1 = {\cdot}5$$

$$\therefore 1120 = \text{M}\,(2{\cdot}71828)^{4\pi \times {\cdot}5}$$

$$= \text{M} \times 535{\cdot}5$$

$$\therefore \text{M} = 2{\cdot}1\text{lb.}$$

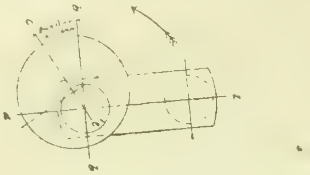
P. R. J.

125. Intermediate Receiver in Compound Engines.—I have been designing and fitting up a compound engine, and am desirous of knowing the true value of the intermediate receiver between the high and low pressure cylinders? A full reply will extremely oblige.—Young Engineer.

Answer.—If a receiver be too small, the pressure in the low-pressure cylinder becomes irregular during admission, and causes back pressure in the high-pressure exhaust. This is not a serious matter, within the usual limits determined by structural considerations. It is evident that a receiver cannot be made smaller than the cubic content of the exhaust passages from the high-pressure cylinder, added to the low-pressure valve casing. This is usually found quite large enough for the receiver, and a diagram shows only inconsiderable variations of pressure. With too large receiver, the losses due to condensation rapidly increase, partly owing to the increased cooling surface and increased time of exposure to its influence.—C.

126. ANGLE OF ADVANCE OF ECCENTRIC.—How can I find the angle of advance of an eccentric when the rods are connected at the ends of the slot link? Any information will much oblige.—J. B.

Answer.—To obtain the angle of advance of eccentric, "J. B." should proceed as follows: Set your crank on one of the *dead* centres. Next draw a line *a a* through the centre of the crank and crank shaft. At right angles to this line draw another line *b b* through the centre of the crank shaft and centre of eccentric sheave *c c*. The angle included in *b c c* is the angular advance of the eccentric.—J. R.



128. COMPRESSION AND RELEASE IN ENGINES.—How is the required amount of compression in a steam engine determined, and at what part of the stroke should release commence? An answer will much oblige.—A BEGINNER.

Answer.—I beg to inform "A Beginner" that there is no particular rule for compression other than that obtained by experience—that is to say, a high-speed engine will require a greater amount of compression than one of slow speed to ease it smoothly over the dead points; whereas in the latter class of engine the momentum of the reciprocating parts, such as the piston, connecting rod, &c., is not nearly so great as in the former, differing as it does at the squares of the velocities, and, for this reason, requiring a greater amount of compression. In no instance should the compression be such that the initial pressure is exceeded, or a serious loss of power will be the result. In the case of release, there should be in all cases a sufficiently early release to prevent excessive back pressure, which is a direct waste of power, as is plainly shown on any diagram taken from an engine troubled with the disease of late release, by the lower portion on the vacuum side having a very sloping curve before it enters on the vacuum line. The curve on the release corner generally, and the corner entering on the vacuum line should be, as nearly as possible, uniform, as any good indicator card will prove to you.—J. R.

129. LOSS OF POWER BY HOT CONDENSING WATER.—Will any of your readers inform me as to the disadvantage under which an engine will labour with the water in lodge or dam at 110 deg. F., instead of at 70 deg., and what will be the difference in I.H.P. to the engine, taking in infection water at 110 deg. instead of 70 deg? The engine is of the compound Tandem type, H.P. cylinder 20in. diameter, L.P. cylinder 38in. diameter, with 4ft. stroke, revolutions 60 per minute, boiler pressure 75lb. per square inch.—YOUNG ENGINEER.

Answer.—The quantity of injection water will be enormously increased to maintain an equal vacuum. The pounds of injection water per pound of steam is—

$$Q = \frac{1114^\circ + 0{\cdot}3\ T_1 - T_2}{T_2 - T_0},$$

where T_0 = the temperature of condensing water, T_1 = temperature of exhaust steam, T_2 = temperature of hot well. Pressure of exhaust is not given, but assuming it as 10lb. per square inch absolute, the temperature would be $T_1 = 193^\circ$; let $T_2 = 120^\circ$, then if $T_0 = 70^\circ$,

$$Q = \frac{1114^\circ + 0{\cdot}3 \times 193^\circ - 120^\circ}{120^\circ - 70^\circ} = 21{\cdot}04\text{lb.};$$

and if $T_0 = 110$,

$$Q = \frac{1114^\circ + 0{\cdot}3 \times 193^\circ - 120}{120^\circ - 110^\circ} = 105{\cdot}19\text{lb.}$$

F. C.

130. EXPANSION OF RAILS BY HEAT.—I have heard it stated that the average expansion and contraction of the railway metals, between the hottest day in summer and the coldest in winter, between London and Edinburgh, is only 3ft. Is this correct? if not, can you say what the difference is?—INQUIRER.

Answer.—The total expansion in England between lowest and highest temperature is, for railway metal, 1in. per 150ft., or nearly 3ft. per mile. Expansion between London and Edinburgh would be 3ft. × 400 miles = 1,200ft.—F. C.

131. CHANGING PULLEYS ON CRANK SHAFT.—I have a steam engine with a 4ft. 6in. driving pulley, running to a 3ft. 6in. pulley on the main shaft, and the engine making 150 revolutions per minute. Would it be any advantage to replace the 4ft. 6in. driving pulley by a 6ft. pulley, and reduce the speed of engine to 110 revolutions per minute? What difference would the above alteration make in the economy of engine? Information will oblige.—VULCAN.

Answer.—Running your engine slower might lead to improved vacuum, but if you put the larger pulley on you must raise your pressure 33⅓ per cent, or reduce the rate of expansion. In other respects, if your ports are the proper size for the speed at which you are running, nothing will be gained.—F. C.

132. PRESSURE ON JOURNALS.—Will some practical reader show me how to calculate the pressure on the guide bars, crank pin, crank shaft, and other journals of a train of gear wheels: Cylinder 18in. diameter, 42in. stroke, revolutions 40 per minute, conecting rod 8ft. 10in. long, driving pinion on end of crank shaft, radius 9in., the centre of pinion to journal 14in. This gears into a wheel of 30in radius, the centre of wheel to centre of journal 14in. On the same shaft is a pinion of 12in. radius, the centre of pinion to centre of journal 16in. This gears into a wheel of 60in. radius; the centre of wheel to the centre of journals is 16in. and 32in. respectively. The end of this shaft is coupled on to a three-roller sugar-cane mill, by Merrilees, Watson, and Co., Glasgow, with three equal pinions of 15in radius. Rollers same radius as pinions; the distance between centre of journals supporting rollers is 78in. A graphic or arithmetical solution would greatly oblige?—ENGINEMAN, North Queensland.

Answer.—The pressure on guide bars will be found from the diagram fig. 1; *aa* and *a'a'* are the faces of the guide bars; *bc* is the connecting rod, in such a position that it is at right angles to the crank *cd*. Produce the centre line of the piston rod, *hb* to *d*, and from *b* mark off to scale a convenient length—*bf*. Draw *fe* and *bg* at right angles to *bd* and *fg*, parallel to *be*; then the total pressure on piston multiplied by *bg*, and divided by *bf*, will be the pressure on the guide. If you have full steam pressure up to this point, this will be the maximum pressure on the guides; if not, you must try other positions, as it will depend on the point of cut-off. To give the figures also, the steam pressure, which you do not give, is required. The maximum pressure on crank pin will be the full pressure on piston at beginning of stroke, and the pressure on the crank shaft cannot exceed this. In respect to the pressure on the journals, they will be a maximum when all the journal centres lie in a horizontal line, and then you may practically take the load upon each bearing to be the pressure on the wheel tooth, plus the weight of wheel and half the shaft. If the centres are not on horizontal lines, the resultant thrust will be found by a parallelogram of forces, as shown at fig. 2.

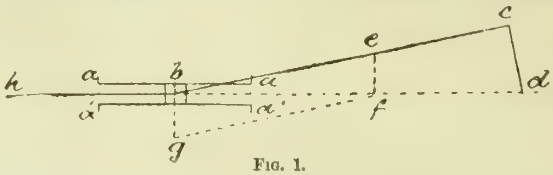


FIG. 1.

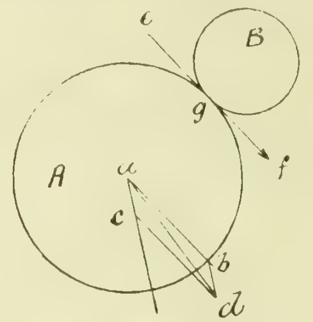


FIG. 2.

The wheel A is supposed to be driven by the pinion B. The arrow *ef* is a tangent to the pitch circles at the point of contact *g*. From the centre *a* of the bearing, and parallel to *ef*, draw *ab* equal (to scale) to the pressure on tooth at *g*; draw the vertical line *ac* equal to weight of wheel, &c., and complete the parallelogram *acdb*; *ad* will be the resultant pressure on the bearing *a*. Knowing the pressure on crank pin, you can calculate successively the pressures on your wheel teeth from their radii.—F. C.

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127. DISTILLED WATER.—I require 20 gallons of distilled water in 10 hours. I propose to obtain this by means of a coil in a cylinder 1ft. 6in. diameter, and 4ft. high. Please show how I can find the size and length of coil to be used, and how much cold water must be admitted in cylinder. Pressure of steam in coil to be condensed, 40lb. Assistance with above will be greatly esteemed.—DOUBTFUL.

133. SMALL ENGINE CASTINGS.—Could any of your readers kindly inform me of the best and cheapest form of engine for driving a 5in. centre lathe, and where I could buy castings?—F. J. H.

134. LIQUID FUEL.—I am told the Great Eastern Railway runs some of their trains with locomotives burning tar and oil, &c., for fuel. Can any of your correspondents give me particulars of the burner or sprayer used, and say if it is applicable to ordinary vertical boilers? How do you start the fire, and what about standing? does the fire go out, as I presume, if the burner keeps at work, too much steam would be made? What do they do about draught? Any particulars would be very acceptable.—W. E. D.

135. RAPID WEAR OF MARINE ENGINE ECCENTRIC.—Would any reader kindly enlighten me with regard to the following?—The wear on the go-ahead eccentric strap for the high-pressure valve of a marine engine is so great that it has to be renewed every trip, and when abroad the go-astern strap has to be placed on the go-ahead block to bring her home. Now, I attribute this to the weight of the valve and the surface on the back of it being exposed to the steam pressure, thus causing a great amount of friction to be overcome. I intend fitting a small cylinder, with a balance piston on the end of the valve spindle, to try and overcome this wear, and I should be very glad if some reader would give me an idea for determining the proper diameter of the piston. The weight of valve is 4cwt. 3qr. 5lb.; weight of eccentric rods' motion and valve spindle about 3·5cwt. The valve spindle is continued through the valve and top of casing; the diameter of part continued is 2⅝in.; size of back of valve exposed to steam is 2ft. 9in. by 2ft. 5½in., with a ring to be deducted from this, 18in. diameter, which takes part of the pressure of the valve; pressure of steam, 95lb. per square inch; travel of valves, 6in.—MARINE ENGINEER.

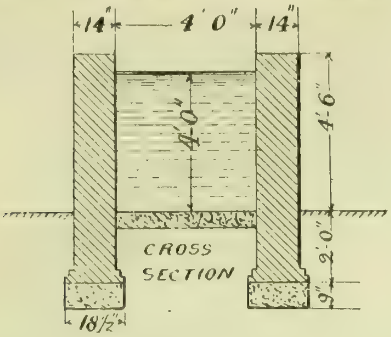
136. FORCED DRAUGHT.—Will any reader kindly state if the above can be applied to a Lancashire boiler, with advantage, where there is insufficient natural draught, which causes large quantities of soot to accumulate in the flues? Also the best form of the above?—PROSPECT.

137. LEAD REQUIRED IN VERTICAL ENGINE.—Can any of your readers inform me how to determine the lead required in a vertical engine of 400 I.H.P. running at 70 revolutions? I notice, in some engines, more lead is put on bottom than top. How is this determined? An answer will much oblige.—BOTHERED STUDENT.

138. SOLID-DRAWN TUBE.—I wish to make a number of lengths of solid-drawn copper tube ⅜in. internal diameter and $\frac{7}{16}$in. external. I shall feel obliged if anyone will give a description of the necessary tools.—L. M.

139. WALLS OF BRICK TANK.—I want to find the strength of the brick walls of a tank 9ft. by 4ft. The bricks are Staffordshire blue bricks, the walls stand 4ft. 6in. above ground, the tank is always full of water to the depth of 4ft. Would the walls 14in. thick be strong enough? What differ-

ence is made to the formula if the brickwork is set in cement mortar instead of lime mortar? I have calculated it from a formula in "Molesworth's Pocket Book," but I am not satisfied with the result. I should feel obliged if you or any reader would kindly enlighten me on this matter.—Municipal.



PATENTS AND INVENTORS' QUERIES.

25. Rights of Partners in a Patented Invention.—If two partners in a patented invention cannot agree to its sale, but one of them works it on his own machinery, and thereby makes an extra profit of 20 per cent by its use, can the other claim a share of profits so made?—K. J., Guiseley.

Answer.—In the absence of an agreement between the parties each has equal rights, and each person is entitled to work the invention independently. If, therefore, you have no agreement with your partner as to division of profits, you cannot claim a share of profits made by his use of the invention; but you can manufacture, use, and sell the invention on your own account, quite independently, and so make profits for yourself. Agreements should always be made between joint patentees.

26. New Pipe for High Pressure Steam and Water.—I have constructed a pipe for high pressure and hydraulic use, which is far more reliable than the pipes used at the present time, and wish to meet some firm or person to introduce it. What steps should I take?—R. S., Deptford.

Answer.—Send us full particulars of your invention, with patent specification and details of any tests you may have made. We shall be pleased to advise you when we know the nature of the improvement.

27. Search for Specification.—In Seaton's "Manual of Marine Engineering," reference is made to a balanced slide valve, patented by Thorneycroft. How can I find the number and date of the specification?—R. D., Hartlepool.

Answer.—All the leading towns in Britain have patent libraries, which are open to the public, free of charge. Yearly indexes are kept in those places of names of patentees, and also subject matter of patents. By referring to these you will readily discover the specification you require. On the leading subjects patented, abridgements are published in separate volumes, few of these, however, extend beyond 1876, as yet.

TO CORRESPONDENTS.

J. H., Ross.—Letter received; we shall enquire.

G. F. B., Walthamstow.—We shall be pleased to give full description of the Willans engine shortly.

H. H. L., Chester.—The weight of a cubic foot of Lignum vitæ is 83lb.

J. G. B., Haslingden.—There is no central electrical generating station in existence, as yet, which distributes 50,000 H.P. for electric lighting purposes, and, accordingly, no reliable estimates can be made of the cost of the plant required. We shall know more about it when the great London companies have been at work for a time.

Anxious, Motherwell.—Letter received. Sketch requires reproduction. Will appear next week.

W. W., Hull.—Apply to any teacher of marine engineering, and you will be informed fully on the necessary qualifications.

Constant Reader, Bristol.—A description of one of Tangye's Hydraulic Jacks appear in our impression of August 9th of this year, and a section of an ordinary hydraulic jack is given in our issue of January 25th of this year.

L., Tewkesbury.—You will find a full description of the Hopcraft furnace in our contemporary, *The Engineer*, of March 22nd, of this year. The paper read before the British Association was a mere trade advertisement, and is not worthy of reproduction.

MISCELLANEA.

There are, it is said, over 1,000,000 miles of telegraph wire in the United States, or enough to encircle the globe forty times. It is estimated that 250,000 persons are engaged in business depending solely on electricity. About 400 miles of electric railway are in operation, and much more is under construction.

Burmah Railways.—A supplement to a recent *Gazette of India* contains some statistics relating to the railways at Burmah. The length of the Burmah State Railway opened for traffic on December 31 last was 333 miles, which was also the mean length opened during the year. The length of line under construction on that date was 2·75 miles, and the total capital expenditure on open lines was Rs2,93,90,076. For the Toughoo-Mandalay line the figures are—length open, 108 miles; length under construction, 116·25 miles; and the total capital expenditure up to the end of 1888 was Rs.1,68,98,808. The traffic earnings of the two lines amounted in 1888 to Rs.33,76,218, and the working expenses to Rs.21,04,258.

Treatment of Water for Boiler Purposes. — In an article in the *Chemical Trades Journal*, Mr. G. E. Davies recommends that water used for boiler purposes should be so treated before entering the boiler that all formation of scale should be prevented, and deprecates the use of substances which merely prevent the scale from adhering to the boiler. As an example of how various precipitating agents may be used in conjunction with one another, a water which contained 5·2 grs. of calcium carbonate, 25·3 grs. of calcium sulphate, 0·15 grs. of magnesium sulphate, 4·27 grs. of magnesium chloride, 17·27 grs. of magnesium nitrate per gallon, were treated with a mixture of 17 grs. of caustic soda—77 per cent—17 grs. of sodium carbonate, 5 grs. of tribasic phosphate of sodium, with the result that of 12·9 grs. of lime only 0·78 grs., and of 6·6 grs. of magnesia only 3·78 grs. remained to enter the boiler, and this at a cost of 3½d. per 1,000 gallons. The precipitate amounted to 25 tons semi-dry sludge—or nine tons dry—from 5,000,000 gallons of this water per week.

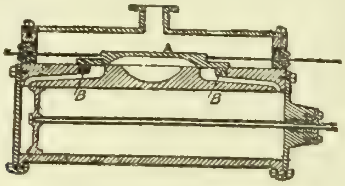
A New Torpedo.—The novel torpedo craft Vesuvius was tested at New York lately, and its performance silenced all the critics of the pneumatic propulsion of dynamite. It demonstrated a capacity to throw all the projectiles which its magazines can carry, namely, 30, with a rapidity far beyond the claims of the contract. The requirement was that 15 shots should be fired within 30 minutes. The actual performance was the discharge of 15 shells, each 8ft. long and 15in. in diameter, with a capacity of 200lb. of explosives, without the slightest trouble, in 16min. 11sec. The air pressure was ample to repeat the discharge. The initial pressure was 750lb., although the reservoirs can supply 2,000lb., and the contract permitted 1,000lb. The fall of the pressure on the firing ranged between 70lb. and 120lb. Firing a broadside, the Vesuvius can discharge 1,500lb. of dynamite within a minute. Admiral Seymour bombarded Alexandria within the Vesuvius's range. The naval officers at the recent test suggested that he could have absolutely destroyed the city, or the forts could have blown him out of the water, if they had been armed with pneumatic dynamite throwers. The Vesuvius had previously demonstrated her accuracy of fire, and her speed is 21 6-10 knots per hour.

Leeds Association of Foremen Engineers and Draughtsmen.—The inaugural meeting of the Leeds Association of Foremen Engineers and Draughtsmen for the session 1889-90, was held on Thursday evening, October 31, at the Wheat Sheaf Hotel, the President (Mr. J. C. Moorhouse) in the chair. There was a very large attendance of members. The election of officers was the first business. The following form the executive, viz.: Mr. J. C. Moorhouse, president; vice-presidents, Mr. Thompson Craister: hon. treasurer, Mr. R. Lupton; librarian, Mr. A. M. Casperson; committee, Mr. A. Towler, Mr. J. H. Briggs, Mr. T. Hargreaves, Mr. W. Whitworth, Mr. A. Atkinson, and Mr. James Stuart; hon. secretary, Mr. J. A. Tempest. Mr. Moorhouse gave the presidential address. After congratulating the members on the satisfactory condition of the association, he referred to the annual excursion on the 7th August to Messrs. Marshall, Sons, and Co., Limited, Gainsborough, in which about 50 members took part, and he only regretted that more had not availed themselves of this opportunity to visit one of the best equipped works in the world. Reviewing the papers read last session, he said they were eminently practical and well written, and gave rise to very valuable discussions. Speaking of the Paris Exhibition, he said that the buildings particularly struck the visitor who was quite at home with the several structures recently erected at Manchester, Glasgow, Edinburgh, Liverpool, &c., for Exhibition purposes. Those at Paris conveyed the impression of being permanent buildings, erected after the most careful thought and design, a credit alike to the designer and the Exhibition. In the exhibits of machine tools in the French and German sections, careful copies of the best of our tools were to be seen, machines which would compare very favourably with the best manufactured in this country, and a noticeable feature of the foreign machines was the care bestowed on the painting of the so-called black parts, a striking contrast to the general practice in this country, where only the actual working parts come in for serious attention. While the exhibition contained few machines really new in design, all the best of the old machines were to be seen, and these were got up in a style which required that we should look well after our own if we would retain our title of the world's factory. He was disposed to think that we should make the very best standard tools in duplicate, and keep a number of all useful sizes in stock that we might be able to execute the orders as the demand sprung up instead of having the whole of the work to do when the rush came. After referring briefly to other exhibits, he resumed his seat amid loud applause.—Mr. R. H. Wood alluded to the electrical welding in the Paris Exhibition, stating that he saw a 2½ inches square bar welded in 2½ minutes. As to duplication, he thought Messrs. Marshall's, of Gainsborough, the finest specimen of this kind of work in the world. At Paris the foreign locomotives struck him as being very much inferior in design to the British.—Mr. Towler also spoke of his visit to the Paris Exhibition, giving sketches of the design of the main buildings.—Mr. Casperson said the foreign builders of locomotives were handicapped by the guage and by Government regulations.—Mr Atkinson was pleased to learn of the great development of electricity at the Exhibition, and he looked for much greater application of it in the near future.—After a reply by Mr. Moorhouse, a vote of thanks to the President for his valuable address, was proposed by Mr. Scriven, seconded by Mr. Atkinson, and carried by acclammation.

ILLUSTRATED PATENTS.

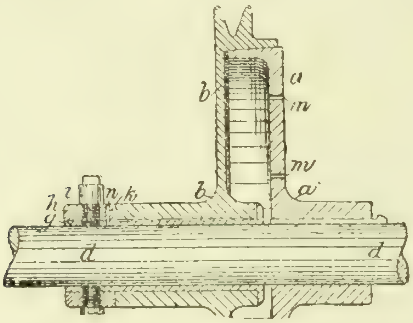
6252. **Steam Engines.** E. A. Jeffries, Wiltshire.

Consists in a method of varying the cut-off without altering the travel of the valve. The valve A is of ordinary construction with lap, and the cut-off is varied by altering the breadth of the steam ports. This is accomplished by a pair of sliding strips B working through stuffing boxes, so that they may be operated from the outside by any suitable lever or screw arrangement. When applied to marine engines, the strips may be made with a long taper in order to permit of accurate adjustment as regards the cut-off.—April 27, 1888. [6½d.]



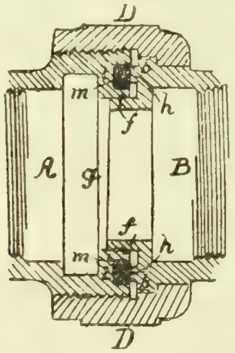
6297. **Friction Clutches.** W., W. Jr., G. H. and E. Kenyon, Dukinfield, Cheshire.

Cone.—The grooved pulley b forming one member of the clutch runs upon a long bush g, upon the shaft d, to which the other member a is keyed. The bush has a collar at one end and at the other a square or flatsided boss h secured to it by screws i, the heads of which form pins for the shifting lever. A hole n serves to lubricate the bearing between the shaft and the bush. Another hole k communicates with a grove between the bush and the boss of the pulley. The groove is continued at right angles at the end of the boss so that oil is allowed to fly out to the friction surfaces. Holes m may be formed in the disc a to allow the escape of air; by restricting the size of the holes or dispensing with them altogether, it becomes impossible to bring the clutch too suddenly into action.—April 28, 1888. [8½d.[



6411. **Pipe Joints.** F. J. Maule, Philadelphia, U S.A.

Relates to means for packing joints with soft metal. A and B are the ends of the coupling into which the pipes are screwed. The ends are held together by a ring D, which screws on the end A, and bears against a shoulder b on the end B. The latter has a gauge f which fits into the end A. A soft metal packing ring i is run into a groove m in the end A and a flange h on the end B is forced against it. When running in the packing, the end A is heated up to the temperature of the melting-point of the soft metal which contracts less on cooling than the material of the end A, and thus becomes firmly fixed in the groove.—April 30, 1888. [8½d.]



6914. **Steam Engines.** R. Mudge Marchant, 26, Wellington Street, Islington, and O. G. Abbott, Stockwell, London, S.W.

Compound; closed circuit; valves.—The H.P. cylinder is either side by side with L.P., as shown in fig. 8, or is contained concentrically within it, as in fig. 3. The cranks are at right angles, with the L.P. crank in advance of the H.P. To the upper side of each piston steam at the boiler pressure is admitted, and cut off by piston admission valves f, f^1. After the H.P. piston d has performed a portion of its down stroke, and steam has been cut off, it passes a port e communicating with the lower side of the L.P. piston d^1. When the H.P. piston approaches the bottom of its stroke a direct exhaust is opened through the side of the cylinder at g. The lower end of the H.P. cylinder is always open to the condenser. The exhaust from the upper side of the L.P. piston passes through an exhaust piston valve to a pumb by which, with the water from the condenser, it is returned to the boiler. The invention applies to both vertical and horizontal engines.

FIG. 3.

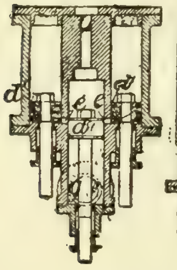
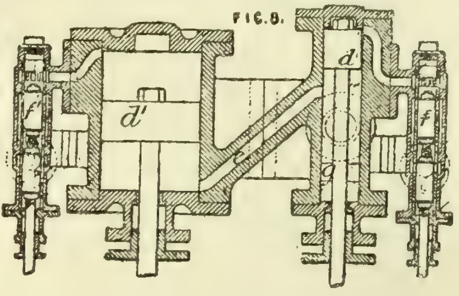


FIG. 8.



Reversing.—For double cylinder engines with cranks at right angles, in which, as in the one dscribed above, the L.P. crank always has to be in advance of the H.P., means are provided for shifting over one of the cranks through a semicircle. The crank discs of the movable crank engage with discs on the shaft by means of spring pawls. A special hand-valve is provided for admitting steam to move one of the pistons without the other, and the eccentrics are loose. May 9, 1888. [11½d.]

Copies of these specifications may be obtained on application to H. Reader Lack, Esq. *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

October 12th.

16051 Petroleum Tanks, W. Devoll, Birmingham.
16056 Boiler Tube Stopper, T. L. Davidson, Glasgow.
16057 Lubricators, A. H. Griffiths, Birmingham.
16062 Mechanical Stokers, A. Bell, Manchester.
16075 Shields for Water-gauge Tubes, G. H. Wall, London.
16084 Electricity Meters, E. de Pass, London. (E. Marès, France.)
16086 Detachable Ball and Socket Link, I. T. Davis, Birmingham.
16091 Hydraulic Rams, J. W. White, Liverpool.
16092 Lock Nuts, J. W. White, Liverpool.
16094 Valves, R. Dawson and G. R. Candelet, Manchester.
16099 Pumps, P. Nézeraux, London.
16101 Steel Melting, I. Beardmore, Glasgow.
16117 Valves, Nettlefolds Limited and C. A. Jones, London.

October 14th.

16132 Slide Valve, P. Wright, South Shields.
16137 Steam Hammers, J. A. Henckels, London.*
16153 Pulleys, G. Chamboredon, London.*
16161 Stuffing Boxes, O. J. Ellis, London.
16163 Windmill, S. Orloff, London.
16164 Signalling, J. F. Wiles, London.
16167 Links, G. Vacherat, London.

October 15th.

16170 Lubricators, A. R. Brown, London.
16187 Steam Boilers, J. A. Stott and A. H. Stott, London.
16190 Furnaces, W. D. Grimshaw, Manchester.
16193 Carding Engines, B. A. Dobson and W. I. Bromiley, Manchester.
16195 Journal Boxes, J. T. Murray, Birmingham.*
16201 Ventilating Fans, W. Sayer, London.
16202 Gas Engines, W. H. Green, London.
16204 Steam Traps, B. Thoens, London.*
16219 Pumps, J. Moss, London.
16220 Lubricator, J. Moss, London.
16237 Electrical Mains, S. Z. de Ferranti, London.
16240 Screws and Nuts, T. Robb, Glasgow.
16242 Water Motors, H. Brown, London.*
16243 Elevators, S. K. Humphrey and W. Tennant, London.
16246 Couplings, A. Drengson, London.

October 16th.

16259 Screwing Machines, S. Dixon, Manchester.
16271 Steam Boilers, R. Kerr, Glasgow.
16273 Ventilating Mines, M. Broadfoot and M. B. Baird, Glasgow.
16286 Soldering Tools, J. Pollitt and J. Mangnall, Manchester.
16292 Axle Lubricator, R. Armstrong, Lasswade, N.B.
16295 Heating Stoves, E. Gregory, Birmingham.
16320 Lathes, J. K. Starley, London.
16321 Cranks, J. K. Starley, London.
16322 Belt Fasteners, W. H. Bristol, London.*
16333 Boilers, F. Le Poidevin, London.
16337 Pumps, A. Karnat, London.
16338 Furnaces, F. E. Ross, London.

October 17th.

16341 Metallic Tubing, O. T. Banks, London.
16345 Vertical Boilers, R. Miller, Greenock.
16352 Stop Valve, J. Robinson, Cornwall.
16353 Smoke-consuming Apparatus, W. McGuffin Greaves, Manchester.
16373 Engine Packing, E. M. B. Faull, London.
16391 Gas Engines, O. Lindemann, London.*
16404 Piston Packing, E. Dönitz, London.

October 18th.

16429 Grinding Mills, R. Graham, Carlisle, Cumberland.
16430 Rotary Engines, A. F. G. Brown and Brown's Rotary Expansion Engine Syndicate, Glasgow.
16434 Gas Engines, J. H. Hamilton and A. Rollason, Newcastle-on-Tyne.
16435 Moulds, F. A. Wallis, Basingstoke.
16443 Corrugated Metal Sheets, H. Smith, Birmingham.
16455 Man-hole Covers, J. Jones, London.*
16459 Lock Nuts, R. Bradshaw, Manchester.
16466 Electric Meters, C. Nichols, Chelsea.
16474 Decarbonising Iron, R. F. Ludlow, London.*
16478 Distillatory Apparatus, A. de Kunwald, London.
16481 Valves, W. P. Gibson, London.
16486 Gas Retorts, A. Coze, London.
16500 Electric Regulators, F. V. Maquaire, London.
16501 Separating Precious Stones, W. S. Lockhart, E. W. Streeter, and W. Bashall, London.

The Practical Engineer,

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THE

PRACTICAL ENGINEER,

NOVEMBER 15TH, 1889.

STEAM JACKETING.

THERE are few questions upon which engineers differ more than the question of steam jacketing, and notwithstanding the great number of experimental engines now in the possession of our professors of engineering at the many well-appointed engineering laboratories so common throughout the country, the matter still seems to be one on which different opinions may be held. An interesting account was given by Major English, R.E., at the Institution of Mechanical Engineers' last meeting, of a series of experiments made by him upon a 16 H.P. engine at work in the Royal Carriage Department of the Woolwich Arsenal. The experiments are in continuation of those previously commenced by him on the same subject. In the discussion which followed the paper Mr. Willans, Professor Kennedy, Professor Cotterill, Mr. Macfarlane Gray, and Mr. Cooper spoke, all of whom seemed to differ somewhat widely from the conclusion arrived at by the author, and to differ also, to some extent, among themselves.

These differences, however, are of a hopeful nature, and no doubt, after a sufficient mass of experimental data has been accumulated, we shall by dint of diligent discussion and examination arrive at some idea of the truth of the question. Meantime we could not take upon ourselves to decide whether the advocates for steam jacketing or their opponents are in error. Apart from the specific points raised by Major English, it may tend to clear matters a little if we endeavour to state the general position of both sides, and indicate where, in our opinion, further experimental work is desirable. However plausible the arguments for steam jacketing may appear, it must not be forgotten that in many of the best recorded results obtained from steam engines the makers of the engines have deliberately discarded the use of jackets, with which their engines were provided at the moment of competitive trial. This occurred in the recent Society of Arts engine tests with the engine of Messrs. Davey, Paxman, and Co., which gave quite phenomenal results for an engine of its dimensions.

The steam jacket was one of the inventions of Watt, and is described in his famous patent, and it seemed a legitimate extension of Watt's ideas to prevent cooling of the cylinder during the admission of steam. At first sight the principle seems unassailable, but after a little consideration doubts begin to arise. As the object of jacketing is to prevent the condensation of steam while at its hottest—that is, during the period of admission from the boiler—it is evident that the jacket must be supplied with boiler steam at full pressure, otherwise the temperature of the cylinder will be lower than that of the inlet steam, and condensation will occur. This, of course, will prevent condensation within the cylinder, if it be so efficiently carried out so that every part of the cylinder walls, cover, and piston does not fall below the highest steam temperature. But, on the other hand, the question at once occurs, Does this save steam? Does it not only transfer the loss by condensation from the interior of the cylinder to the steam jacket? This is exactly the point upon which much difference of opinion still exists, and perhaps Professor Rankine long ago put the best justification of the practice as clearly as the most recent writers. In his work, "The Steam Engine," remarking on the liquefaction of steam in the act of performing work, he says that "liquefaction does not, when it first takes place, constitute a waste of heat or of energy, for it is accompanied by a corresponding performance of work. It does, however, afterwards, by an indirect process, diminish the efficiency of the engine; for the water which becomes liquid in the cylinder, probably in the form of mist or spray, acts as a distributor of heat and equaliser of temperature, abstracting heat from the hot dense steam during its admission into the cylinder, and communicating that heat to the cool and rarefied steam which is on the point of being discharged, and thus lowering the initial pressure and increasing the final pressure of the steam, but lowering the initial pressure much more than the final pressure is increased, and so producing a loss of energy which cannot be estimated theoretically." This puts the whole case most clearly according to the most recent lights, except on the one point of re-evaporation due to communicating with the condenser, which tends to bring the whole moist cylinder surface to the lowest condenser temperature.

Rankine then proceeds, on the liquefaction in the jacket: "Accordingly, in all cases in which steam is expanded to more than three or four times its initial volume, it has in practice been found advantageous to envelop the cylinder in a steam jacket. The liquefaction which would otherwise have taken place in the cylinder takes place in the jacket instead, where the presence of liquid water produces no bad effect; and that water is returned to the boiler."

These statements clearly express the theory followed in steam jacketing, and show its intention to be so to arrange matters that water cannot be formed within the cylinder where the pressure and temperature are constantly varying, but that condensation will be entirely confined to the jacket where the pressure is unvarying. So long as a cylinder contains steam only, the range of temperature of the walls is but small; but so soon as moisture collects, the rapid evaporation of the liquid in contact causes extreme and rapid variations of the temperature of the metal. The liquid, in fact, has a refrigerating action, due to evaporation at the lowest temperature of the exhaust or condenser, and so tends to bring the whole cylinder walls to the temperature of the condenser at every stroke. Take, for example, a cylinder without jacket; then, on admitting steam, there is a certain amount of condensation, and during expansion a further condensation, partly because of work done, and partly because of radiation losses. At the end of the stroke the cylinder contains a considerable amount of water, partly as spray, partly as moisture deposited on the enclosing walls. The release opens, and the cylinder communicates with the condenser or the atmosphere, and at once the reduction of pressure causes the water to evaporate and reduce the whole temperature of the cylinder to that of the steam escaping to the atmosphere or to the condenser. In this manner a serious fall of temperature is occasioned, and not only is the heat lost due to the initial condensation, but a similar amount is lost by evaporation of the water so condensed, as well as a portion required to evaporate the water produced by work done. This causes a wide range of temperature throughout the stroke, and so increases loss. When the whole of the surfaces are efficiently steam-jacketed in such manner as to keep the cylinder, cover, and piston surface at the full boiler temperature, there is no initial condensation, and liquefaction due to work performed throughout the stroke is greatly limited by the sustained temperature. Consequently, steam only being in the cylinders, no great flow of heat to the condenser is occasioned, and the cylinder surfaces pass through but trifling variations of temperature. As the steam jacket is under constant pressure, it only loses by radiation and by heat flowing to make up for the fall of temperature due to work done within the cylinder. Against this action is to be placed the fact that the steam pressure is kept up throughout the stroke by sustaining the temperature at its highest point, and so adding heat continuously while doing work. This is, of course, wrong theoretically, and it depends on the range of expansion whether the loss will be considerable or inconsiderable.

The question of steam jacketing is a very large one, and to decide as to its advantage or disadvantage requires careful consideration for every class of engine. It appears to us that experimenters require to examine much more carefully than hitherto the engines upon which they experiment, and make comparative tests with experimental chambers under more exact conditions, and more completely ascertainable than is the case with actual engines. Much of the difference of opinion is doubtless due to the fact of applying results taken from a particular engine to others of quite different conditions. Before experiments can be universally or even generally applicable they must yield much more definite information, and be capable of much more exact interpretation than any at present made. The task will be a difficult one, but will amply repay any engineer who may have the requisite time and opportunities to devote to it.

THE CLOSE OF THE PARIS EXHIBITION.

After a brilliant success of six months' duration, the great Paris Exhibition, celebrating the centenary of the French Republic, has come to an official end. It was formally closed on Thursday, 7th November, and the exhibitors have already commenced to remove those objects which have aided to attract and interest some 25 millions of people between May and November. Although officially closed, the public are still to be admitted to such parts of the Exhibition as will not be seriously interfered with by the process of removal.

The leading features of the Exhibition of 1889 were undoubtedly the Eiffel Tower and the great Machinery Hall, and these are works worthy in every respect of the great and well-earned reputation of the French as engineers. The whole of the buildings were graceful and striking to a degree, and thoroughly harmonised, to an extent which would hardly have been possible outside of France. Among the minor marvels were the Decauville railway running round the Exhibition, the hydraulic railway of M. Barre, and the great terrestrial globe of 40ft. in diameter. The whole arrangements of the Exhibition were admirable, and the exhibits of the most interesting and varied nature.

We take leave of it with regret, although nothing very novel was produced of an engineering kind.

STEAM PIPES.

It appears that the fatal explosion on board the Cephalonia, to which we referred in a recent issue, was due to the collapse of the combustion chamber top, not to the bursting of a steam pipe, as was first reported. The general anxiety, however, on the subject of steam pipes is so great that the report was at once credited. Sea-going engineers undoubtedly distrust copper steam pipes, and we observe that in the steamship Columbia, described in a contemporary, the copper pipes have been closely wound with wire, on the principle of the wire gun. This should give great safety, as it is difficult to imagine an undetectable flaw in steel wire. Brazing is uncertain at best, and it is very desirable to see copper pipes reinforced in some way.

DANGERS OF ELECTRIC LIGHTING.

In a recent letter to a Glasgow paper, Mr. Bottomly, Sir William Thomson's assistant at the Glasgow University, calls attention to the great number of deaths—over 100 in New York alone—resulting from the use of high-tension alternating currents in electric lighting in America. The high-tension system is doubtless tempting from an economical standpoint, as it permits electric energy to be distributed over wide areas with but slight loss and with small wires. But the dangers are really terrible; and when we find men like Sir William Thomson gravely doubting the possibility of efficient or safe insulation, it is necessary that we should beware that our streets are not converted into death-traps, as the New York streets have often proved. The difficulty of insulating the low-tension current from the transformer from the high-tension circuit is very great, and there are few of us would permit in our houses wires which might at any moment cause death by contact.

Another danger has also been introduced amongst us. In London, on Nov. 1st, an explosion occurred at Albert Gate, due to the ignition of a mixture of gas and air, formed by leakage under the street, by the electric arc or spark from wires passing under the street. The pavement and iron plates were blown up and sent high into the air. Fortunately there was no loss of life or injury. Our electric light companies must proceed slowly until they become familiar with the dangers of their business, if they wish to avoid discrediting the electric light and injuring themselves in the estimation of the public.

The Lehigh Valley Railway Company, U.S.A., have recently had a car constructed to carry a load of 55 tons, the car itself weighing 20 tons. The length of the car is 35ft. 8in., and it is supported by two six-wheeled bogies with 33in. wheels.

HYDRAULIC MACHINERY EMPLOYED IN THE CONCENTRATION AND TRANSMISSION OF POWER.—IX.

THE HYDRAULIC PRESS.

HAVING traced the application of hydraulic power to the most commonly known lifting appliance, viz., the hydraulic jack, and in our examination of this very simple yet typical hydraulic appliance investigated the efficiency of its work done, as against the power given to it, we will now consider a more substantial, although not a more useful, machine. We preface our discussion of the hydraulic press by mentioning the chief principles that we shall have to consider in this powerful agent. The hydraulic press has been known to the public as a really serviceable aid to the engineer since the erection of the Britannia tubular bridge; although long before that time its advantages were fully understood and appreciated by engineers themselves. The chief or primary parts of the press are few in number, and consist (1) of a ram moving in a cylinder; (2) a fixed cylinder to receive the ram and contain the water; (3) a head, or top casting, against which the object to be compressed is thrust; (4) a table, or platten, fixed to the upper end of the ram; (5) a set of bars, or pillars, to connect the head to the projection formed upon the cylinder (or to the base when a separate base is employed to receive the cylinder); and (6) a stop and release valve for controlling the operations of the press. In nearly all cases of general application the ram of the press is unbalanced, and rises by the pressure given to its base, which is hanging in the cylinder, while its weight alone is sufficient to give it the return or lowering motion, and to drive the water out to waste or exhaust. It will thus be quite evident that but one valve is wanted to govern the motion of the press, viz., a supply valve, which will admit the water into the cylinder when moved in one direction, and which will allow the ram to force it out to waste when moved in the contrary direction. We illustrate in figs. 41, 42, 43, the kind of valve very commonly employed for this purpose, this type being known as a hydraulic slide valve. We also give another illustration (fig. 44) of a valve suitable for the same purpose, known as a plug stop and release valve. In figs. 42, 43, 44, A is the connecting branch from the pressure main, or supply; B is the connecting branch for the exhaust or waste water returned from the valve after the press has done its work, and when it is to descend; C is the branch connecting the valve to the press itself. In other words, A is the supply, B is the discharge, and C is the inlet to and exit from the press. The valve is usually made entirely of gun metal; but in order to facilitate renewal and repair, the seat or surface K, upon which the circular slide D works, is not a part of the main casting, but this face is pinned on to the other part of the valve. The valve rod L is enlarged in the centre, and has a hole cut in it to receive the upper portion or stem of the slide. The rod works through packed glands, which are provided with neck bushes, to admit of the enlarged portion of the rod passing through. The circular openings F and G, which lead into the exhaust and connections B and C, are opened and closed by the slide D; and the projecting part of the rod L serves to stop the slide from travelling too far. Should the pressure within the press cylinder become greater than that of the supply or main, by reason of a sudden shock or other undue resistance, then the bye passage H will allow the water to escape through the little shock valve E, and thus prevent damage being caused to the press cylinder. This little shock valve E is usually made in the form of a weighted leather washer, and it is pinned or screwed on to the valve chamber, as shown in plan. The advantage obtained by making the ports circular is due to the gradual opening and closing that is possible when the circular valve uncovers or covers them, and thus preventing sudden shock or strain.

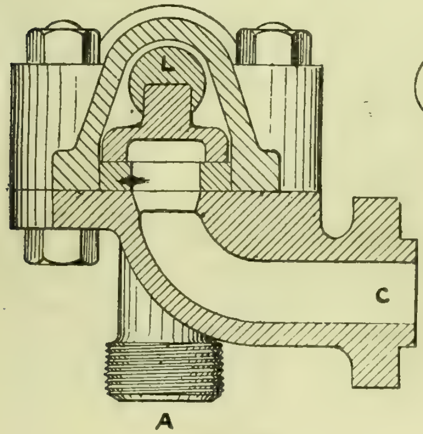

FIG. 41.

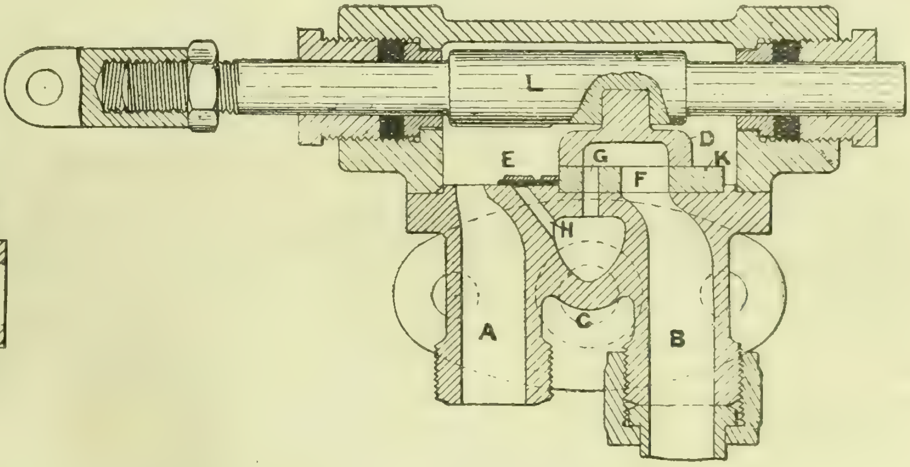

FIG. 42.

The plug stop and release valve (fig. 44) is made of gun metal, with plugs having screwed surfaces, and a plain circular part, with a laced or leather strap made joint. The passage E connects to the press C to the exhaust, and D to the pressure supply or main. Handles upon the end of each spindle regulate the opening and closing of the passages.

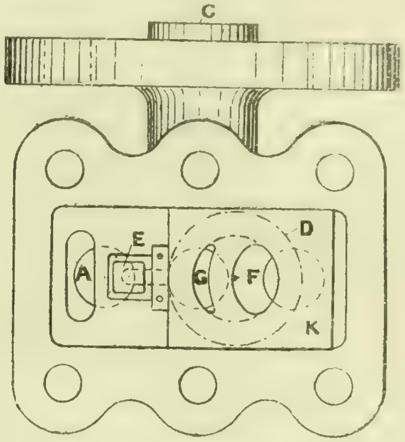

FIG. 43.

We shall illustrate a hydraulic press used for baling or packing purposes, having the table or platten covered or formed with laths, for the insertion of bands or hoops for fastening the bale or material after it has been compressed; similar laths are provided upon the underside of the head of the press. Removable bars or guides are arranged upon the press for keeping the bale or material in correct position. The pressure is given to the cylinder by means of hand pumps fitted upon the base, which is arranged as a cistern for holding the necessary water. A high and also a low pressure pump is attached, for the convenience of the work to be done, seeing that, in packing, the full power is not required for the whole of the stroke. Thus the low-pressure pump is used to first give the preliminary pressure upon the material, and then the high-pressure pump is employed to finish the process. A safety release valve is attached, for preventing undue pressure being given.

For the purpose of making our article as practicable as possible, we will take an example of the work we are now discussing, and follow through the chief calculations required and the leading points to be attended to, either in designing the press in the drawing office or setting the actual parts out in the various shops through which the different portions of the work must pass.

Commencing, then, at the very beginning, we will take for our conditions the following instructions, which we may conceive to be given by those requiring the hydraulic press. The power of the press to be 100 tons; the water pressure to be supplied by an independent pressure pump; the working pressure of the water at the point where the press is to be connected to be 2,000lb. per square inch; the stroke of the press to be 3ft., and the "daylight," or the distance between the platten or table when down and the underside of the head of the press, to be 4ft. 6in.

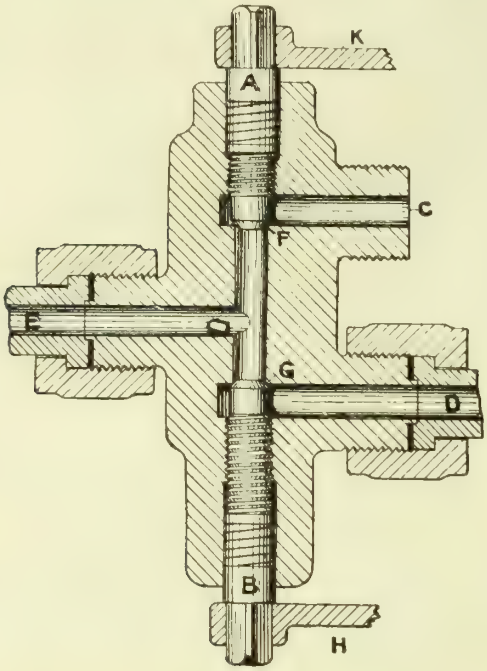

FIG. 44.

Then 100 tons = 224,000lb. = power of press.

Area of ram, ignoring friction, = 224,000 ÷ 2,000 = 112.

Trial or assumed area of ram = 112″ = $D^2 \times \cdot 7854$.

Diameter of ram or D = 11·96″, say 12″.

*Friction of total pressure $= \cdot 04 \frac{P}{D} = \cdot 04 \frac{100}{12} = 746$lb.

Gross power of press = 224,000 + 746 = 224,746lb.

Hence actual area of ram $= \frac{224{,}746}{2{,}000} = 112 \cdot 3$;

And $\therefore$ say D = 12″ = 113″ area.

The above calculations give us the chief point required in designing our press, but the detail consideration we will reserve for our next article.

MODERN GAS-ENGINE PRACTICE.

At a meeting of the Society of Engineers, held at the Town Hall, Westminster, on the 4th inst., Mr. Jonathan R. Bailie, president, in the chair, a paper was read by Mr. S. Griffin, on "Modern Gas-engine Practice."

In dealing with the subject the author confined himself principally to illustrations from actual practice, these being discussed as far as possible in the order in which the various improvements have been introduced. He first described the general construction and principle of the Lenoir engine, taking it as a fair type of non-compressing gas engine. Having alluded to its high gas consumption and general defects, the author proceeded to investigate its chief theoretical requirements, tabulating them in their natural order. He then pointed out how imperfectly they were met—throttling of the entering charge, change of volume after cut-off previous to ignition, late maximum pressure, and insufficient expansion of the working charge being specially conspicuous. Having illustrated these defects by means of an indicator diagram taken from a Lenoir engine, the author proceeded to describe and illustrate the Otto and Langen atmospheric engine, remarking that this motor followed the Lenoir distinctly in the order of time as well as that of improvement. He described its working cycle, and pointed out that although differing so greatly in outward appearance as well as method from the Lenoir, yet that their cycles, and consequently their theoretical requirements, were practically identical. The reasons of its great economy as compared with the Lenoir were then discussed and shown to arise from a better adaptation to theoretical requirements; the charge being introduced without throttling, there being no change of volume after cut-off previous to ignition, prompt maximum pressure and rapid and full expansion of the working charge. The indicator diagram, used in illustration of these points, further revealed the fact that cooling of the charge, during contraction of its volume, increased its efficiency. From the consideration of this engine the author passed to that of the modern compressing gas engine, pointing out that some 25 years since the advantages of compression, together with the double-cycle engine, were fully described in a work by Beau de Rochas, this same cycle, in combination with compression, being afterwards employed by Dr. Otto. He then proceeded to describe the general construction and cycle of the Otto engine, taking it as a fair type of the modern compressing gas engine. Its great economic success was shown to be almost due to the use of compression, coupled with sound mechanical arrangement. The theoretical and practical value of compression having been described and illustrated by means of an Otto indicator diagram, the author quoted the two principal objections which have been urged against the Otto, or two-cycle engine, by practical engineers, viz., first, its cyclical variation and insufficient development of power; second, insufficient expansion of its working charge. He then described several engines, which from time to time have been introduced with a view to improvement on these points. The Clerk engine was described as being the first to successfully obtain an impulse at each revolution of the crank with compression of the charge, the practical gain, however, being counterbalanced by increased complication and negative work. The author's double-acting engine was next described, and the practical advantages claimed for it discussed; the behaviour of the working charge in the cylinder being illustrated by an indicator diagram, taken from a 2 H.P. nominal double-acting Griffin engine. The second objection to the ordinary double-cycle engine—viz., the insufficient expansion of its working charge—was then noticed, and the efforts made by Mr. Dugald Clerk, Messrs. Crossley Brothers, Mr. Atkinson, the author, and others, towards improvement in this direction were briefly alluded to. The author described his experimental engine for obtaining increased expansion, illustrating his remarks by means of a sectional elevation of the cylinder, together with three indicator diagrams, taken with three different grades of expansion. Mr. Atkinson's cycle engine was next described, the behaviour of the working charge being also illustrated by means of an indicator diagram. The practical results of increased expansion were considered, the author pointing out that at best the gain arising from it was very small, and not such as would warrant the introduction of any complication to obtain it, there being the further disadvantage of greatly increased bulk for a given output of power. Having briefly alluded to a number of important points which could not be dealt with by reason of the limited time at his command, the author concluded by indicating a few of the directions in which development of the gas engine may be expected to extend, giving it as his opinion that future gas engines will be constructed upon the lines of those of the present day, improvement being in the direction of detail rather than principle.

COMPLETION OF THE FORTH BRIDGE.

THE bridging of the Forth is an accomplished fact. Two attempts were made on the 6th inst. to fill up the gap between the two halves of the central girder connecting the island of Inchgarvie and the Fife cantilevers, but the weather temperature never rose to a point higher than 52 deg., and the anticipated expansion was never realised. A pressure of 130 tons was brought to bear upon the girder, but at no time was the gap reduced to less than three-eighths of an inch. The actual joining was accordingly abandoned, the intention being to increase the pressure on the next day. When work was resumed at seven o'clock the following morning, however, the weather, although gusty, was extremely mild, the temperature being 58 deg., as compared with 52 on the afternoon of the previous day. To the astonishment of the workmen, they found that the expansion had been so great with the change of weather that the joining holes of the two halves of the girder were exactly opposite each other.

See *Practical Engineer*, April 5th, 1889.

Messrs. D. Harris, W. Westhoven, C. Graham, and Blackburn, without the least ceremony, seized the connecting plates, and the 23 bolts were driven home in a comparatively brief space of time. Mr. Arrol was sent for, but before he had appeared upon the scene the work had been practically completed. The joining is the most delicate work of the whole undertaking; and Mr. Arrol expressed satisfaction at the manner in which the manager had handled the work. The necessity of taking advantage of the favourable opportunity will be apparent when it is stated that the wind blew quite a gale during the day. An idea of the influence the weather had on the structure will be got when it is known that the pressure brought to bear on the structure by jacks on Wednesday was 130 tons, whereas on Thursday the necessary expansion was obtained without any pressure whatever. The filling up of the gap between the top members is a much easier task. A temperature with a contracting rather than an expanding tendency is best suited for the top "booms," so that no delay is anticipated from the weather.

Great progress has been made with the permanent way during the past fortnight. The struts and ties are well advanced along the whole line. It is anticipated that another month will see the end of the bulk of the work which remains to be done. The progress made with the railway between the bridge and Inverkeithing has been the least satisfactory of all the railway connections. This is accounted for by the enormous difficulties which have been encountered at the Ferry hills, where extensive boring and blasting operations had to be conducted. The greatest difficulties in this direction have now, however, been overcome, and it is expected that the work will be finished about the end of January.

THE HARRIS COMPOUND ENGINE.

THE forms of trip gear for steam valves are almost infinite in their variety, but all depend upon the slipping of metallic edges or hooks, at times determined by a governor. Messrs. W. A. Harris and Co., U.S.A., have introduced in America an ingenious form of trip gear in the compound engines made by them. We illustrate it at figs. 1 and 2, of which fig. 1 is an end elevation, and fig. 2 a side elevation. Referring to fig. 2, the rod at the highest point of the figure connects to the wrist plate of the engine, and thus receives motion suitable for actuating the valves, and the lever moved by it carries at its lower part a horizontal catch-plate lever, which would naturally fall down, but is kept in position by a lever at the end of the spindle (see fig. 1) to the left of the figure. The end of this lever travels on a cam slot in a circular cam plate, controlled by the governor. The rod to the governor is the lower one in fig. 2, passing in the same direction as the rod communicating with the wrist plate. The steam valve is driven by the vertical rod (fig. 2) depending from the front lever carrying the catch plate, which engages with the lower lever, and the motion is communicated from the lower catch plate to the upper. This opens the valve, and the valve continues opening till the back lever, supporting the lower catch-plate lever, comes in contact with a cam incline in the slot, where the plates are at once thrown out of gear, and the valve closes, assisted by the weight of the valve rod. The governor varies the position of the back cam plate, and so determines an early or late cut-off. When the lower lever returns again, the upper catch plate is free to slip up and allow the lower to pass, after which it falls into gear before the return. This action, we are informed, is extremely satisfactory and regular.

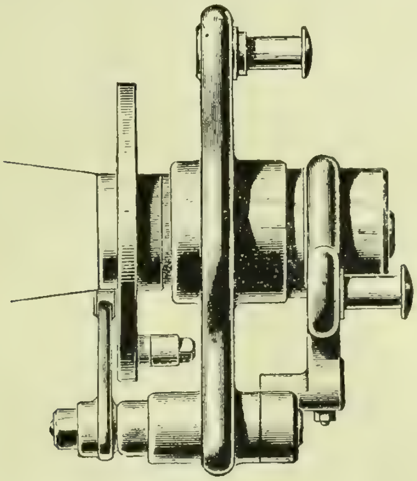
FIG. 1

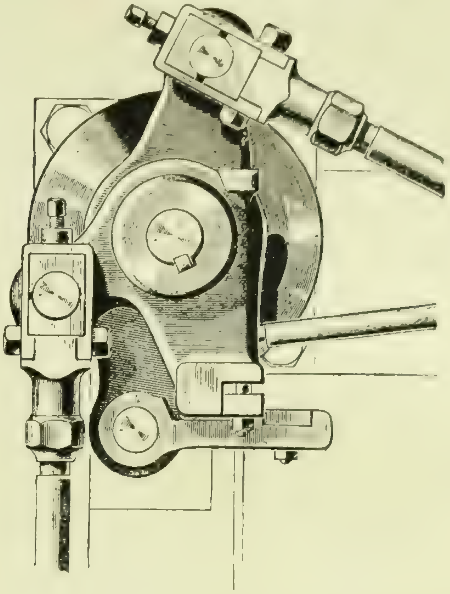
FIG. 2.

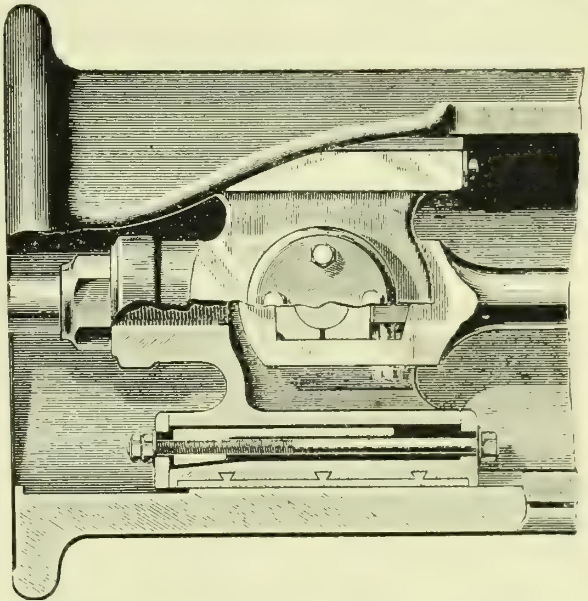
FIG. 4.

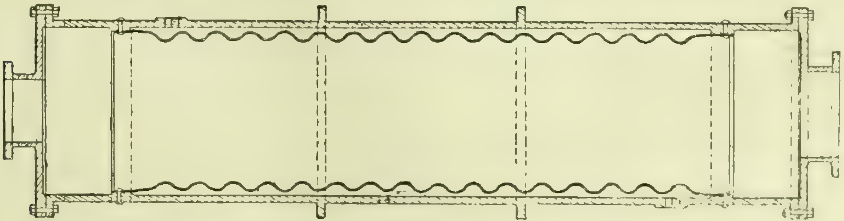
FIG. 3.

Messrs. Harris have introduced an ingenious novelty in their intermediate receiver, between the high-pressure and low-pressure cylinders, by constructing it of a corrugated tube of about $\frac{5}{16}$in. thick iron, and surrounding this with a cast-iron jacket and live steam from the boiler between the corrugated tube and the cast iron. The interior of the corrugated tube acts as the receiver, and its form allows of free expansion and contraction, while the end connections are rigid. This is shown at fig 3. The detail of the crosshead and guide is also shown at fig. 4.

CYLINDER RATIOS OF TRIPLE-EXPANSION ENGINES.*

THE triple-expansion engine promises to displace the ordinary compound engine for marine use, as it in turn displaced the simple engine of thirty years ago. During the past two years the increase in the number of such engines has been phenomenal. This form may now be called the favourite marine type, while it bids fair to establish itself for stationary purposes wherever great power and economy are desired. Whenever the steam pressure exceeds 100lb. gauge the triple-expansion engine is used, while the tendency is toward quadruple expansion when the pressure exceeds 170lb.

Existing practice in proportioning the cylinders of triple-expansion engines is given in Table I. In it the particulars of eighty engines of recent design are given, the engines being grouped according to better pressures. The tendency, as shown, is toward an increase in piston speed and boiler pressure, and a consequent decrease in weight and first cost of machinery. Equal work should be performed in each cylinder, uniform rotative effort secured, and low initial strains in all moving parts obtained. These can be readily obtained by dividing the work among three or more cylinders, as in the triple-expansion engine, and by the use of variable expansion valves and balanced rotative parts.

When the piston speed varies from 750ft. to 1,000ft. per minute, the following cylinder ratios are recommended as the result of a study of Table I. (the terminal pressure of steam in the large cylinder being about 10lb. absolute), viz.:—

CYLINDER RATIOS RECOMMENDED FOR TRIPLE-EXPANSION ENGINES.

Boiler Pressure (Gauge).	CYLINDER RATIOS.		
	Small.	Intermediate.	Large.
130	1	2·25	5·00
140	1	2·40	5·85
150	1	2·55	6·90
160	1	2·70	7·25

170 and upwards—quadruple-expansion engine to be used.

Two methods of ascertaining the diameter of the pistons will now be given.

1. ANNULAR RING METHOD.—In fig. 1 lay down a theoretical indicator diagram of a simple engine for the particular expansion desired. Lay off the back-pressure line as shown. By trial find (with the polar planimeter or otherwise) the position of the lines D E and F G such that the areas marked "A," "B," and "C" are respectively equal. Find the mean ordinate of each area: that of "C" will be the mean unbalanced pressure on the small piston; that of "B" will be the mean unbalanced pressure on the area remaining after subtracting the area of the small piston from that of the intermediate; and that of the area "A" will denote the mean unbalanced pressure on a square inch of the annular ring of the large piston, obtained by subtracting the intermediate from the large piston. We thus see that the mean ordinates of the two lower cards act on annular rings.

Let H = area of small piston in square inches.
I = area of intermediate piston in square inches.
L = area of large intermediate piston in square inches.
Ph = mean unbalanced pressure per square inch from card "C."
Pi = mean unbalanced pressure per square inch from card "B."
Pl = mean unbalanced pressure per square inch from card "A."
S = piston speed in feet per minute.
(I.H.P) = indicated horse power of engine.

Then for equal work in each cylinder we have—

$$\text{Area of small piston} = H = \frac{33000 \times \frac{(\text{I.H.P.})}{3}}{Ph \times S} \qquad (1)$$

$$\text{Area of annular ring of intermediate cylinder} = \frac{33000 \times \frac{(\text{I.H.P.})}{3}}{P_i \times S}$$

$$\text{Area of intermediate piston} = I = H + \frac{33000 \times \frac{(\text{I.H.P.})}{3}}{Pi \times S} \qquad (2)$$

$$\text{Area of annular ring of large piston} = \frac{33000 \times \frac{(\text{I. H. P.})}{3}}{Pl \times S}$$

$$\text{Area of large piston} = L = I + \frac{33000 \times \frac{(\text{I. H. P.})}{3}}{Pl \times S} \qquad (3)$$

This method is illustrated by the following

Example.—Given I.H.P. = 3000, piston speed S = 900 feet per minute, ratio of expansion 10, initial steam pressure at cylinder 127lb. absolute, and back pressure in large cylinder 4lb. absolute. Find cylinder diameters for equal work in each (fig. 1).

The mean ordinate of "C" is found to be $Ph = 37{\cdot}414$ per square inch.

The mean ordinate of "B" is found to be $Pi = 15{\cdot}782$lb. per square inch.

The mean ordinate of "A" is found to be $Pl = 11{\cdot}730$lb. per square inch.

Then by (1), (2), and (3) we have—

$$H = \frac{33000 \times \frac{3000}{3}}{37{\cdot}414 \times 900} = 980 \text{ square inches, diameter } 35\tfrac{3}{8}\text{in.}$$

$$I = 980 + \frac{33000 \times \frac{3000}{3}}{15{\cdot}782 \times 900} = 3303 \text{ square inches, diameter 65in.}$$

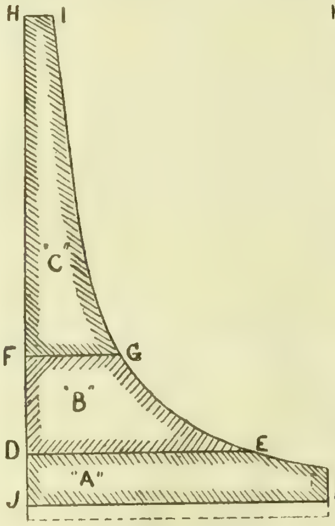

FIG. 1.

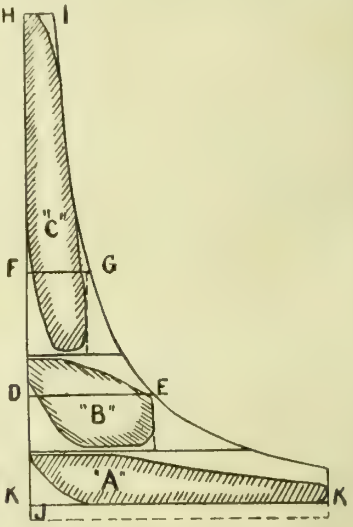

FIG. 2.

$$L = 3303 + \frac{33000 \times \frac{3000}{3}}{11{\cdot}730 \times 900} = 6432 \text{ square inches, diameter } 90\tfrac{1}{2}\text{in.}$$

2. "DROP" METHOD.—In fig. 2 lay down a theoretical card, as in fig. 1. Choose cylinder ratios from the table of recommended values.

Draw FG, DE, and JK in these ratios, dividing the diagram in three parts, "A," "B," and "C." Round off the corners so as to make the figures conform as nearly as possible to the combined card from an engine of this type. The waste spaces are due to "drop," condensation, &c. The mean ordinate of this combined card will give the mean unbalanced pressure on a square inch of the large piston, as if all work had been done in its cylinder. With this find the area of the piston necessary for all the work. Divide this area of piston by the cylinder ratio, thus obtaining the area of each piston as follows:—

Example.—Given data of previous example, and cylinder ratios of 1 to 2·25 to 5·00, find diameter of each cylinder (fig. 2).

The mean ordinate of the combined card is measured to be 17·5lb.; hence—

$$\text{Area of large piston} = L = \frac{3000 \times 33000}{17{\cdot}5 \times 900} = 6286 \text{ sq. in., dia. } 89\tfrac{1}{2}\text{in.}$$

$$\text{Area of intermediate piston} = I = \frac{2{\cdot}25\ L}{5{\cdot}00} = 2829 \text{ sq. in., dia. 60in.}$$

$$\text{Area of small piston} = H = \frac{L}{5{\cdot}00} = 1257 \text{ sq. in., dia. 40in.}$$

The results obtained by the two methods accord quite closely. The main point to be considered is, "How large shall the condensing cylinder be made?" The small and intermediate cylinders may have almost any values, provided variable expansion valves are used.

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* A paper read at the Erie meeting of the American Society of Mechanical Engineers, by J. A. Whitman, member.

TABLE I.—Showing Cylinder Ratios of Triple-expansion Engines for Variations in the Boiler Pressure.

Vessel.	Piston Stroke in Inches.	Cylinder Diameter in Inches.			Cylinder Ratios.			Boiler Pressure. Gauge.	Piston Speed in Feet per Minute.	I.H.P
		H. P.	I. P.	L. P.	H. P.	I. P.	L. P.			
Gunboat No. 1	30	22	31	50	1	2·00	5·17	160	..	3000*
Montebello	16	15½	24	37	1	2·40	5·70	160	1060*	4200*
Iljin	18	17½	27	42	1	2·38	5·76	160	..	3550
Oroya	72	40	66	100	1	2·72	6·25	160	774	6750
Orizaba	72	40	66	100	1	2·72	6·25	160	756	6500
Buffalo	60	33	54	86	1	2·68	6·80	160	570	2278
Bleville	42	21	33	52	1	2·47	6·13	160	490	1223
Vespasian	30	17	29	46	1	2·91	7·32	160	400	600
Aberdeen	33	17	28½	51	1	2·81	9·00	160		
Altmore	36	22	36	66	1	2·68	9·00	160		
Anchoria	48	36	59	96	1	2·69	7·11	160		
Cosmopolitan	39	19½	32	52	1	2·69	7·11	160		
Cremon	42	20	31½	50	1	2·48	6·25	160		
Earnholm	30	17	27	48	1	2·56	7·97	160		
Explora	36	20	33	54	1	2·72	7·54	160		
Gulf of Suez	39	19½	32	52	1	2·69	7·11	160		
Hecla	33	17	28	47	1	2·71	7·64	160		
Mexican	54	36	58	94	1	2·60	6·82	160		
Pacifique	54	26	42	69	1	2·61	7·04	160		
Trojan	60	34	54	89	1	2·52	6·85	160		
Sevona	39	21	35	58	1	2·78	7·63	160		
Athenian	54	36	58	94	1	2·61	6·82	160		
Birkhall	36	17	31	57	1	3·32	11·20	160		
City of Lincoln	42	26	42	68	1	2·60	6·82	160		
De Ruter	42	21	38	66	1	3·27	9·87	160		
Etna	33	17	28	46	1	2·71	7·32	160		
Spartan	60	34	54	89	1	2·52	6·85	160		
Average cylinder ratios for 160lb. boiler press.					1	2·66	7·24			
Dogali	33	30	45	73	1	2·25	5·92	150	842	7600
Ormuz	72	46	73	112	1	2·52	5·93	150	840	8000
Aller	72	44	70	108	1	2·53	6·03	150	828	6890*
Saale	72	44	70	108	1	2·53	6·03	150	828*	6890*
Trave	72	44	70	108	1	2·53	6 03	150	828*	6890*
Trans-Pacific	60	34	56	90	1	2·71	7·01	150	..	4000*
Carmarthenshire	45	27	43	70	1	2·54	6·72	150	568	2340
Libra	42	25	42	67	1	2·82	7·18	150	616	1966
Sobralense	42	2–17	38	60	1	2·50	6·23	150	532	1580
Westmoreland	36	20	33	54	1	2·72	7·29	150	420	900
Royal Prince	39	20	33	54	1	2·72	7·29	150	481	767
City of Edinburgh	48	30	44	73	1	2·15	5·92	150		
Congella	42	21	34	56	1	2·62	7·11	150		
Constantin	..	12½	20½	34	1	2·69	7·40	150		
Ehrenfels	48	25	38	72	1	2·31	8·29	150		
Florence Richards	30	18½	27	48	1	2·13	6·73	150		
Thames	36	21½	33	54	1	2·26	6·31	150		
Vlissingen	18	10	16	26	1	2·56	6·76	150		
Asturiano	36	21½	34	55	1	2·51	6·54	150		
Drummond Castle	57	33	58	88	1	4·09	7·11	150		
Elbe	48	33	53	88	1	2·58	7·11	150		
Ennerdale	33	17	27	52	1	2·56	9·36	150		
Grantully Castle	57	31	51	82	1	2·71	7·00	150		
Jenny Otto	36	20	32	57	1	2·56	8·12	150		
Ocean King	48	26	42	68	1	2·61	6·84	150		
Russia	45	26	41	70	1	2·34	7·25	150		
Remo	33	17½	29	47	1	2·75	7·21	150		
Yeoman	44	25	38	63	1	2·31	6·35	150		
Average cylinder ratios for 150lb. boiler press.					1	2·54	6·90			
Destructor	21	18½	27	42	1	2·13	5·16	145	1023	3829
Oaxaca	60	40	64	92	1	2·56	5·29	145	700	3417
Average cylinder ratio for 145lb. boiler press.					1	2·35	5·23			
Serpent	33	26	37	57	1	2·03	4·81	140	..	4500*
Racoon	33	26	37	57	1	2 03	4·81	140	..	4500*
Bramble	24	18½	29	43	1	2 51	5·40	140	732	1042
Lizard	24	18½	29	43	1	2·51	5·40	140	732	1025
Rattler	24	18½	29	43	1	2·51	5·40	140	810	1291
Wasp	24	18½	29	43	1	2·51	5·40	140	772	1157
Rattlesnake	18	18½	27	42	1	2·13	5·16	140	966	2860
Reina Regente	45	40	60	92	1	2·25	5·28	140	862*	12000*
Windsor	30	18	30	56	1	2·75	9·68	140	..	..
Bengal	66	35	56	89	1	2·56	6·47	140	..	3200*
Coromandel	66	35	56	89	1	2·56	6·47	140	..	3200*
Average cylinder ratio for 140lb. boiler press.					1	2·40	5·84			
Nile	51	43	62	96	1	2·00	5·00	135	807*	12000*
Trafalgar	51	43	62	96	1	2 08	5·00	135	807*	12000*
Baltimore	42	42	60	94	1	2·04	5·01	135	770	10750*
Average cylinder ratio for 135lb. boiler press.					1	2·07	5·00			
Victoria	48	38	58	88	1	2·33	5·36	130	..	12000*
Sanspariel	48	38	58	88	1	2·33	5·36	130	..	12000*
Aurora	42	36	51	78	1	2·00	4·70	130	..	8500*
Australia	42	36	51	78	1	2·00	4·70	130	..	8500*
Galatea	42	36	51	78	1	2·00	4·70	130	..	8500*
Immortalite	42	36	51	78	1	2·00	4·70	130	..	8500*
Orlando	42	36	52	78	1	2·08	4·70	130	832	8662
Undaunted	42	36	52	78	1	2·03	4 70	130	..	8500*
Narcissus	42	35	51	78	1	2·12	4·97	130	..	8500*
Average cylinder ratio for 130lb. boiler press.					1	2·10	4·88			

* Probable value.

EXPLOSION ON THE MISSISSIPPI.

Advices from New Orleans received at Queenstown contain additional details of the terrible boiler explosion which occurred on board the passenger steamer Corona on the 3rd ult., on the Mississippi River, by which 43 persons were killed and 15 of the passengers and crew badly scalded. Captain Sweeney, the owner of the Corona, who was on board at the time of the explosion, and was badly scalded, stated that when the vessel left New Orleans she had 80 passengers on board, and all went well until they were about 14 miles from Baton Rouge, about 10 a.m. He was standing on the boiler deck when the explosion occurred. It shook the vessel from stem to stern, blew the roof off the saloon high into the air, knocked the two large funnels overboard, and tore the main deck open. He saw Captain Blanks hurled into the air through the roof of the saloon. When he looked into the saloon the dead bodies of about 20 passengers were lying about in all directions, some without heads, others with their legs blown off. It was a terrible spectacle. The force of the explosion withdrew the freight piles and pinned down under them the eight men stowing cargo, who were instantly killed. The second engineer was severely scalded, and when endeavouring to escape a heavy log of wood fell on him and pinned him down. The water rose over him in the engine-room before he could be rescued. A little boy was blown overboard and rescued in an unconscious condition. The deck was strewn with dead and dying persons, whose shrieks were most harrowing. Steam was meanwhile hissing about in all directions, and many had plunged into the water to avoid scalding, when the steamer suddenly plunged forward and sank. The captain narrowly escaped going down in the vortex, and after being some time in the water the steamer St. Louis came up and rescued the survivors.

SYSTEM IN LOCOMOTIVE SHOPS.

The marvellous Baldwin Locomotive Works are at present turning out twenty-eight complete locomotives weekly, or at the rate of 4⅔ per day, or a complete locomotive in every two hours and eight minutes of time. These are really astounding figures, and the mind fails to take in their full significance until one has gone through the works, and noted the small army of men employed and the vast equipment of machinery. It has been remarked that there is comparatively little to be seen in these shops which a toolmaker would be apt to consider as indicating remarkably high efficiency, and in this connection the opinion of an eminent engineer, not, however, connected with the works, may be interesting. He seemed to think that the high efficiency is due largely to their system, which enabled them to quickly detect any weak spot, and take measures to strengthen it.

At the beginning of every week, each foreman receives a blank form filled out, which indicates what work must be done in his department that week in order to complete certain engines according to contract. If, for any reason, he thinks that he will be unable to do the specified work within the week, he gives notice to that effect, in order that suitable arrangements may be at once made, either for increasing his output in some way, such as by putting on more hands, by ordering night work in that department, or by sending part of the work to other departments where practicable. Towards the end of the week it is the business of each foreman to ascertain if he is likely to finish the required work, and if not, to give the reason.

When any department is found to be often or habitually behind, it is strengthened in some way, usually by the addition of men or machinery, or both. This plan obviates a great deal of vexatious and expensive delay, and at the appointed times when the erection of an engine should commence, all the parts which are to compose that engine are almost sure to be ready to go together. Any weak link in the chain is at once detected, and every man who is responsible for a part of the work knows that, if his department falls in the least behind, he will be expected to give a satisfactory reason for it within a few days, and before any very serious or irreparable delay takes place.—*American Machinist.*

It is proposed to erect a new bridge across the Tyne, between Newcastle and Gateshead. It would be nearly 2,000ft. long and 50ft. wide, and the suggestion is that the bridge should be constructed of steel chains and suspension rods supporting a strongly-braced platform, the chains to be carried over two high towers, and anchored in solid abutments at each end of the bridge.

THE GLOBE TRIPLE-EXPANSION ENGINE.

CONSTRUCTED BY MESSRS. JOHN MUSGRAVE AND SONS LIMITED, ENGINEERS, BOLTON.

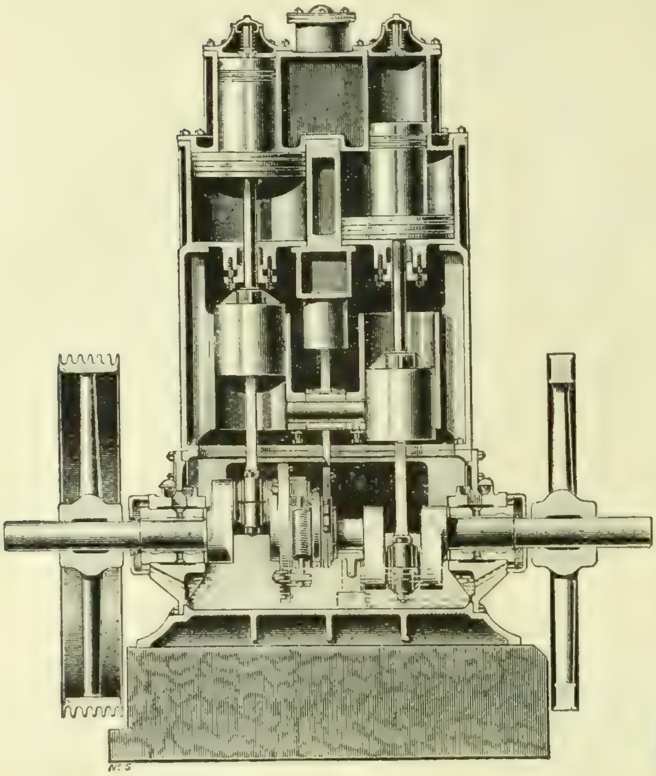


FIG. 1.

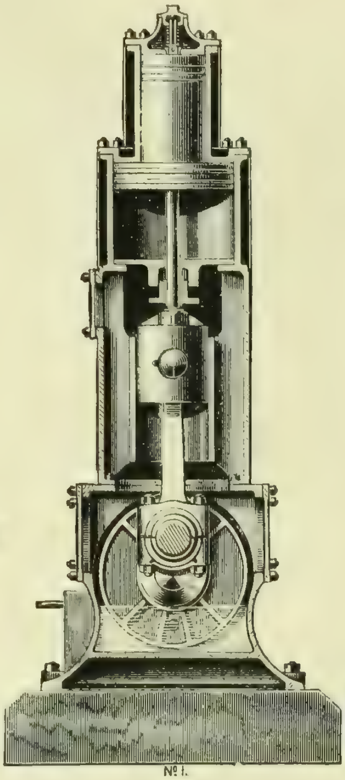


FIG. 2.

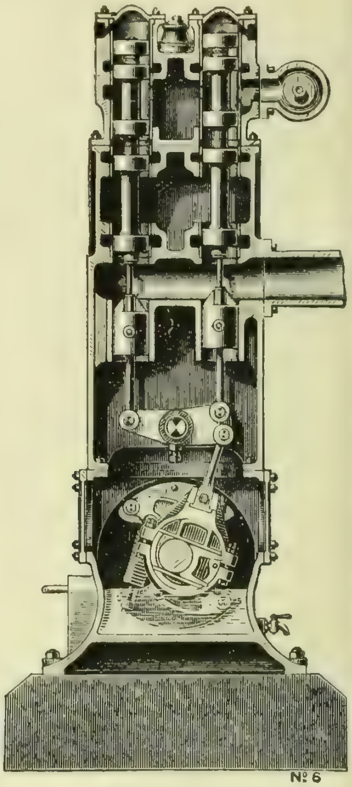


FIG. 3.

THIS engine is constructed by Messrs. John Musgrave and Sons Limited, of Bolton, on the same lines as the compound automatic engine by the same firm, described and illustrated in our impression of the 25th October last. It differs from that engine only in the expansion in three stages, and the necessary alterations in detail to accomplish this. We illustrate the engine in longitudinal section through the cylinders at fig. 1, transverse section at fig. 2, and in transverse section through the valves at fig. 3. This engine also is automatic, and the governor and valves have the same essential features as already described in the compound engine. Each engine contains four cylinders, two low pressure, set side by side, and two high pressure, also side by side, and immediately above the low-pressure cylinders. In place of intermediate cylinders there are annular spaces on top of the low-pressure pistons surrounding the trunks, which extend up into the high-pressure cylinders and form the high-pressure pistons.

The valves, of which there are two (see fig. 3), are vertical, and between the two pairs of cylinders, but on each side of the longitudinal centre line. These valves are connected to opposite ends of a lever arm, and move in opposite directions; in this way they mutually balance each other. The two sets of pistons (each set consisting of one high and one low pressure piston, with the annular space mentioned before forming the intermediate cylinder) are connected by steel piston rods to the crossheads, which carry hardened steel wrist pins, from which steel connecting rods extend downward to the cranks. These cranks are set opposite each other, or 180 deg. apart, so that the pistons, crossheads, &c., move in opposite directions, and balance each other both as to gravity and inertia, while the cranks themselves, by this arrangement, are balanced when running.

The cranks and shafts are all of steel, and the governor is situated between the two cranks, the main eccentric rod being connected to one end of the lever that works the two valves.

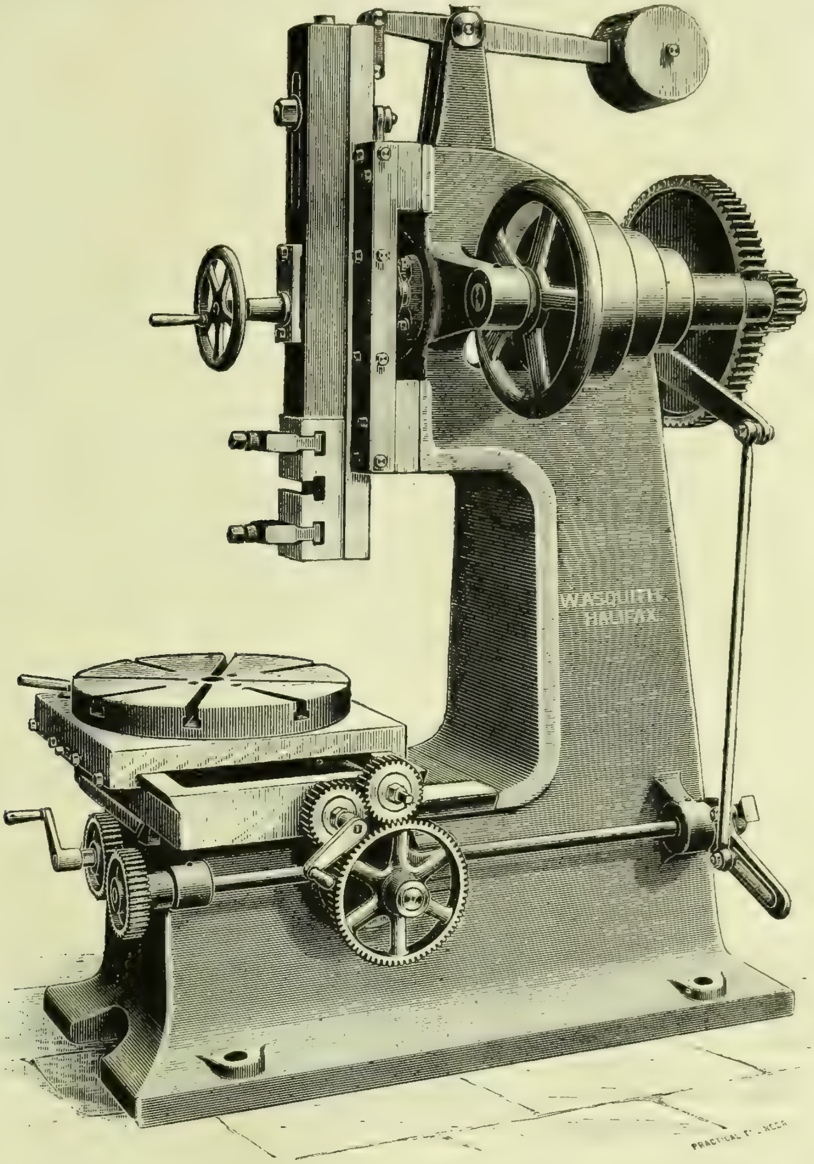
Steam is first admitted to the top of one high-pressure cylinder, pressing its piston down and turning the crank and connections. We will, for the sake of clearness, suppose this to be the right-hand cylinder. As the piston moves downward, the valve, actuated by the governor, cuts off the admission of steam, and a portion of the stroke is made with expanding steam. Just before this piston reaches the bottom of its stroke communication is opened between the right-hand high-pressure cylinder and the annular space in the top of the left-hand low-pressure cylinder, the piston of which is then, as the cranks are opposite, at the top of its stroke. This left-hand low-pressure piston is then pressed downward by the steam discharged from the right-hand high-pressure cylinder, and, when near the bottom of its stroke, communication is opened between the top and bottom of this cylinder, and the steam which acted on the annular ring when pressing the piston down acts on the whole surface in raising the piston up; there is, however, always a back pressure in both the high-pressure and intermediate cylinders, which prevents this upward pressure from lifting the connecting rod and crank away from their bearings, and changing the direction of the strains, but it materially relieves the crank of the work of raising these pistons, and correspondingly reduces the friction. When the low-pressure piston arrives at the top of its stroke, communication is opened either with the atmosphere or with a condenser, and in the latter case we have a vacuum pulling the piston downward on the descending stroke, and acting in accord with the pressure of steam above the piston to keep the strains constant in one direction.

In the above explanation the course of the steam coming from one high-pressure cylinder only has been mentioned, but it will be readily understood that the same action takes place in both sets of cylinders, and that the strains in all cases are always constant in one direction. A further advantage is that the downward stroke of the pistons is cushioned on steam, and so relieve the crank pin of friction.

These engines are more economical than the compound, and steam pressures of 140lb. to 160lb. are recommended to be carried in order to develop their full advantages. Messrs. Musgrave construct special boilers to be used for these high pressures in connection with this engine, and they draw attention to the fact that although these triple-expansion engines cost more to purchase than the compound, yet the boilers are smaller and cost less, so that the engine with greater expansion is much to be preferred when an entirely new plant is being erected.

IMPROVED SLOTTING MACHINE.

Mr. W. Asquith, of Highroad Well Works, Halifax, has designed and constructed a very neat and handy pattern of slotting machine, which we illustrate below. The ram is balanced, as shown, and is firmly and accurately guided in V slides of suitable length. It is driven from a pin, connecting by a link behind, and the stroke may be varied by changing the position of the adjustable crank pin, by moving in slots cut in the face of the driving or crank disc. The crank disc and crank shaft are forged in one piece, and the shaft is of large diameter; while the disc is extra large, so that heavy cuts can be efficiently made. The gearing is all machine cut, and runs at high speed, with but little noise. The feed action moving the work across takes place at the top of the stroke, in order to ensure that no lateral motion occurs while the tool is cutting, which is very liable to break the tool. The machine has a maximum stroke of 8in., and the feed arrangements are automatic in the longitudinal, transverse, and circular motions. Quick return motion can be applied, when required, by elliptical gearing. The weight of the complete machine is 38cwt.



The whole machine and details are of the best work and finish, and extremely creditable to the maker.

The Governors of the Durham College of Science have forwarded a letter to the Belgian Minister of Foreign Affairs thanking the King of the Belgians for a donation of £500 sent by his Majesty towards the erection of the George Stephenson Engineering Department of the college.

EXPERIMENTS ON CONDENSATION AND RE-EVAPORATION OF STEAM IN A JACKETED CYLINDER.*

The engine with which the trials were made is a double-cylinder one of 16 nominal horse power, made by Messrs. Marshall, Sons, and Co., of Gainsborough, and is used in the Royal Carriage Department for factory purposes, and occasionally for electric lighting. The cylinders are horizontal, and attached to a wrought-iron framing underneath the boiler, each being 10in. diameter and 14in. stroke; the piston rods, of 1·6in. diameter, pass through one end only, and are connected to a double-throw crank shaft with a flywheel 5½ft. diameter on one end. The power is taken by means of a belt from a pulley 4ft. 2in. diameter on the other end of the crank shaft. The main slide valves are of ordinary pattern, flat-faced, double-ported, with 0·7in. outside lap, 0·125in. inside lap, and 2·6in. travel; the angular advance of the main eccentrics is 30 deg. Flat-faced expansion valves with no lap work on the back of the main valves, over ports measuring 8·625in. by 0·625in.; and the cut-off is automatically regulated by the action of a governor lifting at about 206 revolutions per minute, and shifting the expansion-valve connecting rod in a slotted lever, which works on a fixed pin at one end, and is actuated at the other by an eccentric set at 131 deg. angular advance, with 2·75in. throw. The mean clearance volume in each cylinder is 0·051 cubic feet, or 0·081 of the volume swept through per stroke, which is 0·628 cubic feet. The clearance surface is 2·30 square feet, and the surface exposed during the stroke is 3·05 square feet.

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*Paper read before the Inst. Mechanical Engineers, by Major Thos. English, R.E., Superintendent Royal Carriage Department, Woolwich.

The load on the engine during the experiments consisted of one Brush dynamo, running light at about 680 revolutions per minute, and one Crompton dynamo, running at 825 revolutions per minute, and driving from three to fifteen arc lamps, with a potential of 165 volts and a current of 110 ampères under the full load, the engine running at about 120 revolutions per minute. Indicator diagrams were taken from each end of the cylinder, with two Richards indicators, having springs of 48lb. per inch, and two Crosby indicators, having springs of 50lb per inch. The cylinders themselves are liners, 0·625in. thick, inserted in a single casting, which forms the jacket, and is supplied with steam coming direct from the boiler, separately from that used in the engine. The jacket is of about 0·35 cubic foot capacity, and is provided with a drain cock at the lowest point, from which the condensed water was collected by means of a steam trap. About 7·3 square feet of the exterior surfaces of the two cylinders are exposed to the jacket steam. The boiler is of locomotive type, with a grate area of 10·5 square feet; the firebox is of iron, measuring 3ft. by 3ft. 4in. by 3ft. 2in. deep to the bars. The heating surface is 285 square feet, including the firebox above the bars and fifty iron tubes, 2·5in. outside diameter and 7ft. 10in. long. The surface covered with non-conducting material is 118 square feet, and the uncovered surface of the firebox is 44 square feet. The boiler is ordinarily lagged with wood covered with sheet iron; but the wood was removed during the progress of the trials, and various non-conducting materials were substituted for it, the primary object of the experiments being to determine the relative values of these. The average evaporation per lb. of Barnsley hard steam coal was 8·43lb. of water from and at 212 deg. Fah., the rate of combustion with full load being about 14·2lb. per square foot of grate per hour. The feed pump, consisting of a single-acting plunger, 3in. diameter and 3·375in. stroke, was driven continuously by the engine, the excess of water not required for the feed being returned to the feed tank. Steam for the blast, when required, was obtained from an adjacent boiler. The steam passing through the engine was led through an exhaust pipe, 4in. diameter and 17ft. long, to the same surface condenser which was used in the author's previous experiments. The details of this condenser, which was worked by a separate boiler, are given in his former paper (Proceedings, 1887, page 479), and it is therefore unnecessary to repeat them here. In order to measure as accurately as practicable the quantity of feed water used, it was determined to weigh both the feed water into the boiler, and also the condensed water after passing through the engine. For this purpose the feed tank, containing about 200 gallons, was mounted on a weighing machine, and filled by a hose; the collecting tank from the condenser, also holding about 200 gallons, was similarly mounted on a weighing machine; and small supplementary tanks were provided, into which the feed suction pipe and condensed water collecting pipe could be divided whilst the main tanks were being refilled or emptied respectively during a trial.

As the object of the trials was two-fold—firstly, to ascertain the weight of water evaporated per pound of coal, and, secondly, to ascertain the weight of water used per stroke of the engine—the following method was adopted: Steam having been raised to the required pressure, the engine was run with the load on, and the fire was allowed to burn down until as little as possible remained in the grate, and the steam pressure began to drop. Firing was then commenced with weighed coal, and the weights of water in the feed tank and in the collecting tank were noted. When the fire had been got into a proper condition for maintaining a steady pressure of steam, a counter was connected, and the weights of tanks were again noted. The counter was disconnected after a previously arranged number of minutes had elapsed, and the weights of the tanks were noted; the difference between these and the weights at the commencement was taken as the weight of water used during the number of revolutions indicated by the counter. The running of the engine was continued until the steam pressure again began to drop, and the fire had got as nearly as practicable into the same condition as at the commencement; the weight of coal used was then noted. The weights of the tanks were also noted at this time, and the difference from the weight at the commencement of firing with weighed coal was taken as the weight of water evaporated during the trial. Any calculated amount due to difference of height in the gauge glass was added to or subtracted from the weight of the feed tank, as required. The result of this double system of weighing has certainly been to confirm the opinion expressed by the author in his previous paper, that the weight of water used can be obtained more accurately from a collecting tank than from a feed tank; and the weights employed in the calculations are those obtained from the collecting tank, with one exception, No. 26, when a leakage through the condenser was detected.

Indicator diagrams were taken as frequently as practicable, not less than sixteen during any one trial, and the indicator springs have been subsequently tested and found correct. Fifty-five trials in all were made, out of which the first eight and five of the remainder were rejected for doubtful measurements, leaving forty-two of which the results are here recorded; the duration of each trial varied between one and six hours. The tightness of the condenser was tested in every trial, and the engine was maintained in good running order throughout.

In certain of the trials, Nos. 30 to 35 and 37 to 39, an auxiliary slide valve was fitted, communicating with each end of each cylinder by pipes furnished with a stop cock, by means of which a graduated amount of atmospheric air was admitted to the cylinder during the exhaust, and was compressed together with the steam, the object being to ascertain whether the initial condensation could be reduced by this means. This proved to be the case, but the resulting gain in economy of steam consumed was almost exactly counterbalanced by the increased back pressure.

Twenty-one of the trials were made with circulation of steam through the jacket, and twenty-one with the drain cock shut. Nos. 45 and 55 of the former and Nos. 39 and 40 of the latter, made with a very light load and consequent small consumption of steam per stroke, gave results which showed that the steam was being sensibly superheated, presumably by the heat of the smokebox which envelopes the steam supply.

Three trials (Nos. 18, 21, and 22) with circulation through the jacket, and three (Nos. 23, 24, and 25) with the drain cock shut, were made with the air pump of the condenser disconnected, and, therefore, condensing at atmospheric pressure.

The general result of the observed amounts of net condensation appears to the author to be strongly confirmatory of the view advanced in his previous paper—that the initial condensation is extremely sudden, and that there is an excess of re-evaporation over condensation during the whole of the forward stroke.

(To be continued.)

A SMALL CUPOLA.

By Thos. Wathey.

Some time ago I visited a small foundry in Saratoga, and there saw something that struck me as being new in connection with a cupola. It was not so much the cupola that drew my attention, as it was the idea of heating the blast before it mingled with the fuel and metal in the cupola. In giving a description of it I may not give the exact dimensions, but I suppose they will be near enough for practical purposes. The cupola has a drop bottom. Its outside shell is made in two sections, the bottom section being about 2ft. in diameter, about 2ft. 6in. high, and is bricked up to the top in the regular way. The upper section is the same size as the lower one, but instead of having brick inside, it has an iron jacket, forming an annular space between it and the outer shell. The blast pipe is placed in the rear of the cupola. The blast enters the annular space at the top, and escapes at the bottom, into the lower branch of the blast pipe, and from there enters the tuyere box, continuing about three-quarters around the shell, and projecting about 1in. beyond the shell.

The stack is made of sheet iron, with a bonnet fitting the top of cupola; the stack is of the telescope type, with weights attached to its upper portion, so that it can be raised or lowered at will. The height of cupola proper from the lower plate is about 5ft. and it is about 16in. inside diameter. From 1,000lb. to 1,200lb. of metal can be melted at one cast. It is suitable for iron and brass.—*American Machinist.*

Sir Edward Watkin has enlisted the services of competent engineers to advise him on the subject of the tower which it is proposed to erect in London. Competitors will have confidence in the judgment expressed by such men as Sir F. Bramwell, Mr. B. Baker, of Forth Bridge celebrity, and Mr. T. A. Walker, contractor for the Severn Tunnel and the Manchester Ship Canal. Two prizes are offered, of 500 guineas and 200 guineas, for the best designs, the height of the tower to be 1,250 feet. As the competition is open to the world, it would be a victory he deserves if M. Eiffel himself entered the lists and carried off the chief award. The London tower will be one good story higher than the structure in Paris, and let us hope it will be at least as graceful.

BOILER EXPLOSIONS.

Board of Trade Reports.

Report No. 332. This explosion occurred on the 28th January last, at Bowerfield Ironworks, Stockton-on-Tees, and five workmen were injured, but happily without serious consequences. The boiler was of the externally-fired type, with hemispherical ends set vertically, and was made of iron. Its length was 36ft., and diameter 5ft.; all plates were lap and single riveted; Cylindrical shell $\frac{3}{8}$in. thick, ends $\frac{7}{16}$in., and heat was supplied with waste gases from two furnaces, one to the right and one to the left. The explosion was caused by shortness of water, and the plates were thereby rendered red hot, and unable to sustain the working pressure of 45lb. per square inch. The explosion was very violent, and ruptured the fifth tier through the solid plate, then circumferentially detaching a portion of the upper end of the boiler, which consisted of three cylindrical tiers. This portion was projected upwards like a rocket, in a line almost vertical, wrecking the roof, and falling within ten feet of the original vertical position of the boiler. The explosion also tore away the plating in a circumferential direction, stretching it out in an arm 30ft. long, the extreme end of which made a revolution and a half, resting on the beams of the roofing, demolishing the flues, and scattering the brickwork in various directions. There appears to have been but one feed pipe for a whole range of twenty boilers, and the difficulty of feeding each must have been considerable. Two pumps were on this pipe, but one became disabled, and, while repairing, the other had not power enough to supply the water required. The fittings for indicating the water level were also unsatisfactory.

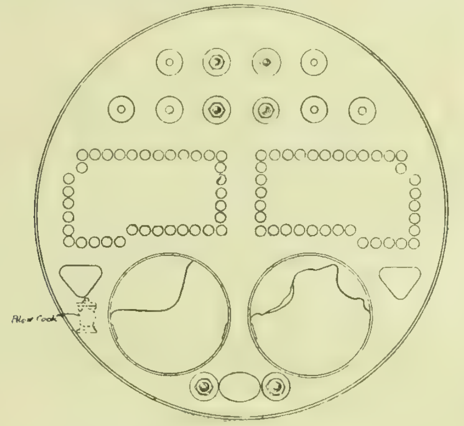
Report No. 333 deals with the explosion of a traction engine boiler, which occurred at Bradford-on-Avon, on the 13th March of this year. One man was killed, and four others injured. The boiler was of the ordinary locomotive type, without special features, and was made in 1861, but was in good general condition. The explosion was caused by reckless use of extreme pressures. From the evidence it appears that, although the boiler had been originally constructed for a working pressure of 80lb. per square inch, a pressure of 200lb. had several times been used, and obtained by screwing down the safety-valve spring so as to entirely prevent the action of the valve. The man in charge was entirely unskilled, and under the circumstances it is difficult to see how an explosion could have been avoided.

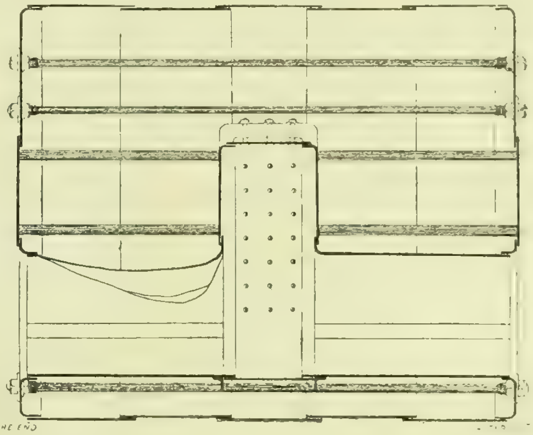
Report No. 334 refers to the explosion of a tube in the boiler of a tramway engine, which occurred at Bradford, Yorkshire, on the 15th March of this year. The driver was fatally injured, and died eight days after. The boiler is of the customary locomotive type, with copper fire-box and brass tubes, and has not been inspected except by the Tramways Co.'s employés. The tube which gave way was wasted locally close to the fire-box tube plate, the part that ruptured being reduced to paper thinness. The engineer-surveyor-in-chief remarks that these furnace doors should be provided with proper fastenings, and it is scarcely credible that a boiler should be provided with no means of regulating the draught except by opening the furnace door. With the door properly fastened when shut, if a tube were to burst the chances of injury to life would be considerably reduced.

Report No. 335 describes the explosion of a bone steaming kier at Merthyr Tydfil, Glamorganshire, on the 6th March of this year, by which one man was killed and another seriously injured. The explosion was due to the incautious screwing up of the setting up screws when the kier was under steam, and being tried for the first time. The screw gave way, and freed the end of the brace bar, which of course allowed the steam to escape. The explosion was due to rashness and bad design, and would not have occurred if the joint had been properly designed and made.

Report No. 336. This explosion occurred on 26th March of this year, on board the British Yeoman, owned by the British Shipowners' Company Limited, and resulted in the death of one man and injury of four others. The boiler was of the vertical type, and supplied steam to condenser and for working steam winch. The fire-box collapsed and was destroyed, due to the wasting of the fire-box plates, and possibly over pressure, as the safety valve and pressure gauge were also defective.

Report No. 337 describes an explosion which occurred on board the steamship Advance on the 2nd April of this year, while the vessel was loading at the Penarth Dock, Glamorganshire. The fireman was killed, but no others were injured. The wrought-iron boiler was of the ordinary cylindrical multitubular double-ended type, and the shell was about 15ft. 8in. in length, and 13ft. in diameter, with plating about 1in. thick, as shown in our illustration. Four furnaces were fitted, each 4ft. in diameter and about 6ft. long, made up of two plates $\frac{9}{16}$in. thick. The joints were butt, with double straps, single riveted. There were two combustion chambers, each common to two furnaces, in the direction of length of the boiler. It was built by Messrs. Rankin and Blackmore, and put into the ship in 1880. The boiler had been regularly inspected, and was examined the day before the explosion took place, and found to be in excellent condition. The vessel was classed 100 A1 at Lloyd's. The furnaces collapsed because of shortness of water, and the crown plates became so heated that they were no longer able to withstand the rapidly-rising pressure. Mr. Trail remarks there seems no doubt that the explosion was due to shortness of water, but how it became low does not seem clear. It was, however, evident that it resulted from the carelessness on the part of some person. The engineer of the watch appears to have been absent from the engine-room from the time the pressure was just showing on the gauge until the occurrence of the explosion, and the boiler was, during that time, left in the charge of a person who appears to have been at least temporarily incapacitated. Under these circumstances such casualties are likely to occur.





THE MANUFACTURE OF THE ALLOYS OF ALUMINIUM IN THE ELECTRIC FURNACE (COWLES' PROCESS).

(*Continued from page 752.*)

The energy required to produce 1lb. of contained aluminium depends of course upon the grade of alloy; the average being 18 H.P. per hour. The crude metal from the furnace is then refined and remelted in a reverberatory furnace; each "run" is sampled, and the percentage of aluminium ascertained by analysis. The nature of the reaction that takes place in the electric furnace is not very easy to ascertain. The reduction of the ore takes place in an air-tight box, and in presence of an enormous excess of carbon. It may be assumed that at the intense heat of the electric arc the ore melts and gives up its oxygen to the carbon—

$$Al_2O_3 + 3C = 3CO + Al_2$$

The presence of copper or iron is immaterial, as the reaction takes place with ore alone; but in absence of the alloying metal the liberated aluminium absorbs carbon and is converted into a carbide, According to the theory of Prof. Hampe, the decomposition is supposed to be electrolytic; but an experiment was made by the Cowles Co., using an alternating current, which proves that this is incorrect. The furnace used was 48in. by 12in. by 24in., with current of 900 ampéres, with E.M.F. of 50 volts. Alternations per minute, 11,000. At the end of 1½ hours we obtained 45lb. of 4 per cent aluminium bronze.

This investigation was purely of an experimental character, and it cannot be doubted that on the larger commercial scale the result would be more satisfactory. The results obtained were identical with those given by the continuous current in every way, the resultant slags similar in composition.

The slag from the electric furnace is really only melted unreduced ore, and not a slag in the proper sense of the word. Its approximate composition is—

Al_2O_3 - 90 SiO_2 - 2·00 - F_2O_3 - 4·00 - CaO - 3·9 - P - 0·10.

These works produce about 200lb. of contained aluminium per 24 hours, the most valuable alloy being aluminium bronze, which is supplied in grades containing 1¼ to 11 per cent aluminium. To obtain these the rich surface product containing 15 to 20 per cent aluminium is re-melted and reduced to the desired percentage with metallic copper, and cast in 12lb. ingots.

I have now described the most important features of the electro-metallurgical industry as carried on at Milton, and will proceed to describe the chief properties of the alloys produced, and some results obtained from them. With copper, aluminium forms a series of interesting and beautiful alloys, varying in colour from bluish white to red gold and pale yellow, and also differing widely in physical and mechanical properties. Alloys containing 60 per cent to 70 per cent aluminium are very brittle, glass-hard, and beautifully crystalline; with 50 per cent the alloy is quite soft; but under 30 per cent the hardness returns. The 20 per cent bronze has a whitish yellow tint, and somewhat resembles bismuth; it is very brittle, and can be pulverised in a mortar. The brittleness of alloys containing more than 11 per cent prevents their use, but from 11 per cent down to 1¼ per cent they are of very great value, possessing great tensile strength, high resistance to compression, low specific gravity, and greater resistance to corrosion than any alloy known.

The following gives the density of these alloys, compared with other metals and alloys:—

Metal.	Density.
Aluminium bronze 3 per cent.	8·69
„ 4 „	8·62
„ 5 „	8·37
„ 7·5 „	8·00
„ 10 „	7·69
„ 11 „	7·23
Brass	8·38
Cannon bronze	8·23
Cast „	7·20
Cast steel	7·71
Iron	7·80
Nickel	8·57
Silicon	2·67
Platinum	21·50
Gold	19·30
Lead	11·40
Silver	10·50
Copper	8·90
Tin	7·50
Zinc	7·10

The standard "A" grade, containing 10 per cent aluminium, behaves as a true alloy—that is, will not liquate out into different combinations. It resembles pale gold in colour; its tensile strength in castings runs from 75,000lb. to 90,000lb. to the square inch, with from 4 per cent to 14 per cent elongation.

The following is a report of a test of 10 per cent bronze produced by the Cowles process, made by Professor Unwin, and alluded to in his work on the "Testing of Materials of Construction," p. 348. The bar was 0·499 in diameter, and was placed in shackles which have spherical bearing surfaces, so that the tension was extremely uniform on the section:—

Breaking weight, 7·195 tons = 36·78 tons per square inch, 86,743lb.
Elongation in 10in., 3·326in. = 33·26 per cent.
Contraction of area, 0·078in. = 39·87 per cent.
Elastic limit, 3·47 tons = 17·74 tons per square inch.

(To be continued.)

The engineer, Maurice Koechlin, of Zurich, who constructed the Eiffel Tower, has requested from the Federal authorities a concession for the construction of a railway from Lauterbrunnen to the summit of Jungfrau.

HEAT ENGINES OTHER THAN STEAM.—III.

(Continued from page 752.)

The next engine to which I have to call your attention (the "Atkinson") is one which, in appearance at least, is very different from any other. I think, perhaps, I had better first describe to you the engine as it now exists, and then occupy your time for two or three minutes while I relate to you the phases of development through which it has passed.

You will have realised from the description of the Crossley and the Clerk engine that among the peculiarities of these engines is the fact that an impulse to the crank is so infrequently given. By means of the linked-rod arrangement of the Atkinson gas engine (*Practical Engineer*, page 107) there are, for each revolution of the crank shaft, four strokes of the piston, this allowing (whilst maintaining a similar "cycle" to that of the Crossley and Clerk) of one impulse to the crank for each revolution; the arrangement is such also that each four strokes, two out and two in, are of unequal length, and it is only when these four strokes are completed—*i.e.*, at the completion of each revolution—that the "cycle" is complete.

Let us look at the cardboard model I have here, and let me place the piston in the position which it occupies at the commencement of the first "out" stroke—*i.e.*, in that position when its next movement will be outwards, and when it will draw in its charge of gaseous mixture. I make the stroke, and you will see that the crank shaft has travelled through about 60 deg. out of the 360 deg. which make up the complete revolution. The next 60 deg. (about) of movement of the crank shaft causes the piston to make the first "in" stroke, this being the compression stroke, when the charge of gaseous mixture is compressed. The lengths of the levers are such that while the "out" stroke (the suction stroke) was, say 6¼ inches, this "in" stroke (the compression stroke) is only 5 inches—*i.e.*, there is a space left at the back of the piston, between it and the cylinder cover, into which the charge has been compressed.

Let us now move the crank shaft further onwards, for about 98 degrees, and you will see that the piston again moves outwards, this being the explosive stroke, and it moves outwards for as much as 11¼ inches; the further 128 degrees of movement of the crank shaft (the movement sufficient to complete the revolution) causes the second "in" stroke to be made, when the products of combustion are expelled, and this stroke moves the piston inwards for 12½ inches, and brings it to that position which it occupied at the commencement of the "cycle." The lengths of the successive strokes are:

No. 1	Out stroke (suction)	6¼ inches.
No. 2	In stroke (compression)	5 „
No. 3	Out stroke (combustion)	11¼ „
No. 4	In stroke (expulsion)	12½ „

You will easily realise that, in addition to the advantage obtained by the greater regularity of turning effort upon the crank shaft, such an arrangement as this, which will give proper, defined, and varying lengths of movement of the piston, is commendable.

There is no doubt that the fact of the charge of gaseous mixture being exposed only to the heat of a portion of the cylinder, instead of to its whole length before being ignited, is advantageous.

In the Atkinson engine used in the motor trials the cylinder was 9½ inches diameter, and the radius of the crank of the engine was 12⅞ inches. The arrangement of linked rods, by which the succession of movements of the piston is obtained for each revolution, will be understood best from the cardboard model which I have been working.

You will see from the illustration, as in the Crossley engine, the cylinder is single-acting and open-ended; that the piston is sufficiently long to form its own guide in the cylinder; that one end of the connecting rod is attracted directly to it; the other end being attached to the toggle joint of this pair of levers. The other end of one of these levers is attached to the crank, on the crank shaft, and the other end of the second lever is anchored to the engine frame. The variation in the lengths of the strokes of the piston is obtained by jointing the outer end of the connecting rod, not precisely to the centre of the toggle joint, but to a point on the anchored lever nearer to the centre of the anchorage.

The ignition in this engine is performed by an igniting tube somewhat similar to that employed in the Crossley engine, but in this case there is no valve for opening communication from the igniting tube to the combustible charge, the moment of ignition being determined by the position of the tube.

There are several other practical points in connection with this engine which compel me to linger a little longer about it, although our time is passing very rapidly.

The Atkinson construction of engine, as you will see, lends itself to simplicity of arrangement. At first it seems that a large proportion of the power which is developed in the engine must, of necessity, be absorbed by the friction of the working of these linked rods; but when we compare the performances of the engine with, say, the Crossley, we find that in the motor trials, at full load, the indicated horse power was 11·15, the brake horse power 9·48, and that the ratio of brake horse-power to indicated horse power was, therefore, ·850, as against the Crossley engine ·861; while the gas consumed in the Atkinson engine per indicated horse-power per hour was, as a total, 19·22 cubic feet, the Crossley, as you will remember, being 20·76; the difference between the two engines being in these respects very slight, although the Atkinson engine was somewhat the smaller.

We shall find that in the third of the modern gas engines, over which we must spend some few minutes directly, the efficiency — *i.e.*, the ratio of brake horse power to indicated horse power—is not quite so satisfactory, nor is the gas consumption quite so low; but it is almost certain, in practical day-to-day working, neither one of these three engines has much economical advantage over the other.

The Atkinson gas engine, as it now exists, is very unlike the one first introduced by this firm. The original engine was called the "Differential" gas engine; as you know, the one we have just been considering is called the "Cycle" gas engine.

In the differential engine (see diagram No. 19) there was a somewhat similar peculiar arrangement of toggle-jointed levers, and these were worked by two pistons, which approached and receded from each other in a horizontal cylinder placed towards the bottom of the engine. The diagram (fig. 19) shows the levers and pistons in four positions throughout the revolutions of the crank shaft.

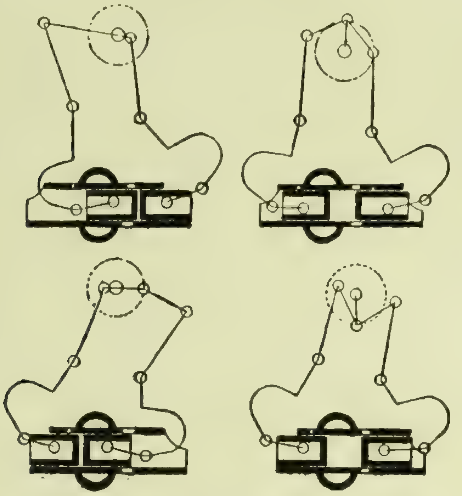


FIG. 19.

The principal advantage claimed for this engine was that the whole operations of admission, compression, ignition, expansion, and discharge are performed in this single cylinder by the action of two automatic valves, which are never exposed to the pressure of explosion, the pistons themselves being able to act also as valves, uncovering the inlet, igniting, and exhaust ports when required. The engine, however, in spite of this, was not so simple and economical as the "Cycle" engine, the later and more improved type.

The more modern engine experimented with at the motor trials which I must describe is the engine known as the "Griffin" engine (see *Practical Engineer*, vol. iii., page 145).

It is a double-acting engine, which, working with full load upon it, ignites a charge of gaseous mixture at each end of the cylinder at every third stroke; that is to say, at every one and half revolutions of the flywheel there is an impulse first in one direction, and then in the other.

The "cycle" for each end is as follows: The piston moves outwards, drawing in the charge of gas and air; it returns, compressing the mixture; this is ignited, and combustion takes place; the piston then moves outward under the pressure; it then returns, ejecting the products of combustion; it goes out again, drawing in a "scavenger" charge, as it is called, of atmospheric air, thus cooling the cylinder and diluting any products of combustion left behind from the previous charge; it then returns, ejecting the "scavenger" charge.

The operation at the other end of the cylinder follows the same sequence.

The engine, in general arrangement, is practically similar to an ordinary horizontal steam engine, or to the Lenoir or the Hugon gas engines, having the exhaust valves on one side and the gas and air inlet valves on the other. These valves are lift valves, however, and not slide valves. The ignition of the explosive mixture is, in this engine, a direct flame ignition, somewhat similar in principle to that of Barnett, already described.

The working cylinder of the engine tried by the judges in the motor trials was a little over 9in. in diameter, the stroke being 14in. The indicated horse power was 15·47, the brake horse power 12·51; the ratio of brake horse power to indicated horse power was nearly 81 per cent, and the total quantity of gas consumed per indicated horse power per hour was about 23 cubic feet.

You will see that in all modern gas engines which I have described there is compression of the mixture immediately prior to the ignition, and you will realise that when it is necesary to start the engine, unless some special means are provided, the putting of the engine into the condition of having drawn in its charge of gaseous mixture, and of having compressed it, can only be done by turning the engine rapidly by manual power.

The necessity for this turning has, to a very large extent, limited the development of the gas engine for large powers. Messrs. Crossley, pioneers as they are in every improvement in connection with the gas engine, some years since devised an apparatus consisting of a small cylinder or reservoir, generally placed below the working cylinder of the gas engine, which can, at will, have a communication opened from it to the main cylinder behind the piston. Into this small reservoir, when the engine is working, air or products of combustion under pressure are delivered, these forming a store of power to be used when it is desired to start the main engine into motion.

This device has not been very largely adopted, and the starting difficulty still remains one which requires time and experiment before its satisfactory solution will be attained. That it will be overcome, and soon, is certain, for, as I have said, there are many able men who are day by day seeking for improvement in the gas engine.

I have purposely omitted (in order to avoid complication) from all the descriptions of gas engines which I have given you any mention of the modes by which the speed of these engines is regulated or governed. These modes of governing vary in the details of their arrangement, but all the more recent are practically based on the principle of cutting out an explosion when the speed exceeds the normal. This is done by having a valve controlling the gas inlet. This valve is operated by the governor, and, being closed when the normal speed is exceeded, prevents the admission of gas to the cylinder, the valve being opened and admission again taking place only when the speed has been reduced by the required amount.

Other devices have been suggested, having for their object the lessening of the quantity of gas allowed to pass into the cylinder at each explosive stroke while maintaining the quantity of air constant, in this way weakening or diluting the mixture when the speed of the engine exceeded the normal. But this mode of governing has been found to be very unsatisfactory, for at times the mixture would be too weak, and at other times would be too rich, in gas, and in either of these cases it would not "fire" in the cylinder, but the unburnt charge would be expelled from the engine at the next in-stroke of the piston, thus not only wasting the gas, but rendering some serious accident probable.

The principle of cutting out an explosion, therefore, when the normal speed of the gas engine is exceeded, is the one now almost universally adopted.

Let us see the economical advantages which this mode of governing gives the gas engine over the steam engine. By it the fuel (gas) from which the power is obtained is supplied to the gas engine automatically, and in exact accordance with the necessities of the work which the engine is doing; that is to say, as the work varies, so does the quantity of fuel which is consumed vary; the number of explosive strokes in a given time varying automatically, and without attention by the driver.

You will realise, therefore, that this necessity (if I may so put it) of the construction and working of the gas engine gives it, from an economical point of view, a vast advantage over the steam engine; for in this latter engine an equal advantage could only be obtained if the governor regulated automatically, without the intervention of the driver or the stoker, and as the work varied the quantity of coal put into the boiler furnace.

Broadly speaking, it may be said that, in practice, the amount of fuel consumed in a gas engine is always proportional to the work being done by the engine, no matter how this work may vary; while in the steam engine, in practice, the fuel consumed depends almost entirely on the stoker or driver, and does not automatically vary as the work on the engine varies.

I have shown and described to you three of the principal distinctive forms of gas engine commonly in use. Each of these performs a different cycle of operations in turning the heat developed in the cylinder into mechanical work. The "Crossley" gives an impulse for every two complete revolutions, the "Atkinson" an impulse for each revolution, the "Griffin" an impulse for each 1½ revolutions. In the "Crossley" and the "Atkinson" engines the impulses are always given while the piston is moving in one direction. In the "Griffin" engine, which is double acting, the impulses are alternately with the piston moving first in one, then in the other direction.

(*To be continued.*)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

SMOKE IN STOKING.

To the Editor of "The Practical Engineer."

SIR,—I should like to know the opinions of some of your practical readers on the smoke question. I am at present employed as stoker in a Manchester warehouse. My master gives me to understand that wetting the coal will prevent it from smoking. This I cannot see. To me, wetting appears to cause the fire to smoke all the more. I shall be much obliged for experienced opinions on this and other points in stoking, so as to reduce smoke.—Yours, &c., STOKER.

QUERIES AND REPLIES.

119. Machine for Washing Mill and Furnace Ashes.—Can any reader refer me to makers and description of machinery for washing and cleaning the ashes from mill and puddling furnaces? Information will much oblige.—R. T. C.

Answer.—I have a machine under my charge washing 100 tons per day of coke, oven ballast, ashes from the boilers, and ashes from gaswork fires, and another in course of erection. The makers in this district are Robert Wilson and Son, Railway Forge, Bishop Auckland. The machine is Robinson's patent washing machine. The patentee is R. Robinson, Esq., Howlock Hall, near Bishop Auckland, Co. Durham, who can give full particulars.—J. D.

126. Angle of Advance of Eccentric.—How can I find the angle of advance of an eccentric when the rods are connected at the ends of the slot link? Any information will much oblige.—J. B.

Answer.—In the case of a vertical engine, turn the engine till the eccentric is on its upper dead centre. This may be known by the valve ceasing to rise, as it becomes motionless before descending. Stretch a string, or apply a straight edge, between the centre of valve rod and centre of crank shaft. The angle which this makes with the crank is the angle of advance. This angle is most easily got by sighting, in the majority of cases. As there are two eccentrics, the quadrant must, of course, be first run over to the end, and kept there while the engine turns to the top of the sheaf which is in gear. The advance of the other eccentric can be obtained by running over the quadrant to that side, turning the sheaf to the top and sighting, as before.—C.

127. Distilled Water.—I require 20 gallons of distilled water in 10 hours. I propose to obtain this by means of a coil in a cylinder 1ft. 6in. diameter, and 4ft. high. Please show how I can find the size and length of coil to be used, and how much cold water must be admitted in cylinder. Pressure of steam in coil to be condensed, 40lb. Assistance with above will be greatly esteemed.—Doubtful.

Answer.—A copper coil ½in. outside diameter, with ½in. clear space between the coils, and ¾in. clear of sides of cylinder would require a length of 201ft. The volume of cooling water to be passed through the cylinder should be equal to twice the cubic content of the cylinder per hour, or say twelve cubic feet of water per hour.—C.

128. Compression and Release in Engines.—How is the required amount of compression in a steam engine determined, and at what part of the stroke should release commence? An answer will much oblige.—A Beginner.

Answer.—Theory says that the amount of compression should be such as to compress the exhaust steam shut in into the clearance spaces at a pressure equal to the initial pressure of the steam. Loss due to the clearance spaces is thus avoided. There would also be this further advantage in an unjacketed cylinder, viz., the cylinder would be heated up to the initial temperature of the steam by the work done upon it, and initial condensation would be greatly reduced thereby. The mean pressure would, however, be greatly reduced by such extreme compression. In practice, the useful extent to which cushioning may be carried depends mainly upon the speed of the engine. Thus, in very fast running engines, in order to arrest the momentum of the moving parts, so as to bring them gradually to rest, and reverse their direction of motion without shock, a large amount of compression is necessary in some cases, as much as 60 per cent of the stroke. A table is given by Mr. D. K. Clark, in his "Manual of Rules, Tables, and Data for Mechanical Engineers," setting forth the best period of compression for different periods of admission, the percentage of clearance being 7; various back pressures being given. From this table it will be seen that the more expansively the steam is worked the greater the period of compression should be; and the greater the proportion of back pressure to initial pressure, the less should the period of compression be. It is also stated that the compression should vary as the percentage of clearance; the release should take place at about one-twelfth from the end of the stroke. Some engineers adjust the period of compression so that the final pressure shall just be sufficient to bring the moving parts to rest. Given in pounds per square inch of piston area, by the formula

$$P = \frac{W}{S}\,\frac{V^2}{AR},$$

in which W = weight of reciprocating parts in pounds;
V = the velocity of the crank pin in feet per second;
A = the area of the piston in square inches;
R = the radius of the crank feet;
S = 32·2.

Then, working by Boyles' law, viz., PV = a constant, we have clearance volume : (period of compression + clearance volume) : : the back pressure in the cylinder when exhaust closes : P the pressure found by the above formula.

$$\text{So that period of compression} + \text{clearance volume} = \frac{\text{Clearance volume} \times P}{\text{Back pressure}}$$

$$\text{and period of compression} = \frac{\text{clearance volume} \times P}{\text{back pressure}} - \text{clearance volume.}$$

Compression.

129. Loss of Power by Hot Condensing Water.—Will any of your readers inform me as to the disadvantage under which an engine will labour with the water in lodge or dam at 110 deg. F., instead of at 70 deg., and what will be the difference in I.H.P. to the engine, taking in injection water at 110 deg. instead of 70 deg? The engine is of the compound tandem type, H.P. cylinder 20in. diameter, L.P. cylinder 38in. diameter, with 4ft. stroke, revolutions 60 per minute, boiler pressure 75lb. per square inch.—Young Engineer.

Answer.—With such an excessive injection temperature, a much larger supply of water would have to pass through the condenser, and it would be impossible to keep a good vacuum with a temperature of discharge. Extra load on the pump and loss of vacuum would be the first disadvantages. It would also be found that the valves would not stand the high temperature, and would give constant trouble. The practical difficulties with such an excessive temperature cannot be calculated. They would certainly exceed by many times any theoretical calculation based on the data given. 70 deg. is as high a temperature as can be used with economy.—C.

130. Expansion of Rails by Heat.—I have heard it stated that the average expansion and contraction of the railway metals, between the hottest day in summer and the coldest in winter, between London and Edinburgh, is only 3ft. Is this correct? if not, can you say what the difference is?—Inquirer.

Answer.—Taking a range of temperature of 75 deg. Fah. over a distance of 400 miles, the expansion would be 1,077ft., or nearly a quarter of a mile.—C.

131. Changing Pulleys on Crank Shaft.—I have a steam engine with a 4ft. 6in. driving pulley, running to a 3ft. 6in. pulley on the main shaft, and the engine making 150 revolutions per minute. Would it be any advantage to replace the 4ft. 6in. driving pulley by a 6ft. pulley, and reduce the speed of engine to 110 revolutions per minute? What difference would the above alteration make in the economy of engine? Information will oblige.—Vulcan.

Answer.—The only advantage to be gained by the substitution of a 6ft. for a 4ft. 6in. driving pulley, is, that on account of the engine running slower, the cost of maintenance would not be so great, or, in other words, it would not knock itself to pieces so quickly. The cost of working, however, or the amount of fuel required would be the same in each case, for although the engine would be run slower, the steam would have to be of proportionately higher pressure; that proportion being = 6ft. : 4ft. 6in. = 4 : 3. So that, assuming the steam pressure at present employed in the cylinder to be 30lb. per square inch, it would have to be increased to 40lb. if the proposed change is carried out. Another disadvantage attending the alteration would be, that with a 6ft. pulley driving on to a 3ft. 6in., the arc of contact of the belt on the latter pulley would be less than when driving with a 4ft. 6in. pulley, to make up for which the belt would have to be stretched tighter, and would probably not drive so well.—Hydra.

135. Rapid Wear of Marine Engine Eccentric.—Would any reader kindly enlighten me with regard to the following?—The wear on the go-ahead eccentric strap for the high-pressure valve of a marine engine is so great that it has to be renewed every trip, and when abroad the go-astern strap has to be placed on the go-ahead block to bring her home. Now, I attribute this to the weight of the valve and the surface on the back of it being exposed to the steam pressure, thus causing a great amount of friction to be overcome. I intend fitting a small cylinder, with a balance piston on the end of the valve spindle, to try and overcome this wear, and I should be very glad if some reader would give me an idea for determining the proper diameter of the piston. The weight of valve is 4cwt. 3qr. 5lb.; weight of eccentric rods' motion and valve spindle about 3·5cwt. The valve spindle is continued through the valve and top of casing; the diameter of part continued is 2⅜in.; size of back of valve exposed to steam is 2ft. 9in. by 2ft. 5¼in., with a ring to be deducted from this, 18in. diameter, which takes part of the pressure of the valve; pressure of steam, 95lb. per square inch; travel of valves, 6in.—Marine Engineer.

Answer.—The total weight to be balanced is 4cwt. 3qr. 5lb., the weight of the valve + 3cwt. 2qr., the weight of the motion, or, reducing to pounds, a total weight of 930lb., but if the eccentric rods are very long it will be better to make the area of the balancing piston such as will give a little in excess of this, so that the rods may be always in tension instead of alternately in tension and compression. Then if the top of the balancing cylinder be connected by means of a pipe to the low-pressure casing, and the under side is open to the high-pressure casing, so that the effective pressure on the balancing piston equals 95lb. less the pressure in the receiver; or should the receiver pressure not be approximately constant it would be advantageous to connect the top of the balancing cylinder direct with the condenser. In this case we should have a greater effective pressure, or 95 plus that due to the vacuum in the condenser, and a much smaller piston would suffice. Taking the former case, and assuming the pressure in the receiver to be constant, and 20lb. to the square inch, we have $95 - 20 = 75$lb. per square inch, and the total weight to be balanced is 930lb. Then,

$$930 = 75 \times \text{area of piston, and area of piston} = \frac{930}{75} = 12{\cdot}4 \text{ square inches, or}$$

4in. diameter. This is the effective area required, but must be corrected for the rod, which is 2⅜in. diameter = 4·43 square inches area, so that if the piston of the balancing cylinder is attached to this rod so that the rod does not pass through it, we have an area on the top side of the piston of 4·43 square inches, acted on by the pressure of the receiver steam, viz., 20lb. per square inch, or a load of 89lb. Adding this to the weight, we have $930 + 89 = 1019$ as the total weight to be balanced, and the effective area of the under side of the piston must be $\frac{1019}{75} = 13{\cdot}6$. Adding the area of rod, we have $13{\cdot}6 + 4{\cdot}4 = 18$ square inches, or diameter of balancing cylinder required 4·8in.—Valve.

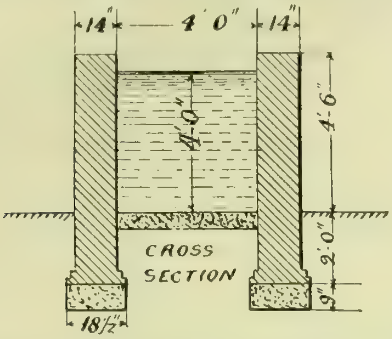
Answer.—No doubt the rapid wear of the eccentric straps is due to excessive pressure, the exact amount of which cannot be ascertained from the particulars given, as the back pressure of exhaust tending to force the valve from its face cannot be arrived at from the data supplied. The total weight of the valve and gear being 930lbs., a balance piston would only be 4¼in. diameter with a steam pressure of 95lb., unless the top were connected to the low-pressure casing, which would not be advisable, as this introduces the question of steam passing the balance piston into the low-pressure casing. Are you sure that the relief ring on the valve is perfectly tight? these rings are very apt to leak, thus allowing pressure to accumulate on the back, and reducing the efficiency of the arrangement considerably; a small pipe connected to the valve would enable you to test it when working for leakage, and at the same time serve to relieve the accumulation if any. From the writer's experience, 100lb. per square inch of bearing surface should not be exceeded, if the eccentrics are to run smoothly, and even then if lubrication be neglected they give trouble, an instance occurring recently where the lines wore about an ⅛ of an inch in two or three days running, entirely due to the neglect of lubrication.—Orion.

Answer.—As the majority of high-pressure valves are unbalanced, the fault should be sought in the eccentric itself. It has probably been made narrower than usual, and with rubbing surface too small. The substitution of the present eccentric sheaves by wider ones will be found cheaper than a back balance, and while the balance will most likely prove ineffective and troublesome, the change of eccentrics will, with equal likelihood, put an end to the annoyance. The piston of a back balance should be of such a size that the pressure on it does not exceed the pressure of steam upon an area equal to the exhaust port in cylinder, plus one steam port, that being the usual rule for calculating the pressure holding a valve to its face. Of course "Marine Engineer" has made sure that his valve is not bottoming in the slot, for in such a case there will be a heavy drag on the rod, quite enough to account for the wear. If this be so, the link motion will work laboriously. If the engine is new, it is probably the eccentric which is wrong; if old, it is probably the valve.—C.

137. Lead Required in Vertical Engine.—Can any of your readers inform me how to determine the lead required in a vertical engine of 400 I.H.P. running at 70 revolutions? I notice, in some engines, more lead is put on bottom than top. How is this determined? An answer will much oblige.—Bothered Student.

Answer.—There is no rule for determining the lead which should be given to any particular engine, practical experience being relied upon in fixing the amount, which may vary from $\frac{1}{64}$th to ¼th of an inch on the top, according to the pressure of the steam. If the leads are made the same both at top and bottom, there would be a great difference in the cut-offs, due to the obliquity of the connecting rod, and, in order to equalise the cut-off, it is usual to give about a quarter of an inch more lead at the bottom than at the top; that is to say, if the lead at the top is ⅛in., then it will be ⅜in. at the bottom, which would give a variation in the cut-off of about two or three inches, according to the length of the stroke and the ratio of the connecting rod centres to the crank.—ORION.

139. **WALLS OF BRICK TANK.**—I want to find the strength of the brick walls of a tank 9ft. by 4ft. The bricks are Staffordshire blue bricks, the walls stand 4ft. 6in. above ground, the tank is always full of water to the depth of 4ft. Would the walls 14in. thick be strong enough? What difference is made to the formula if the brickwork is set in cement mortar instead of lime mortar? I have calculated it from a formula in "Molesworth's Pocket Book," but I am not satisfied with the result. I should feel obliged if you or any reader would kindly enlighten me on this matter.—MUNICIPAL.



Answer.—I do not consider your wall sufficiently strong. Good practice demands a factor of safety for such works of at least 2, and the stability of the wall above the ground is all that is to be relied upon. The pressure against 1ft. length of the wall is that of a triangular prism of water 4ft. high by 4ft. wide, of which the weight is $\frac{4 \times 4 \times 62\cdot5}{2} = 500$lb. The centre of pressure is in the centre of gravity of this triangular prism, one-third of the depth of water from the bottom, or $1\frac{1}{3}$ft. Therefore the overturning moment is $500 \times 1\frac{1}{3} = 666\cdot\dot{6}$ft.-lb., which, multiplied by the factor of safety, becomes $1{,}333\cdot\dot{3}$ft.-lb., to which the moment of resistance must be made equal. If w = weight of brickwork per cubic foot, h = height, t = thickness of wall, and M = moment of resistance to overturning, then $M = w \times h \times t \times \frac{t}{2} = \frac{w.h.t^2}{2} = 1{,}333\cdot\dot{3}$; $t = \sqrt{\frac{2 \times 1{,}333\cdot\dot{3}}{150 \times 4\cdot5}}$ $h = 4\cdot5$ft. Assume $w = 150$lb., then

$$t = \sqrt{\frac{2 \times 1{,}333\cdot\dot{3}}{150 \times 4\cdot5}} = 2\text{ft. (nearly).}$$

If your bricks are not the weight assumed, the correct figures must be filled in. The bricks should be set in hydraulic lime, or cement mortar. The former will generally set better, if not so quickly.—F. C.

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133. **SMALL ENGINE CASTINGS.**—Could any of your readers kindly inform me of the best and cheapest form of engine for driving a 5in. centre lathe, and where I could buy castings?—F. J. H.

134. **LIQUID FUEL.**—I am told the Great Eastern Railway runs some of their trains with locomotives burning tar and oil, &c., for fuel. Can any of your correspondents give me particulars of the burner or sprayer used, and say if it is applicable to ordinary vertical boilers? How do you start the fire, and what about standing? does the fire go out, as I presume, if the burner keeps at work, too much steam would be made? What do they do about draught? Any particulars would be very acceptable.—W. E. D.

136. **FORCED DRAUGHT.**—Will any reader kindly state if the above can be applied to a Lancashire boiler, with advantage, where there is insufficient natural draught, which causes large quantities of soot to accumulate in the flues? Also the best form of the above?—PROSPECT.

138. **SOLID-DRAWN TUBE.**—I wish to make a number of lengths of solid-drawn copper tube $\frac{3}{8}$in. internal diameter and $\frac{7}{16}$in. external. I shall feel obliged if anyone will give a description of the necessary tools.—L. M.

140. **COMPUTING POWER OF COMPOUND ENGINES.**—(1) I wish to know how to compute the lift and I.H.P. approximate of compound and triple-expansion pumping engines, and ordinary marine or land engines, having given diameter of cylinders, stroke, piston speed, and steam pressure at H.P. cylinder. I have seen it computed by ascertaining the ratio between H.P. and L.P. cylinders, and by that means finding, from steam expansion table, what the mean pressure of steam would be on pistons; but I do not know exactly how to find this ratio, and, having found it, to ascertain (by steam expansion table) what portion of stroke this is equivalent to cutting off at. (2) What usually determines the relative sizes of steam cylinders in compounds—I mean what ratio do they usually have one to another?—DRAUGHTSMAN.

141. **POWER OF HOISTING BLOCK.**—It is found by trial that when P is on the point of lifting W by means of a single fixed pulley, $P = (1 + m)$ W, where m is a fraction depending on the friction of the parts of the machine. If three such pulleys are combined into a "block and tackle," find the power requisite to raise a given weight by means of it.—STUDENT.

142. **IMPACT ON BEAM.**—A beam will safely carry a stationary load of five tons with a deflection of two inches. From what height may a weight 200lb. be let drop upon the same beam without deflecting it to a greater extent?—STUDENT.

143. **CONSUMPTION OF FUEL.**—Will any reader kindly supply me with the following information, taken from the most modern practice of our principal engine builders? 1. What is the consumption of coal per I.H.P. for (*a*) ordinary high-pressure steam engines working expansively; (*b*) ditto condensing; (*c*) ditto compound non-condensing; (*d*) ditto compound condensing; (*e*) ditto triple-expansion non-condensing; (*f*) ditto triple-expansion condensing. 2. What difference does steam jacketing make in coal consumption? 3. Is there any material difference in the consumption of coal per I.H.P. shown by engine, in multitubular, Lancashire, and Cornish boilers? Any information relative to the above, also *re* consumption of coal per I.H.P. for direct-acting steam pumps, such as Worthington type, will be esteemed by—F. J.

PATENTS AND INVENTORS' QUERIES.

28. **GUNPOWDER ENGINE.**—Are there any patents in existence for engines actuated by the explosion of gunpowder or similar substances, and what are their numbers and dates?—T. B., Leeds.

Answer.—There are many such patents, and we believe that engines have been experimentally run in this way, but the idea is entirely fallacious. There is no economy either in weight or power to be obtained from the use of such engines. We shall give you the numbers of a few of the patents in next issue.

29. **MACHINE FOR MAKING TWISTED NAILS.**—Is there any machine in existence which produces twisted nails, and if so, is the machine patented G. F., Birmingham.

Answer.—Twisted nails are produced by a machine constructed under Nichol's patent. We believe considerable quantities of these nails are in use.

TO CORRESPONDENTS.

F. M. Y., Tarn, Yorkshire.—There are no specified books to read or examinations to pass in order to become a mechanical engineer. Many colleges now grant diplomas in engineering, but the best way to become an engineer is to enter the workshops, and study science as well.

MISCELLANEA.

THE CONEMAUGH.—The work of clearing the Conemaugh River is rapidly progressing, yet large piles of débris still remain, and among it can be seen, here and there, the remains of freight cars and railroad equipment. In most cases the woodwork has been burned, the ironwork only remaining. The new bridges over the river, on the Pennsylvania Railroad, are being pushed to completion with great rapidity.

The *Times* Berlin correspondent says: It is rumoured that serious attention is being paid in official circles to the project of connecting the Baltic and Berlin by a sea-going ship canal. Admiral Batsch once discussed the question whether this might best be brought about by deepening the Elbe or the Oder. He decided in favour of the latter, and now it is said that a committee is actually being formed to give effect to this proposal, or at least to examine it.

STEEL FIREBOXES.—One effect of the copper ring is now seen. When copper was forced up to a high price, it was determined to use steel for locomotive boilers and fireboxes; and two engines so fitted are, we believe, now at work on the London and North-Western Railway. If the experiment here be successful, it will affect the copper and steel trades; and there is no reason why it should not succeed here as well as it has done in America.

NAPHTHA RESIDUUM FUEL.—The attempt which one of our great English railways is making on a small scale—to use petroleum as fuel—is being practically made in Russia on a large scale. All the steamboats in the Caspian seas are using naphtha residuum and oil as the fuel. In Moscow the factories are also taking to it; and on the Volga steamboats are beginning to use it. Cheap petroleum for some purposes may check the advance in the price of coal.

AN UNDERGROUND RAILWAY FOR PARIS.—The scheme has been much talked of, but it may be remembered the project prepared by M. Baihaut was rejected by the French Parliament. M. Yves Guyot, Minister of Public Works, has completed, however, another plan on a much smaller scale than the preceding one, and intends to put it before the Chamber next January. M. Guyot does not mean to press for a State subvention. He sees his way to carrying out the scheme without Government aid.

The Canadian Pacific Company is now seeking designs for three vessels to form their fleet of passenger steamers to ply between England and Halifax. The order for three twin screw vessels to make the journey between Vancouver Island and Yokohama has already been given to the Naval Construction and Armaments Company, of Barrow. The whole will be built according to Admiralty specifications for the equipment of mercantile cruisers, and will be an important addition to our cruiser strength where it is most wanted, in the Pacific. The through service to Japan must be in working order for the mail service by January, 1891, under the terms of the Government contract and subvention, and it is confidently hoped to complete the trip in 23 days.

Sir William Thomson, at the dinner of the electrical engineers, did justice with unstinted enthusiasm to the distinguished man who passed away the other day, Mr. Joule. The justice done to Joule in the obituary notices that appeared was somewhat arid and meagre, excusable, perhaps, by his exceedingly retired life, and the unobtrusive steadfastness with which he worked at science for its own sake, irrespective of popularity or money-making. From a man of the eminence of Sir William Thomson, this declaration as to Joule's status in science is worth noting: "Both in electricity and mechanical action he laid the foundation of the great development of thermo-dynamics, which would be looked upon in future generations as the crowning scientific work of the present century. It is not all due to Joule, but he achieved one of the very greatest monuments of scientific work in the present century." If anything like advocacy is needed to secure Joule a monument in Westminster Abbey, this encomium ought to suffice.

French Engineers and the Birmingham Cable Tramway.—M. Boreaux (chief engineer of roads and bridges to the Paris municipality), M. Bienvenue (also attached to the engineering staff), and an interpreter visited Birmingham recently in order to make an inspection of the Hockley cable tramway, with a view to the construction of a similar line on the Belleville and Montmartre routes in Paris. M. Boreaux has been over on one if not two former occasions, and was so favourably impressed with the construction of the tramway that he thought it worth while to make a reinspection with one of his colleagues. The visitors were shown over the route and driving machinery by Mr. Pritchard and Mr. Kincaid, the engineers by whom the line was designed. They left Birmingham for Edinburgh to inspect a somewhat similar line there. It may be mentioned that the working expenses of the Birmingham cable tramway have been lately considerably reduced, while the mileage receipts show continued improvement.

Employment in the Engineering Trades.—If any falling off in the trade were probable, it would be making itself felt at the present time of the year, but judging from the reports issued by the trades union organisations connected with the engineering industry, there is no indication of any slackening off in activity. The report issued by the Amalgamated Society of Engineers this month is again of a very satisfactory character. Perhaps there are a few more pattern makers on the books, and a slightly larger number of unemployed members generally, taking the whole of the districts throughout the country, but this does not represent any decrease of activity. Taking the whole of the districts of the society, the number of members in receipt of out of work support is rather over two per cent of the total membership, but in the Manchester district it still remains slightly under two per cent. With regard to the condition of trade, the reports from all the various districts show that activity is being well kept up, and no real slackening off in any important centre of industry is reported, whilst there is apparently every prospect of a continuance of the present healthy condition of trade for the ensuing year.

When Tangye Brothers, the well-known engineers, had but a small concern in St. Paul's Square, Birmingham, they purchased the patent of a hydraulic lifting jack, and proceeded to manufacture large numbers of the article, with which a man can lift more by the pressure of a single finger than can be raised by the combined strength of two men working the old screw-jack. But at that time labour-saving apparatus was not so readily taken up as now, and the patent jack remained on the hands of Tangye Brothers so long that serious financial difficulties, consequent upon the capital being locked up, stared the little firm in the face. Just at that time the Great Eastern had been completed, and unsuccessful attempts made to launch her. Then came an offer of £10,000 to any firm who would undertake to convey the great ship to the water. Tangyes accepted, and with their hydraulic jacks lifted the leviathan completely from her cradle and into the river. Thus they not only secured the much-needed capital, but also the best possible advertisement for their jacks. Mr. Richard Tangye, in telling the story one day, characteristically concluded with: "And so we launched the Great Eastern, and the Great Eastern launched us."

Application of Electricity to Locomotives.—The uses to which electricity may be applied are steadily increasing. Some interesting experiments have been concluded on the Philadelphia and Reading Railroad for the purpose of testing its effect in increasing the tractive power of a locomotive. The apparatus consisted of a small dynamo and engine, mounted upon the locomotive. This supplied a current, which was passed to the rear driving wheels, and it is claimed for the invention that it caused increased friction between the wheels and the rails, superior to that obtained by the use of sand, and that it enabled the locomotive to draw a heavier train. The experiments were carried out on the Trackville grade, which averages 185ft. to the mile. With the dynamo running and a train of forty-five cars attached to the locomotive, the ascent was made in twenty-eight minutes. Without the aid of the electric agent, it is stated the same locomotive train would occupy fifty-five minutes in covering the same ground. A low-tension current is used, and the increased friction, it is claimed, is under the complete control of the engine-driver. If the invention turns out to be of practical use, it will be of great advantage to railway companies, as it would obviate in many cases the use of a "pilot" to assist a train up a heavy incline.

The Society of Arts.—The first meeting of the 136th session of the Society of Arts, or "the Society for the Encouragement of Arts, Manufactures, and Commerce," as it is more formally called, will be held on November 20th, when the Duke of Abercorn, the chairman of the council, will deliver the opening address. An interesting programme has been arranged for the four meetings before Christmas, Dr. Gladstone lecturing upon "Scientific and Technical Instruction in Elementary Schools"—on which occasion Mr. Mundella will preside—Dr. Armand Ruffer on "Rabies and its Prevention," Mr. Trueman Wood (the secretary to the society) on "The Paris Exhibition," and Sir Robert Rawlinson on "London Sewage." Among the more striking lectures to be given after Christmas, I learn, will be one by Mr. George Findlay, the general manager of the London and North-Western Railway, upon "Modern Improvements in Facilities for Railway Travelling"; another by Sir Douglas Galton upon "M. Girard's Sliding Railway," with which Mr. Gladstone was so much struck when recently visiting Paris; and a third by Mr. Frederick C. Danvers upon "The Records of the India Office." But the dates for these and other spring addresses have not yet been fixed. Five courses of "Cantor Lectures" will be delivered, these being upon "Modern Developments of Breadmaking," "The Electromagnet," "Stereotyping," "Some Considerations Concerning Colour and Colouring," and "Sugar, Tea, Coffee and Cocoa: their Origin, Preparation, and Uses," while the customary juvenile lectures always delivered during the January holidays will deal with "The Story of a Flame." As far as can yet be decided, the annual conversazione will take place on Wednesday, June 18th.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

October 19th.

16506 Stop Vaves, T. Parkinson, Blackburn.
16508 Lathes, W. H. Astbury, Altrincham, Cheshire.
16515 Crushing Machines, J. Scott, Bristol.
16517 Carding Engines, W. Lord and F. Woodhead, Manchester.
16526 Steam Winches, C. Douglas and M. Douglas, Sunderland.
16529 Steam Motor, J. Williams, Liverpool.
16547 Steam Generators, C. Huelser, London. (H. Martin, France.)
16561 Bearings, G. F. Simonds, London.

October 21st.

16571 Furnaces, N. Downing, Stockton-on-Tees.
16574 Expansion Gear, H. Muncaster, Wellington, Shropshire.
16583 Condensing Apparatus, A. Collingridge, London.*
16588 Preventing Corrosion, J. Orme, London.
16595 Glazing Leather, H. Borgenschild and F. Busch, London.
16602 Propulsion of Boats, R. H. L. Wheeler, London.
16603 Coal Sorting Machinery, M. A. Humboldt, Barmen.*

October 22nd.

16631 Cartridges, A. Locher, London.
16634 Governors, G. A. C. Bremme, Liverpool.
16636 Packing, J. Bural, Cardiff.
16638 Filtering Apparatus, J. Brown, Longport, Staffordshire.
16645 Steam Generators, S. W. Ludlow, London.*
16646 Gas, D. H. Knapp, London.*
16648 Electric Railway, M. Wheless and S. E. Wheatley, London.*
16649 Copper and its Alloys, G. G. Mullins, London.*
16651 Brazing Band Saws, L. A. Groth, London. (I. Frænkel, Switzerland.)
16653 Brakes, J. Coulman, London.
16656 Weighing Machines, A. P, Trotter, Westminster.
16666 Valves, W. P. Thompson, Liverpool. (H. D. Haverkamp, Holland.)*
16681 Axles, A. C. Auster, London.
16686 Hydraulic Presses, C. A. Piat, London.
16700 Indicators, C. Spratt, London.
16701 Projectiles, J. O'Kelly, London.
16706 White Lead, P. Bronner, London.

October 23rd.

16721 Dynamo-electric Machinery, J. Fraser, London.
16730 Steam Dryers, J. Hall, Manchester.
16731 Tapping Machine, G. Farmer, Bilston, Staffordshire.
16738 Rail Joint Support, P. M. Justice, London. (The Long Spring Truss Co., United States,)*
16744 Fire Clay, J. Hall, London.
16747 Coupling Boxes, H. Johnson, London.
16757 Machine Tools, W. Ferguson, London.*
16761 Steam Engines, T. H. Williams, London.
16763 Air Condensers, J. Popper, London.*

October 24th.

16770 Bending Metal Pipes, H. M. Brigham, Manchester.*
16782 Refrigerators, W. H. Haines and J. Baker, Birmingham.
16701 Rock Drills, T. E. Bickle, Plymouth, Devonshire.
16793 Raising Steam, F. G. Broughton, London.*
16811 Link Motions, M. Kuhn, London.
16828 Marine Engines, R. Bruce, Glasgow.

October 25th.

16835 Pipe Joints, A. Eadie and J, Tannahill, Glasgow.
16839 Electric Meter, J. Perry, London.
16841 Spring Wheel, R. Nightingale, Dublin.
16842 Governors, J. Burtinshaw, Manchester.
16850 Utilising Sound Waves, F. H. Purchas, Halifax.
16851 Steam Condenser, Tangyes Limited and J. N. Floyd, London.
16875 Steam Boilers, C. Wells, London.
16882 Moulds, J. Müller, London.*
16885 Bridges, H. H. Lake, London. (E. Thomas, France.)*

October 26th.

16895 Pneumatic Carrying Apparatus, W. H. Blakeney, Dundee.
16905 Steam Engines, C. Wells, London.
16913 Rotary Engines, A. F. G. Brown and Brown's Rotary Expansion Engine Syndicate, Glasgow.
16920 Steam Pumps, R. Holt, Rochdale.*
16929 Lubricators, J. Rebmann, London.
16933 Fire Bars, A. Beldam, Liverpool.
16934 Seamless Steel Tubes, W. Pilkington, C. T. Bishop, and A Brownsword, London.
16943 Spindle Taps, A. Seeley, London.
16945 Raising Water, W. P. Theermann, Salford.
16946 Wheel Motor, C. Barnett, Godalming.
16951 Printing Machines, W. S. Foord, London.
16954 Motors, W. James, London.

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THE

PRACTICAL ENGINEER,

NOVEMBER 22ND, 1889.

INVENTORS' CLAIMS IN PATENTS.

It has been said, with considerable truth, that all engineers are of necessity inventors, and accordingly it is not surprising that the great majority of practical workers in this field, at some portion of their career, become patentees interested in special improvements. To those of our readers who are inventors—and they are many—it is of vital importance that the claims made in their specifications should be, not only well grounded in fact, but also clearly and correctly expressed. In all complete patent specifications the inventor is expected to conclude with one or more claiming clauses, in which he explicitly points out to the world the really novel features of his invention, and distinctly separates the matters referred to in the specifications which are common property and necessary for the carrying of the invention into effect, from those of which he regards himself the exclusive owner and originator. These latter confer the special advantages which the inventor has sought to attain, while the former are necessary details, required to completely elucidate the mode of applying the invention, or to show the class of processes or operations which it is intended to improve.

Having in view the great activity of inventors during this century, and more especially during the past ten years, which has caused the accumulation in our patent libraries of specifications to be numbered in hundreds of thousands, it is very evident that if a patent is to be valid extreme care is required in framing claims in such a way as to claim the novel points of the invention without including that which is already common property. As the validity of a patent depends very much upon the proper wording of the claims, and the financial benefit of an invention which a hard-working inventor may have perfected with much expense and toil may be entirely lost to him through carelessness or ignorance in drafting the specification and claims, we need not apologise for treating this subject here. It must be of vital importance to many of our readers. First, then, we may consider the class in which most inventions may be ranked. These are inventions which involve no new discovery or fundamental principle, but consist in some new combination of already known parts, intended to effect a purpose more perfectly or economically than had previously been possible. Improvements in steam-engine details are generally of this kind. Since the time of Watt and his contemporaries we are not aware of any absolutely new departure involving a change in the principles which guided the early steam engineers; and yet the united efforts of succeeding generations of inventors have so modified the practice of the past that our present engines are vastly superior in economy. The best modern steam engines do not consume more, for equal power, than one-fourth of the fuel consumed at the beginning of the century by the very best engines then made.

Expansion, compounding, and even triple and quadruple cylinder expansion, together with the use of high steam pressures, were all known very early in this century, and were described in patent specifications; but the practical details required in order to use the improvements effectively have only been invented after much labour and time. The details of valve gear, valves, governors, cylinders, pistons, packing, and so on through every part of the steam engine, form the subjects of numerous patents, all having one object in view, and all dealing with the same general principles. Many of those patents are worthless as a means of protection to the inventors through faulty wording of the specifications and claims, caused in some cases by ignorance of the exact mechanical nature of the improvements dealt with, and in others by ignorance of their relation to previous patents on the same subject. To efficiently word and arrange a claim or claims for a new valve gear, for example, the expert employed by an inventor should be himself a skilled engineer, and understand thoroughly the exact points of improvement aimed at, as well as the difficulties of former valve gear, sand the patents in existence upon the subject. Otherwise, he would be entirely unable to apprehend the points of departure in the combination under examination, and he would probably be unable to claim them in such a way as to secure the greatest advantage for his client.

Inventors, then, should always make it a point to search themselves, or have searches made for them, on any subject to which they pay attention, or upon which they contemplate any considerable expenditure of time and money. If the invention is an important one, a very careful examination of previous patents is absolutely necessary, in order to arrange the claims in a just and satisfactory manner. As the result of a somewhat extended acquaintance with patent specifications on many engineering subjects, we often regret the amount of wasted effort expended by engineers in re-inventing old devices. These devices are frequently included in specifications dealing with valuable inventions, and by the fact of their being claimed as novel seriously weaken patents which would otherwise be strong and unassailable. This re-patenting of old inventions is continually in progress, and it is easy to select a series of patent specifications, on almost any subject, in which year after year the same invention is claimed as novel. That this practice is a common one is readily seen from the fact that few specifications are allowed to pass through the ordeal of the law courts without preliminary amendment by way of disclaimer—that is, amendment by disclaiming portions of the invention which have been found by diligent search to be old. The diligent search should have been made before the claims were framed, and if invariably done few patents would be lost from this cause instead of many, as at present. Most mechanical inventions, then, consist of new combinations of old parts, and the claims cannot be properly adjusted without reference to, and full understanding of, the work accomplished by previous inventors.

The second class of patents may be considered as containing all inventions which for the first time apply to a useful purpose some new principle or scientific discovery, and such inventions are comparatively few in number. In those cases there is little difficulty with the claims, as it is only necessary to claim a few modifications of the apparatus used to carry out the invention to practically cover the whole ground. In British patent law a new principle cannot be claimed; but the first to apply the principle to a useful purpose can always obtain a practical monopoly of the principle in its application to that particular purpose, by a little care in framing his claim. Watt thus obtained a practical monopoly of the separate condenser, Nelson of the hot blast, and Graham Bell of the telephone. In all these cases new principles were involved. The French invention of Giffard's injector is also a case in point. By it water could be forced into a steam boiler against the full steam pressure by the steam from the boiler at the same pressure, a feat deemed impossible before, and little understood till long after. This led in time to the development of the exhaust steam injector, a still more wonderful invention, as it forces water against boiler pressure by the discharge steam from an engine.

In like manner the Bessemer steel process involved the discovery of entirely new principles in handling and treating iron and steel, and no discovery of like importance in steel production was made until the appearance of the basic process, which turns on the apparently small matter of the action of a basic or alkaline earth lining in steel converters upon the phosphorus contained in the steel. To this class also belong nearly all great chemical discoveries, such as the preparation of aniline from nitro-benzol, or alizarine from another coal-tar product. The ammonia-soda patents, which, in the hands of Messrs. Brunner, Mond, and Co., have created such a revolution in the alkali industry, are not of this class, although admirably useful and complete, but belong to our first division of combination patents, as the re-action of ammonium carbonate and sodium chloride, resulting in the formation of sodium carbonate and ammonium chloride, had long been known to chemists.

Still another and very important class of patents may be discussed, namely, those in which some well-known apparatus or principle has been applied to some new purpose, sufficiently removed from the original purpose to constitute a new invention. The regenerative patents of the late Sir C. W. Siemens were examples of this. The regenerator was known as applied by Dr. Stirling and Capt. Ericsson to hot-air engines; but its application to furnaces was sufficiently novel as to constitute a new and useful invention.

In all these types of patents, whether dealing with engineering, metallurgical, or chemical processes, the greatest care must be exercised in framing the claiming clauses, having regard not only to past patents and processes in actual use, but also to possible developments and modes of accomplishing the same purpose by slight differences in detail, if the patent is to secure for the inventor the pecuniary reward for which he has laboured hard.

THE PROPOSED FORTH AND CLYDE SHIP CANAL.

It appears that the movement for the construction of a large ship canal between the Forth and the Clyde has become definite, and the promoters have obtained the opinion of Mr. E. Leader Williams, chief engineer of the Manchester Ship Canal, as to its practicability and prospects, while Messrs. D. and T. Stevenson, of Edinburgh, have prepared plans and estimated the cost of the undertaking. Two routes are under consideration—the direct route, which would involve the ships entering the Clyde; and the Loch Lomond route, which would give the entrance on the west side of the canal by Loch Long to Loch Lomond, and so avoid the river altogether. The former plan would cost, it is expected, about £5,000,000, and the latter £8,000,000.

Mr. Williams approves of the Loch Lomond route, as it would allow shipping to enter at all states of the tide, and he considers that the saving of time and the avoidance of the dangers of the East and West Coasts of Scotland would secure for the canal a large and remunerative traffic.

ECRASITE—A NEW EXPLOSIVE.

Ecrasite is a new explosive, said to be the invention of two engineers, Siersch and Kubin, of the Austro-Hungarian army, and stated to be impervious to damp, shock, or fire, while it develops destructive energy, when compared with dynamite, as 100 to 70. Elaborate experiments are being carried out with it by the military authorities at Vienna, who find it suitable for rifle cartridges and loading shells. It is not smokeless, and the noise of the explosion is louder than gunpowder. Like most new explosives, it contains nitro compounds.

REPORTED FAILURE OF BAKU PETROLEUM.

According to a German contemporary, a careful exploration of the Baku district has been made for the Russian Government by a mining engineer, A. M. Kouschin, and he reports a gradual failing of the Baku oil wells. He finds the naphtha confined to a limited zone, and new borings made by the Nobel Company and other firms outside of this zone have proved futile. The total naphtha remaining is estimated as equivalent to an annual production at the present rate extending over seventeen and a half years. Under these circumstances, he reports against the laying down of a pipe line, as the expenditure would not be returned by the time the present Baku wells are exhausted. This is a serious state of affairs for the Russian petroleum trade.

JET PROPULSION OF SHIPS.

According to Dr. Jackson, an American inventor, vessels can be propelled at great speeds by water jets issuing under high pressure. He states: "With a pressure of 3,000lb. to the square inch, through a ¾in. nozzle, the Etruria could be driven twenty miles an hour;" and further, "Dr. Jackson attributes the fact that the utility of the principle has never been thought out before to the fact that it has hitherto been considered by scientific men from the point of view of mechanics rather than physics."

When will American and many other inventors study the attempts made in their departments by their predecessors, if they will not take the trouble to become acquainted with a moderate amount of science? High-pressure jets as means of propulsion have been proposed repeatedly, tried often, and have failed as often. There is no difficulty whatever, and no shadow of novelty, in propelling a vessel in this way, but only a vastly increased expenditure of fuel and engine power as compared with the ordinary screw propeller. Attempts have been made repeatedly in Britain and on the Continent, and vessels of considerable dimensions have been so driven, but with one uniform result—undeviating commercial failure. We remember ourselves a steam ferry which crossed the Clyde at Glasgow using the water jet for many years, and have often sailed in it, but there was no advantage. In these matters theory should be consulted, and theory points out that great loss accompanies jet propulsion, which is more than borne out by the results of practice. If inventors will not be warned by scientific theorists, they might at least inform themselves of previous attempts and failures.

ENGINE PATTERNS.—IX.

I HAVE now given illustrations of several different types of cylinders, sufficient, I think, to enable anyone to understand the principles of their construction. The number might be multiplied almost indefinitely, because almost every little variation in design requires some special modification in construction, but there would be little advantage in pursuing the subject of cylinder patterns further. In this article I will, therefore, discuss the principles of construction of cylinders which are mainly made by a process of striking up, and so conclude this section of my subject.

In the making of the bodies of cylinder patterns of large size, the cost of both timber and labour is reduced to a minimum by the employment of loam. It is seldom that many castings are required off cylinders of large size, and there is therefore no objection to the temporary character of the loam work. The saving in timber and labour is not a net gain, because there is much extra work involved in the foundry in the striking-up. But the economy is nevertheless very considerable, and the more so the larger the sizes of the cylinders. In cylinders under 15in. or 18in. in diameter, it would scarcely pay to employ loam, but when we get over those sizes, and especially when we come to 3ft., 4ft., 5ft., or more, there is great economy. But, of course, in a loam cylinder there is just the same amount of pattern work involved in the fittings as in the case of a complete wood pattern, because steam chests, flanges, feet, and core boxes have to be made by the pattern maker in wood, just as in ordinary patterns. Only in the making of the body, therefore, is time and timber saved.

When the body is made in loam there are two methods of striking it up—one shown in fig. 78, the other shown in fig. 79. Fig. 77 shows a cylinder casting, and in fig. 79 its pattern is formed by striking the pattern body against a horizontal board, and in fig. 78 by striking the mould with vertical boards. The first method is adopted with work of small diameter, the latter with large work.

Taking fig. 79A, A is the board used for striking the body. On this board the length B is equal to the length B in the casting, fig. 77, and length B in the loam pattern, fig. 79. The diameter struck by the edge C is equal to the diameter C in the casting, fig. 77, with, of course, the allowance necessary for boring, and also equal to the diameter of the prints C in fig. 79. The diameter struck by the edges D D is equal to the diameter D in fig. 77, and D in fig. 79. The flanges E in fig. 79 have, therefore, holes bored in them to the diameter C, and abut against the shoulders of the loam pattern struck by the edges, whose distances apart are measured by B. The flanges therefore are only abutting, and are held in position by the hands of the moulder during ramming up. The pattern body thus complete with its flanges is seen in fig. 79, and the steam chest, the feet, and other fittings are made in wood and attached thereto. It is not usual to strike the flanges E E in the loam unless they are of considerable thickness; the reason being that thin webs of loam and keen edges are not easily struck up and preserved intact. Hence the employment of wood by preference.

In fig. 79, F is the core bar upon which the core plate, hay bands, and loam are carried. The loam pattern, when finished, is commonly brushed over with tar, to harden the surface and facilitate delivery from the sand. Such a pattern will stand several consecutive mouldings with care, perhaps half a dozen.

The central cylinder core is of a plain cylindrical form, and is, therefore, struck against a straight champered edge. It may be struck upon a separate core bar, or on the same bar as the pattern. In the latter case, the core is first finished and blacked, and the pattern profile is then struck upon it with board A, in fig. 79. After the pattern is moulded, the portion struck by board A is stripped off; the blacking allowing of its ready peeling off without damaging the core beneath, and the core is then blacked afresh ready to go into the mould. When only one casting is required, this superposition of pattern on core is usually adopted as a matter of economy.

If the same cylinder, fig. 77, were made by a loam mould, the process would be as follows: In fig. 78 the dotted line A represents the first or bottom joint of the mould, which would be first struck with a plain board bolted to the striking bar according to the usual method. Having the bed struck to this joint and dried, parting sand is strewn over it, and the body of the cylinder with its flange is struck with the board B, also attached to the vertical striking bar, and having its bottom edge resting on the joint face A. The striking radius C of this board equals the radius of D in fig. 77, minus the distance *a*, fig. 78, which distance *a* is the radius of the bar to which the board is bolted. The distance E in fig. 78 equals the distance E in fig. 77, and the projections F F on the board strike the flanges. The bottom flange is struck with a tongue-piece screwed to the face of the board, which tongue-piece is removed when the mould is made, and before the main board is lifted out of its place. The bevelled shoulder or "check" G strikes an annular recess, into which the top of the mould drops and is centred. The board by which the top is struck is seen at fig. 78 H, and its check is seen to be an exact reverse of G. This mode of concentric centring is necessary because it is impossible to see the interior of the mould after the cope is placed on. The top of the mould has, of course, to be struck with the check uppermost, and then be turned over into its place.

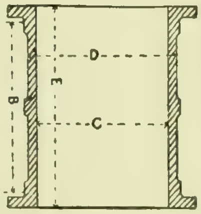


FIG. 77.

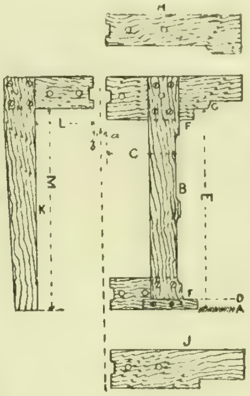


FIG. 78.

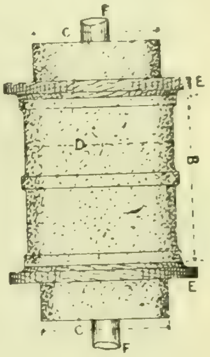


FIG. 79.

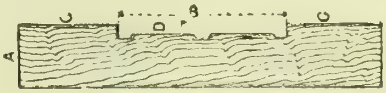


FIG. 79A.

It is obvious that the method of striking the bottom flange F by means of a tongue is open to the objection that the loam will tumble down to a greater or less extent. Of course the practice is to let the earlier coats of loam stiffen before applying the later ones, and, with care, an overhanging portion can be struck in this manner. But when the flange is very much undercut a different method is usually adopted. The bottom face and the edge of the flange are struck with a board like J, fig. 78, making the bottom joint therefore at D, and the main striking board B then terminates at line D. The board B may then strike the body mould on another bed, whence it will be transferred to its proper situation over D, or the space occupied by the bottom flange may, when struck and dried, be temporarily filled up with sand, parting sand strewn over the joint D, and the upper part of the mould be struck *in situ*. When dried it will be parted at D, the sand removed from the bottom flange, and the body replaced.

The board for striking the central core is shown at K. It is necessarily bolted to the bar at the top end only. The radius L corresponds with the radius of C in fig. 77, minus the radius *b* of the bar. The length M equals the length E in fig. 77. There is, therefore, no print used, the cores in large loam cylinders being centred by measurement only. The core is struck on a separate bed and afterwards transferred to the mould; or it is struck upon the bed A in fig. 79A, the outer portion of the mould being removed to make room for the striking board; or the core will be struck first and then removed temporarily while the outer part of the mould is made. The taper of the edge of the board is given to reduce its weight and tendency to sag while being swept round.

As I have nothing to do in this series with the details of moulding, I make no mention of the methods of bricking up, venting, and sweeping up of the loam.

In my next I shall take up the subject of slide valves.

J. H.

STATE OF THE SKILLED LABOUR MARKET.

THE following memorandum has been prepared for the *Journal* by the labour correspondent to the Board of Trade: With but slight exceptions, the reports of the leading trade unions continue to show a highly prosperous condition of the skilled labour market. Seasonal influences remain favourable, and, as yet, not even the outdoor trades have shown any sign of a falling off in the demand for labour. The coal, iron, shipbuilding, and engineering trades are very fully employed; so much so, in some cases, that the amount of available labour is not equal to any material increase of production. The printing trade is much better than it has been for some months back: but the cotton trade remains depressed, and in the spinning branches the proportion of unemployed labour is very considerably above the average. There are now but few disputes pending in the shipbuilding and cognate industries, and of nine societies directly connected with this important branch of trade, having a total membership of 125,703, only 2,023 are out of work, a proportion of but 1·6 per cent. Altogether 20 societies have sent in their returns. These show an aggregate membership of 205,246, which is an increase of 6,610 upon the figures of two months ago. Of this total but 3,657 are reported out of work, as against 4,284 for last month, a decrease of 627, and a reduction in the percentage of unemployed members from 2·1 to 1·8. For the corresponding month of last year the proportion was 4·4, and for that of 1887, 8·6. Twelve societies report their trades generally to be "very good," five "good," two "moderate," and one "bad."

A NEW ATLANTIC CABLE.

ARRANGEMENTS have been perfected for the commencement next year of a Canadian Atlantic cable. The capital expenditure of the company is estimated at 1,600,000 dols., of which the cost of manufacture, laying, and equipping the cable will consume the greater part, but the cost will be one-fifth less than any of the Anglo-American cables. The new cable is to extend from near Clew Bay, in Ireland, to Greenly Island, the Straits of Belle Isle. On the eastward end connection will be made with the Imperial Government Postal Telegraph Service, and on the westward with the Dominion Government. Thus the company will simply have a cable 1,900 miles long, and no outlay for terminal cables and inland telegraph lines will be required. Canadian business messages already number 800 a day on all the different routes, and are on the increase, and in view of Pacific cable communication the business will receive large additions.

WHY THE TEUTONIC IS NOT FASTER THAN THE CITY OF NEW YORK.

VARIOUS conjectures have been indulged in why the Teutonic is a slow ship, one of the latest being this:

"The Teutonic's screws are placed one a little forward of the other, so that they overlap. This is reported to be the reason why she is no faster, the after wheel not getting solid water."

The real reason is that the Teutonic has not power enough aboard.

The question may be put thus: If it takes 20,000 horse power to drive a ship 560ft. long by 63ft. wide at 20 knots an hour, how many horse power will it require to drive a ship 582ft. long by 57ft. wide 20 knots an hour? Answer, 20,000 horse power; for there is but little difference in the displacement of the two vessels. Unfortunately, the engines of the Teutonic are some 3,000 horse power less than the City of New York's engines, and this is quite enough to bring her last into port. If the Teutonic's engines were driven up to 90 revolutions per minute, as those in the City of Paris have been, there would be a different story to tell, for the Teutonic herself evidently "drives" easier than the City of Paris or City of New York. There is no reason that we know of why they should not be so driven unless it is lack of boiler power and lack of nerve. This last is quite as much a factor in high speed as mere mechanical conditions. Not every chief engineer has the courage to drive 10,000 horse power engines up to 90 turns per minute, which is really an incredible velocity, entailing fearful responsibilities on the builders and all concerned. To see such a mass of iron in motion at these velocities is awe-inspiring to any man of brains. Imagine three connecting rods in line, weighing five tons each at least, flying up and down 180 times a minute each, or three times in a second? Consider the enormous cranks whirling away in the darkness below at half the speed, and the great shafts sullenly grinding away through the long tunnel.

These things have their effect on the men on watch in a very marked degree, and the finer the organisation of them the greater is the strain. It is an exceptional crew that can stand the stress of such work as this, and no one can stand it for long. A few months of such work is enough to kill an obelisk. As for the overlapping of the ends of the screws, that, it seems to us, has no effect on the speed. The after wheel is, in any event, driven some revolutions faster than the forward screw, and the overlap is so small that it can hardly affect results.

Chief Engineer Sewall, of the Teutonic, does not think she has had a fair test yet, owing to the weather she has had to encounter. He says that under favourable circumstances and good weather, with the late improvements in her screw, she will do much better. Throughout the last trip the average speed was kept up to 18½ knots an hour, with 79 revolutions of the screws (19½ft. diameter) to the minute, as against 70 revolutions to the minute with a diameter of 21½ft. of the screw, before the reduction of 12in. in the length of each blade was made. The coal burned averaged 240 tons per 24 hours, as against 212 tons before the screws were reduced in length, making an average of 18½ knots against 17 knots per hour under the old system, or a gain of 36 knots per day for the additional consumption of 28 tons of coal.—*New York Engineer.*

UNIVERSITY COLLEGE, LIVERPOOL.

THE Walker Engineering Laboratories in connection with this college have now been formally opened, and will constitute an important feature in the buildings and work of the rapidly-developing institution. The engineering laboratories are situated in Brownlow Hill, near Brownlow Street, which the chemical laboratories face. The new building is a handsome structure, and carefully arranged to meet the requirements of the laboratories, Professor Hele Shaw and the members of the engineering committee having devoted to it the utmost attention to ensure perfection. The joinery department, where patterns will be made; the main laboratory, where the great testing, drilling, slotting, and other machines are arranged; and the boiler-house, with its boilers for generating steam to work the machines and to work the engine to provide the electric light, are all situate on the ground floor, and in the vestibule is a statue of the late Duke of Albany. Upstairs are the lecture and class rooms, which may also be reached by a spiral iron stairway from the main laboratory. The whole building with its fittings is the gift of Sir A. B. Walker, and the cost may be stated at £20,000. On the opening day Sir John Coode, president of the Institution of Civil Engineers, made a thorough inspection of the laboratories in company with a deputation from the City Guilds of London Institute, and all were much pleased with the building and the arrangements. Early in the afternoon Sir A. B. Walker and other gentlemen were entertained by the president (Lord Derby) and council of University College. This was followed by a public meeting in St. George's Hall, where the annual distribution of medals and prizes took place under the presidency of Lord Derby, and Sir John Coode delivered an address on engineering. In the evening there was a reception at the laboratories, when Lady Walker formally declared the building open and unveiled the statue of the Duke of Albany, presented by her munificent husband.

A continuous spinning machine, just completed, is on exhibition at the works of the M'Lagon Foundry Co., New Haven, Conn. It is said to be entirely novel, and to solve the problem of continuous wool spinning.

PNEUMATIC MOULDING MACHINERY.

We have received a pamphlet on this subject, describing a method of machine moulding which has come extensively into use in America, and is now being introduced into this country. Until recently machine moulding has been very little in use, and hand labour has almost entirely been relied on. One of the difficulties encountered in moulding is the proper ramming of the sand, and this is a matter which can only be overcome by skill and care on the part of the moulder. If the sand is too soft, the cast is made larger than the pattern, as the metal when poured expands the sand; and if, on the other hand, the sand is rammed too tight, a porous casting will be the result, as the gases formed cannot be liberated. This difficulty of ramming the sand has been overcome by the machine under notice in a very novel manner. We give two illustrations of a simple form.

Fig. 1 shows the machine closed, and fig. 2 open. It consists of a lower box and a cover, which is thrown back and lowered on by a hinge arrangement, as shown. In the cover are placed indiarubber bags, to which we will refer immediately. The lower part, or box, of the machine receives the pattern, which can be raised or lowered within it by means of a rack and lever on the side. A plate is made the exact outline of the pattern to be used, simply by pouring soft metal round it, and this is called the stripping plate. Through this the pattern is passed in the box, just before the sand is pressed against it, and after the sand is moulded the pattern is lowered again into the box, and the stripping plate then supports the mould.

The pressing or ramming is done by means of indiarubber bags in the lid, which, when the lid is closed and ready for action, are filled with compressed air. The indiarubber bags of course yield to the sand so as to conform to the shape of the pattern, and as the pressure is continuous, the ramming of the sand is therefore uniform, and sound castings are produced. In the form of machine we illustrate, a pressure of fifty to sixty pounds per square inch is used. A pressure gauge is fixed to the lid, and when the pressure of air sufficient for ramming the sand for any particular pattern is reached, notice of this is given by means of a safety valve of the ordinary type. In the machine shown, it is necessary to make all the top parts of the boxes first, and then to change the patterns and prepare the corresponding bottom parts.

There are other forms of apparatus besides this simple machine, in which the necessity for changing the patterns is obviated. Instead of one apparatus for withdrawing the pattern, two are used. This type of machine is distinguished as the "Double" or "Rotary" machine. Further improvements have been introduced. For instance, the manner in which the patterns were raised has been altered, and the lever and rack movement actuated by the use of compressed air, which is made to act on a piston underneath the pattern, and so raise it up to be moulded. The area of this piston is made large enough to give rather more pressure than that of the air bags, and as the result the piston is able to lift the pattern up and also to sustain it against the sand whilst the pressure in the air bags is ramming the sand home.

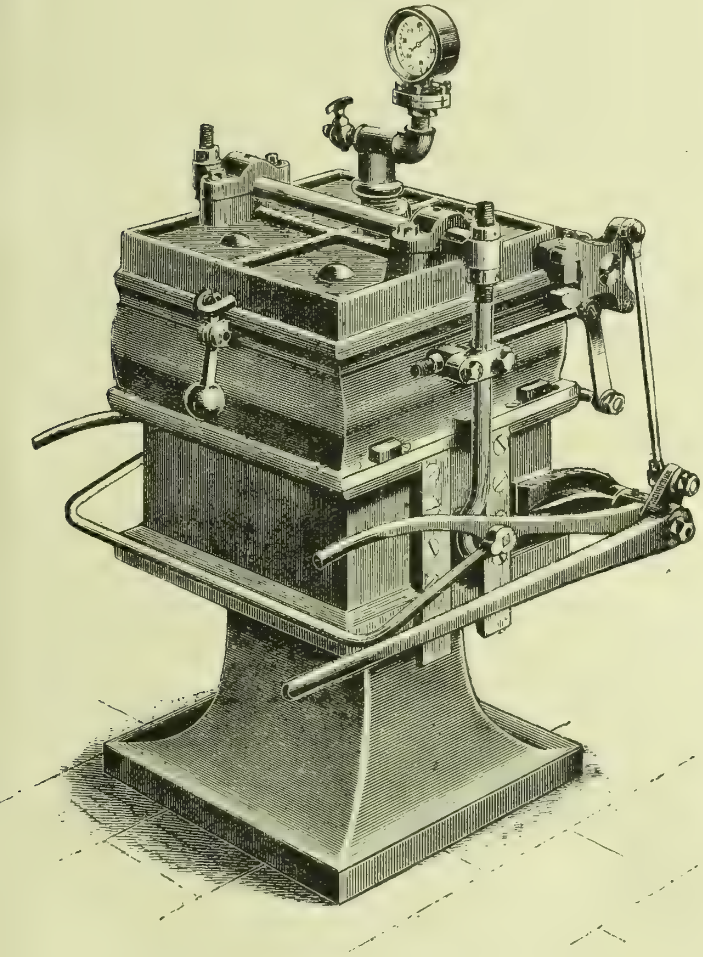


Fig. 1.

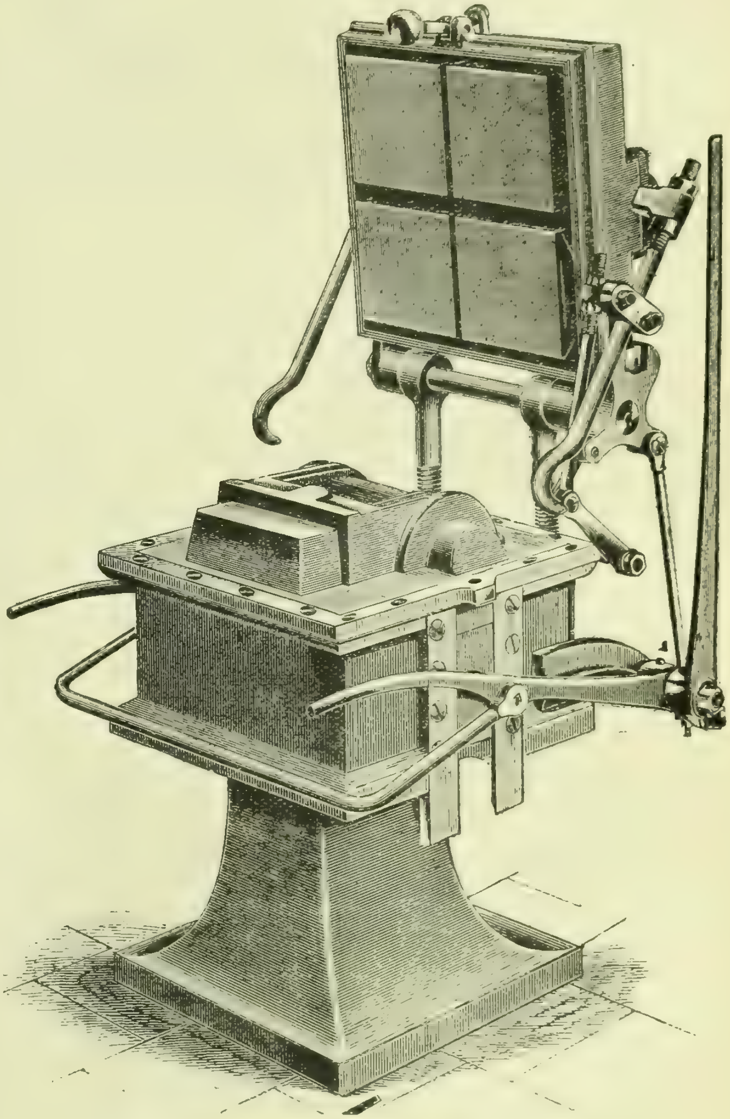


Fig. 2

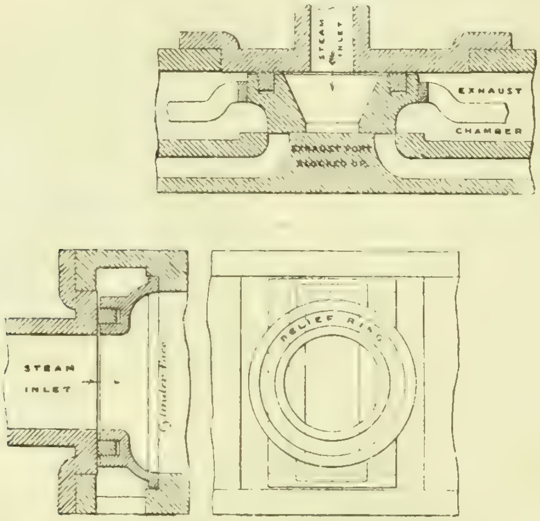
These machines, which were introduced by the Atlas Engine-works Company, Indianopolis, U.S.A., are becoming extensively used in America, and a company has been formed over there, called "The Pneumatic Company of Indianopolis." In England, this pneumatic moulding machine has been used by Messrs. Marshall, Sons, and Co., Gainsborough, who speak in high terms of its speed, and the high quality of the castings produced from it.

BALANCED SLIDE VALVES.*

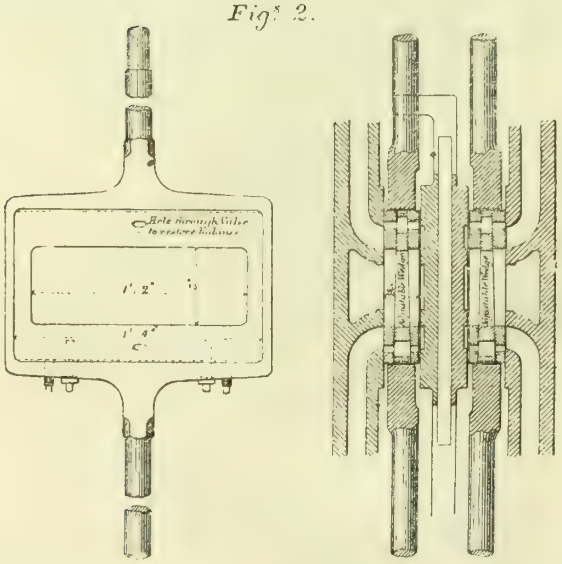
By John Carter Park, M.Inst.C.E.

This communication is illustrative of various forms of balanced or partly balanced slide valves, which have been from time to time experimented with on the locomotives in use on the North London Railway, with the dates of their introduction (see figs. 1 to 11).

Fig. 1



Figs. 2.



Figs. 1, $\frac{M}{1}$ (1856), show a form of valve having the steam admitted through the steam-chest cover to the inside of the valve, the steam chest being relieved of pressure, and communicating only with the exhaust; the steam lap in this case is on the inside, which reduces the size of the valve.

Figs. 2, $\frac{M}{95}$ (1863), show a pair of balanced valves as applied to a six-wheeled coupled goods engine No. 11, having inside cylinders. Each valve is in three pieces, and works between two parallel faces, the valves being fitted with adjustable wedges to take up the wear. The valves were never tight, and the difficulty of obtaining and maintaining parallel faces when hot was so great that they were taken out after a few weeks' trial.

Figs. 3, $\frac{M}{4}$ (1867), show a valve on Thomas Adams' principle, having a relief ring fitted to the back of the valve, and working between the cylinder face and the steam chest cover. The relief ring is kept up to the cover face by the spring shown. The valve exhausts the steam through the steam-chest cover, the ordinary exhaust port being blocked up, and the engine had a very free exhaust; it ran for about six months, but the valve ultimately had to be taken out, owing to leakage through the relief ring.

Figs. 4, $\frac{M}{5}$ (1867), show another form of a pair of Thomas Adams' valves, fitted within a very narrow space to an inside-cylinder engine. These valves had two relief rings, and ran for some six months; they, however, required too much attention to keep tight, and they had to be replaced by the ordinary valves.

Figs. 5, $\frac{M}{6}$ (1868), represent another valve of cast-iron on Thomas Adams' principle, fitted with one large relief ring; this valve was applied to a standard passenger outside-cylinder engine, and great trouble was experienced in keeping it tight. The back of the valve, though bored out truly to receive the ring, was not found to be round when hot; the ring used to stick, the packing ring would not remain tight, and although the leakage was reduced to a minimum, still it increased the consumption of fuel, and the valve was replaced by the old one.

Figs. 6, $\frac{M}{7}$ (1869), is a form of valve designed by the late David Park. It was fitted to an outside-cylinder passenger engine. The novel feature in this valve was that a large portion of the load on the valve was taken by the relief ring and carried on a steel roller running on a bridge piece inserted over the exhaust port. This valve soon gave trouble, owing to the wear of the roller and the seizing of the pin. It was replaced by the old valve after two or three months' trial.

Figs. 7, $\frac{M}{10 \text{ and } 12}$ (1871), are two views of Outridge's form of balanced valves fitted to an outside-cylinder engine. The port face is covered by a plate having the steam and exhaust passages through it, corresponding to those in the cylinder face. The valve works at right angles to the ordinary face between two port faces, one being adjustable to take up the wear, and the size of the valve is reduced to about one-half the ordinary size. The plate is free to drop away from the cylinder face when steam is shut off to avoid "pumping," and rests against the stud S. The difficulty in obtaining steam-tight parallel faces was again experienced; but after careful adjusting, the valve was sufficiently tight to run, which it did for some months. The reversing lever was easily handled, with steam at 160lb. per square inch full on, and the wear was very slight on the face of the valve; but constant attention was required to keep it tight, and it was replaced by the old valve, there being no saving of fuel.

Figs. 9, M, represent a pair of Dowe's valves tried on an outside-cylinder engine. In this class of valve the relief frame is connected to the back of an ordinary valve by a flexible steel diaphragm, so that the valve is practically one piece. Owing to the inability of this valve to leave the faces when running without steam, pumping is set up, causing a partial vacuum in the steam chest; the diaphragm soon failed and took a permanent set steam blowing through, and finally it cracked round the frame.

Figs. 10, $\frac{M}{9}$ (1873), show a pair of cast-iron balanced slide valves designed by Mr. Manico, and tried in No. 63, inside-cylinder passenger engine. There were only two parts in this valve, namely, the valve proper and the relief plate. The valve was simply a frame, perforated on its inside and outside edges, to give quick admission and release; the relief-plate had duplicate steam ports on the inside, and was free to leave the valve when steam was shut off, thus avoiding pumping. The valve was in perfect balance, and the reversing lever was quite free with steam full on. These valves at first gave promise of success; but, after a few weeks, it was found that the relief plate, although 1⅝in.

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* Proc. Inst.C.E., vol xcviii.

Figs. 10.

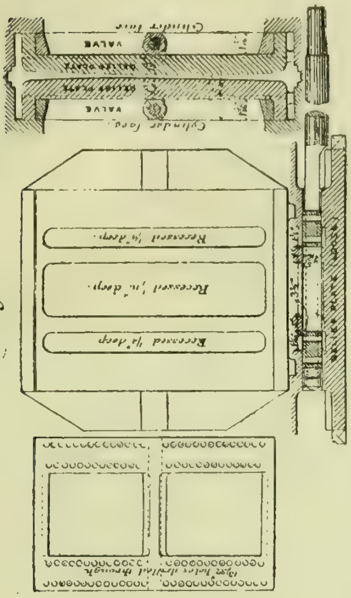


Fig. 11.

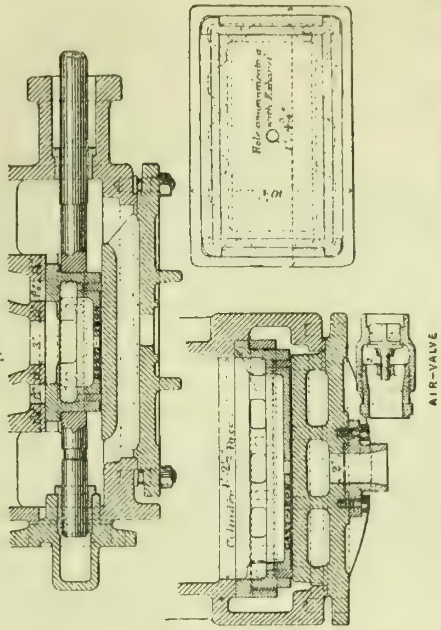


Fig. 9.

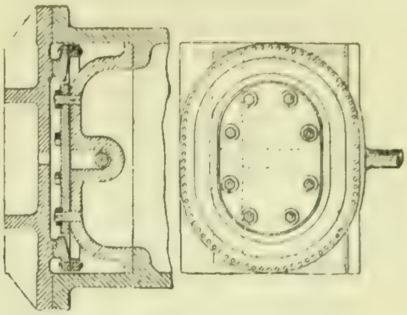
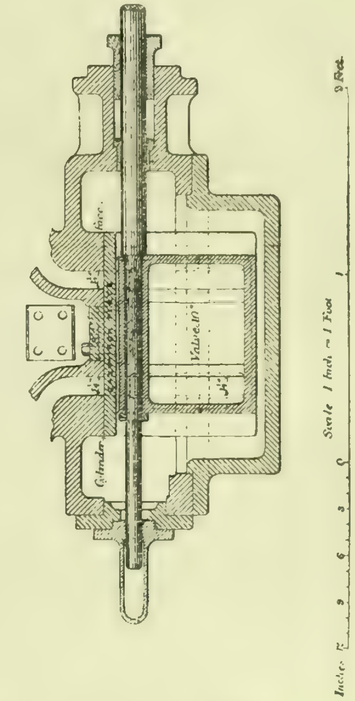
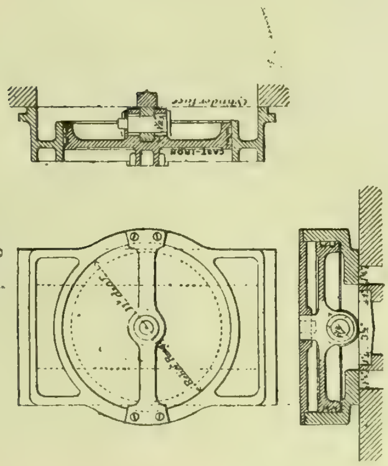


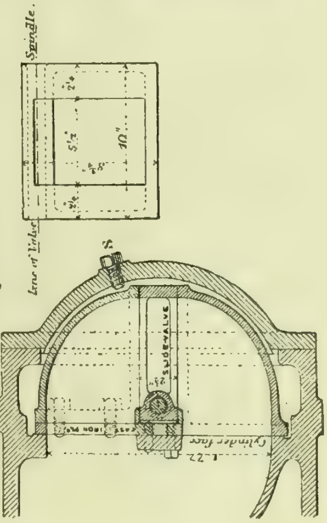
Fig. 8.



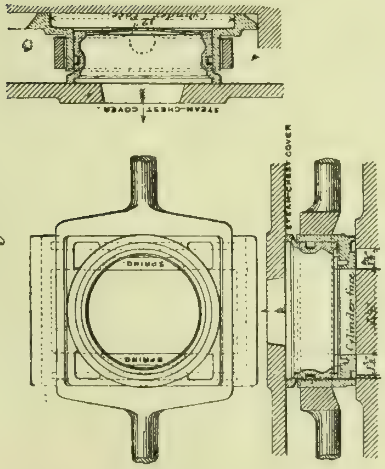
Figs. 6.



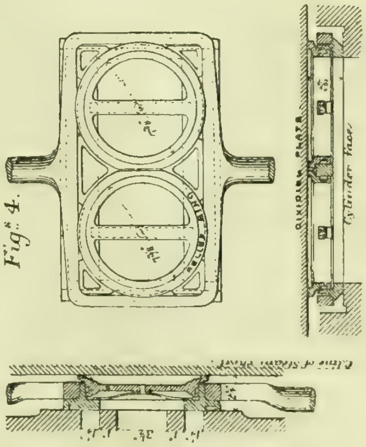
Figs. 7.



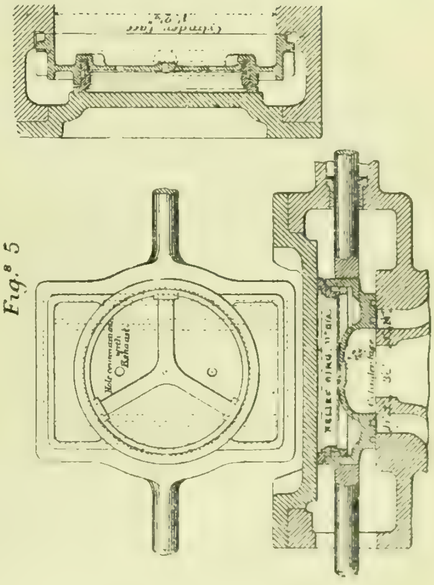
Figs. 3.



Figs. 4.



Figs. 5



thick, sprang slightly with the pressure, causing the valve to wear hollow and steam to blow through.

Figs. 11, $\frac{M}{74}$ (1886). This form of valve is similar to the valves in use on the Grand Trunk Railway of Canada, except that the valve works vertically instead of horizontally. It is simply an ordinary valve with packing strips fitted to the back to work against the inside face of the steam-chest cover; the packings are kept up to the face by twelve spiral springs, and the steam-chest cover is provided with a port to convey the steam to the front end of the chest. The air valve opens inwards, and prevents a vacuum being formed when running without steam; a hole drilled in the back of the valve puts the space within the area of the packing strips in communication with the atmosphere. Although carefully fitted, these valves were never tight, and were replaced by the old valves.

THE MANUFACTURE OF THE ALLOYS OF ALUMINIUM IN THE ELECTRIC FURNACE (COWLES' PROCESS).

(*Continued from page 786.*)

THE elongation in different parts of the bar was much more uniform than with iron or steel.

One inch lengths measured after fracture.

No. 1	2	3	4	5	6	7	8	9	10	11	12
1·27	1·27	1·26	1·28	1·27	1·26	1·28	1·29	1·34	1·36	1·44	1·44

The high elastic limit in a material so plastic is noteworthy. In *resistance to compression* this metal equals the best cast steel; its *transverse strength*, or rigidity, is about 40 times greater than ordinary brass; its limit of elasticity equals steel of the same tensile strength and elongation. Forged, tempered, and annealed, its elongation equals the best grades of steel of the same length.

The "special" grade contains more aluminium than "A" grade; is higher in tensile, transverse, torsional strength, and elastic limit. Its elongation is less, ranging from nil to 8 per cent. The following was a test made at Washington Navy Yard of metal of this grade, supplied by Cowles Co.'s works.

TEST AT WASHINGTON NAVY YARD OF COWLES CO.
"SPECIAL GRADE" ALUMINIUM BRONZE.

Specimen.	Dimension of Specimens.		Wt. applied in	Elastic Limit per sq. inch on original Cross Section	Wt. per sq. inch on original Cross Section.	Elongation per Cent.	Reduction of Area per Cent.
	Length in inches.	Diameter in inches.	Lbs.	Lbs.	Lbs.		
No. 1*	2·00	·500	22,485	……..	114,514	0·45	0·00
No. 3	2·00	·501	21,650	79,894	109,823	0·05	39

*Cu 89· Al 10· Si 1·0 = 100.

TEST MADE BY THE LEEDS FORGE COMPANY, LIMITED.
"SPECIAL GRADE" ALUMINIUM BRONZE.

Specimen.	Dimensions in inches.		Tensile Strength in Tons.
	Diam.	Area.	Total per sq. inch.
1 round bar casting.	·285	·0646	57·27 (128,400lb.)

The B, C, D, and E grades, containing 7½, 5, 2¼, and 1¼ per cent aluminium respectively, decrease in tensile strength from about 65,000 per square inch in B to 25,000lb. in E grade; the transverse and torsional strength, elastic limit, and resistance to compression decreasing as the aluminium is lowered; elongation increasing in the same proportion. The E grade metal will stretch nearly two-thirds of its length before rupture, which exceeds that of pure copper by about 100 per cent. A piece of C grade wire can be twisted through several hundred turns before breaking. A rolled bar of C grade (5 per cent), tested at the Phœnix Works, Rohort, Germany, gave—

Tensile strength .. .. 82,880lb. to sq. inch—37 tons.
Elongation .. .. .. 60 per cent.

Average strength in castings:—

Grade.	Tensile Strength per square inch.	Elongation.
"A" special (11 %)........	90—100,000	0—8·0 %
"A" bronze (10 %)........	75—90,000	4—14 %
"B" „ (7½ %)	55—65,000	20—40 %
"C" „ (5—5½ %)....	35--45,000	30—40 %
"D" „ (2½ %)	30—35,000	40—50 %
"E" „ (1½ %)	25—30,000	40—55 %

All grades of this bronze under 11 per cent can be rolled, swedged, or drawn cold, and it is the only bronze that is not "hot short," and can be worked at a bright red heat as easily as wrought iron. Under the hammer it can be drawn out to the fineness of a needle. The rolling of sheets, rods, bars, and wire is done at bright heat, only the finishing done cold. Rolling or working this metal in any way makes it stronger and tougher. A "rolled" rod, "B" grade, tested at the Otis Iron and Steel Works, Cleveland, Ohio, showed tensile strength 83,000lb. to the square inch, with 39 per cent elongation before breaking. In the casting this metal had but 60,000lb. to 65,000lb. tensile strength, with 20 per cent elongation. The fractures of the special and "A" grades exhibit a crystalline structure; the lower grades are extremely fibrous. The beautiful colour, and power of resisting corrosive influences, make aluminium bronze valuable in art metal work.

(*To be continued.*)

ON A GERMAN COMPOUND.

A RIDE on a German compound locomotive is not without its interesting features. It is not to be supposed that high speeds are not attained in Germany under certain conditions, or that railroad travel is there less dangerous than in the United States. The expenditures for the maintenance of the roadway and equipment are kept as small as possible. A German locomotive has but few finished parts. Nearly everything is painted. In the cab all of the mountings are painted black, and the interior has only those fittings which are absolutely essential to the proper working of the engine. A new compound locomotive recently built at Chemnitz was painfully plain and ordinary looking in its fittings, but the accuracy of the fits and the smoothness of operation were in no way excelled by the more brilliant-looking French and English engines. In economy it is doubtful if it is excelled by any locomotive on the face of the earth.

From Reichenbach, at 9 o'clock p.m., the compound moves a large train up a steep grade at a reasonable speed, and down the decline on the other side at a velocity approaching 60 miles per hour. The roadbed is not the smoothest, and the locomotive rolls from side to side. It is dark, and there is no headlight on the engine. An occasional switch lamp is all that is visible in front with the exception of the signals. These lamps are strange looking devices, with an upright, square face for the safety position, and a face in the form of an oblique parallelogram for the danger position. Rushing along in a strange country at 60 miles an hour, without a headlight, and without any possibility of knowing what is in front, is exciting. In the cab, an occasional gleam from the incandescent fuel as the door is opened blinds one for a minute, and when the door is closed even the switch lamps are invisible until the eye recovers from the glare of the furnace.

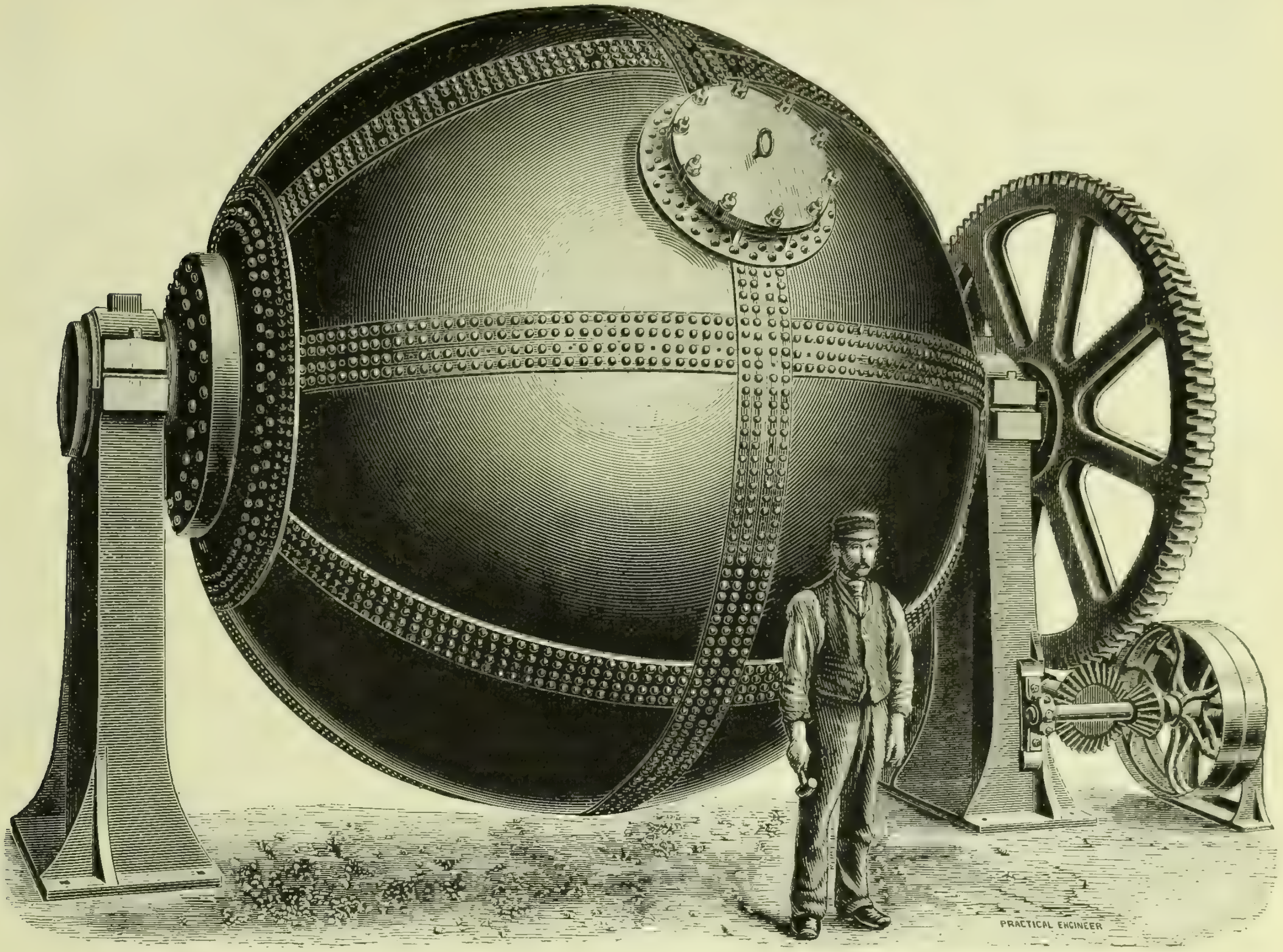
The fittings on the locomotive in the cab are veritable curiosities. The mountings are unfinished and painted black. The steam gauge is small, only about 4in. in diameter, and registers differences in pressure of about 10lb. only. It is graduated for atmospheres. The injector is a complicated-looking affair, and the fireman experiments several times before he succeeds in starting it. The cab lamp resembles a policeman's dark lantern. It shines only in one direction, and is used by the fireman to inspect his coal, the water glass, and other portions of the cab mountings; and at other times it is hung up on a wire hook, from whence it sheds light upon the steam gauge. The cab is large, not unlike the American, open at the back. The side windows are hinged, and swing inward. The reversing gear is operated with a screw, and no protection is placed over the fire door to prevent the light from reaching the engineer's eyes.

The locomotive starts the train with rapidity, and, except for the long interval between the exhausts, it works to all appearances exactly the same as the simple engine. The fires burn brightly under the long, slow discharges of steam from the low-pressure cylinder, and there is little smoke *when the furnace is fired properly*. However, in Germany, with all their principles of economy, there exists the same fault that is common in the United States with regard to firing locomotives. There, as in many cases here, the locomotives are run without brick arches, and the coal is shovelled in with as little apparent purpose or mental exercise as would be used if the object was merely to get rid of the coal. Occasionally the fireman stirs up the fire with a long poker, but at other times he devotes his attention to experimenting with the injector, and shovelling coal in a haphazard manner into the fire-box and closing the door immediately, thus causing the black smoke to roll in huge volumes from the top of the stack.

The springs upon which the compound locomotives are mounted are flexible, and the engines may be termed easy riding; but the tracks are in many places no better than the average American track, and not so good as our best roadbeds. Therefore, as one may suppose, the locomotives roll considerably.—*Master Mechanic.*

WOOD PULP DIGESTER.

CONSTRUCTED BY MESSRS. R. DAGLISH AND CO., ENGINEERS, ST. HELENS.



We illustrate here a very large wood pulp digester constructed by Messrs. R. Daglish and Co., of the St. Helens Engine and Boiler Works, St. Helens, who have, we are informed, over a score of digesters of the same type in hand for England and America. The digester illustrated is of the best Siemens-Martin mild steel plates, double riveted, butt strips, and having the inside rivet heads and holes countersunk, so as to finish with a level interior surface. This allows of the proper contact of the lead lining and the thorough protection of the steel of the digester from the chemical action of the liquid contained. The lead lining is laid on in large sheets, and clamped to the shell by clamps screwed up from the outside. The manhole door, 2ft. in diameter, allows of the admission of the wood and sulphite solution, and when securely closed steam at 70lb. per square inch is admitted through the trunnions, and the digester is rotated slowly by the bevel and worm gearing shown. The whole construction is massive and simple, while thoroughly safe and reliable. The internal diameter is 12ft., and the thickness of the plates $\frac{11}{16}$in.

A NARROW FIELD FOR COUPLER INVENTORS.

To invent and patent automatic freight car couplers which couple with a link is as foolish and unprofitable as it would be to make liver pads for Egyptian mummies. And yet people are still engaged in this idiotic business, putting into it their time and money, and, no doubt, dreaming dreams of future success and wealth. What gorgeous visions, what castles in Spain, have glittered on the horizon of the car coupler field to the wild-eyed multitude of inventors! One feels a thrill of sympathy in thinking how those cloud castles vanished, how the brilliant colours changed to dull, hopeless grey.

It may be taken for granted that the man who now tries to patent a link car coupler is perfectly ignorant of the business to which his invention relates. There is an element of grim humour in the fact that the great majority of car couplers have been invented by people who knew nothing about the construction of cars, the handling of trains, or the conditions of railway freight traffic. To their minds the chief problem has been to get something that would couple—as though coupling were a new or a difficult thing. But those who are now putting time and money (we refuse to add "and brains") into car couplers which couple by means of a link, or a link and pin, are evidently ignorant of the fact that the railroads of this country have decided against couplers of that type, and that railway officers will not even look at a new patent coupler which couples with a link. When two years ago the railroads of this country voted by letter ballot to adopt as standard a hook coupler, coupling in a vertical plane, all further effort to improve link-draw bars became not only useless but ridiculous. The fact is that there has been for some years hardly a possibility of devising any new and valuable improvement on automatic draw-bars of the link type. There are several couplers of this class which are, in all important details, about as near perfect as any such coupler need be.

It may be added that one glance at the drawings of the newly patented link couplers which appear in the Patent Office Official Gazette, and occasionally in technical papers, is enough to show that they are absolutely worthless. Indeed, most of them are more ridiculous than anything in *Judge* or *Puck*. While we will not assert that any technical paper which encourages ignorant inventors to continue their useless work of "improving" link couplers by publishing cuts of their abortive and absurd inventions is committing a moral wrong, we do say that it is not creditable to do so. The really commendable course would be to impress upon all its readers the fact that for inventors there is absolutely nothing in the link coupler field. For some years to come, if not for ever, the railways will refuse to test a new coupler of that class.—*Master Mechanic.*

THE STRENGTH OF BOILERS.*

By James C. Spence, M.I.N.A.

For many years the opinion has been gaining ground among engineers that the rules at present in force prescribe a greater thickness for the shells of marine boilers than practical experience shows to be necessary. The engineers of H.M. Navy, acting on this experience, have recently made great reductions in the thickness of the shells without making any corresponding reduction in the thickness of other parts of their boilers. And Mr. A. C. Kirk, speaking at last year's annual meeting of the Institute of Naval Architects, said that if the designers of boilers for the mercantile marine were their own masters, and not subject to official control, they would long since have altered their practice in the same direction.

The object of this paper is to bring to notice a new method of calculating the strains on boilers, which, if correct, would allow enormous reductions in the thickness of marine boiler shells without making any reduction in the factors of safety or any radical change in designs. An examination of the present theory on the subject, and a reference to one or two elementary principles, will put in a clear light the difference between the proposed theory and that now in use.

As all cylindrical vessels may be considered as made up of a series of narrow rings, it is assumed that their strength is independent of their length, and that it varies directly as the thickness of their shells, and inversely as their diameter. This generalisation is adopted without modification as the basis on which the shell scantlings of all marine boilers are proportioned. It is accepted without question by all practical men, even by those who are vaguely conscious that it prescribes an excessive thickness. It is taught authoritatively by all professors and writers on the subject, and it is enforced by all the power of the double censorship—Board of Trade and Lloyd's—under which engineers are forced to work. But as it is of much greater importance to have our practice right than to be unanimous in our theory, the writer asks you to weigh the arguments which he considers prove that the present theory is absurdly wrong. For a boiler is not an open ring, nor a series of such rings, but a structure composed of a short ring and two strong ends. The strength of the structure is partly dependent on the strength of the ends, and the proportion of length to diameter is not, as we have hitherto supposed, a matter of indifference, but a matter of vital importance.

To make this evident we have only to examine an extreme case. Suppose a flat boiler plate ⅜ of an inch thick, riveted to two strong flanged plates 12in. apart, and having an unsupported strip 6in. wide between flanges. This plate would be capable of standing a pressure of 100lb. per inch. To roll this plate into a circle would certainly not weaken it, and therefore if B and C were to represent the ends of a cylinder 1ft. long, and A A represented the shell of that cylinder, then we might make the diameter of that cylinder as great as we pleased without any increase in the thickness of the shell, which would never be weaker than a flat plate, and as the length of section of end plate resisting rupture would increase directly as the diameter, we might safely assume that the whole bursting pressure would be borne by the ends, and neglect as of no account the strength of shell plate. In fact, the greater the diameter of this short cylinder, the more evident it is that its strength depends on its ends and not on its shell. From this point of view, the strength of cylindrical vessels, with ends securely fastened to shells, depends on the resistance to rupture of the shells and the ends. In very long vessels the shell bears such a large proportion of the total strain that we may leave the ends out of our calculation. In very short vessels the ends bear so large a proportion of the total strain that the strength of the shell may be ignored; but in marine boilers, where the ratio of length to diameter approaches equality, it cannot be safe to deal with either factor as the sole one.

Both theories assume that the bursting pressure on any section is the same in magnitude and direction, but the first of these assumes that the total strain is borne by the shell plates, that this strain is distributed uniformly along these lines, and that there is no strain on end plates; while the second theory assumes that the total strain is distributed over each point of the section resisting fracture, that it varies inversely as the distance of each point from the centre of the section, and that it is the same on each point of the rectangle as in the corresponding point of the rectangle. This, of course, assumes that the structure is strong enough to stand the pressure brought upon it. If, for instance, the end plate were too weak, and either fractured or stretched beyond its elastic limit, then, and then only, a greater strain might come upon the shell plates than estimated, but until the end plates are fractured or crippled they must bear their due proportion of the strain.

If this new theory is correct, we can now see the magnitude of the errors we have been committing. The area of the end plates in some cases is nearly twice the area of the shell, and consequently in a boiler 15ft. diameter by 10ft. long only one-third of the total pressure comes upon the shell plates and two-thirds on the ends. In a boiler 10ft. diameter, by 15ft. long, two-thirds of total comes upon shell and one-third on ends. It is also evident that if the diameter of a boiler equals its length, its section will be a square, and the strain on each of the four sides of that square will be equal, and one-half of total strain will be carried by shell, one-half by ends. That is to say, if we allow for the strength of ends as well as shells, then—

In a boiler where diam. = ⅔ of length, shell plates ⅔ the thickness now used would suffice.
" " diam. = length, " ½ " " "
" " ⅔ diam. = length, " ⅓ " " "

If it is true that the ends of boilers bear the above share of the pressure tending to rupture the cylindrical shells, then the theory that tells us that we may neglect their strength has led us into other errors besides that of wasting material in making our shells excessively strong. For while we have been racking our brains to save another half percentage of plate section in shell plates, we have riddled our end plates with tube holes, and cut out great holes for furnaces and doors, as if in fact, as in theory, their strength was of no importance. That no disaster has resulted from this may be due to the fact that we have vast reserves of strength never considered, that our furnace holes are compensated by strong furnaces, and that we have a large factor of safety which covers a multitude of sins.

And again. If a boiler is made throughout of uniform strength, all the parts will elongate together; if the pressure exceeds the elastic limit of the material, the rivet holes will elongate so that leakage will prevent any explosion or sudden fracture, but if our boilers consist of very strong shells and weak ends, we run the risk that fracture might take place through a weak part of front, before the uselessly strong joints of shell commence to leak. That is to say, in a boiler where the strength of each part is proportioned to its strain, the worst risk we run is that of leakage; but in a boiler where the greatest strength is put where the least strain comes, we run the risk of explosion. At this point our argument might be concluded, but as it assumes that we have all been led astray by what seemed to be perfectly sound reasoning, can we venture to revolutionise our practice in accordance with this new theory? To this it might be answered that it is better to trust to a theory which allows for two factors in a problem, than to a theory which avowedly neglects one of these factors, especially when we find that the neglected one is frequently the most important of the two. There is, however, a much better answer than this; there is ready to our hands actual experimental proof, not only that the old theory is wrong, but also that the new theory here propounded is a very close approximation to the truth.

This proof is to be found in the series of experiments recently made by Mr. John Scott, who read a paper on the strength of boiler shells at the last meeting of the Institute of Naval Architects. The figures, facts, and arguments brought out in this discussion are now to be considered.

Mr. Scott built a boiler 7ft. 8in. diameter by 11ft. long, consisting of shell, ends, and stays, omitting furnaces, combustion chambers, and tubes. He tried to test this to destruction, but only succeeded in making it leak. This result admits of a very simple explanation. The shell was built of steel plate, having an elongation of from 25 to 29 per cent. This elongation, as you are aware, is not produced uniformly. Below the elastic limit the elongation is so small that it requires delicate measurement to detect it, but when the strain reaches this limit the elongation increases rapidly and suddenly, and at the same time the area of section begins to contract rapidly. A test piece slightly elongated by a strain below its elastic limit returns nearly to its original condition when the strain is released, but when the strain has exceeded that limit the piece remains stretched and area contracted. Now, it is evident that a boiler built of steel of this description cannot be strained by water pressure to much above the elastic limit of the structure, for at this point the rivet holes would all begin to stretch rapidly, and the thinning of the plates would destroy the efficiency of the caulking, and a boiler with rivet holes and caulking stretched could not hold water at a high pressure. Now, this is exactly what happened with Mr. Scott's boiler at a pressure of 620lb. to the inch—the leakage overpowered the pumps. Having a very large water supply, they were able to keep up this pressure for five minutes, but unable to increase it. When the pressure was reduced it was found that it had produced no fracture, and no serious disturbance of the structure, proving that the elastic limit had not been greatly exceeded, for had the strain approached the breaking strain of the material, they would have seen a very serious disturbance of the structure; the experimenters would have seen it swelling visibly before their eyes. These considerations and a comparison of the final test with previous tests, at lower pressures, show that the strain on shell plates had reached and passed the elastic limit, but they also show the strain was far below the point of rupture.

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*Abstract of paper read before the North-East Coast Institution of Engineers and Shipbuilders.

Now, if the old theory that all the pressure came on the shell was correct, then the strain on the solid plate of shell was 78 per cent of its ultimate strength = 22 tons per inch; the strain on shell plate in line of rivets was 93½ per cent of its ultimate strength = 26 tons per inch, and under that strain the boiler held water at a pressure of 620lb. for five minutes. Yet Mr. Manuel, in the discussion that followed the reading of this paper, gave a series of tests with a riveted joint similar to that used in experimental boiler, and showed that the elastic limit was reached at 15¾ tons per inch; that the joint was to all intents and purposes crippled as a joint, with a strain of 20 tons to the inch, although it did not finally rupture till the strain was 28·7 tons to the inch. And we are supposed to believe that this boiler held water for five minutes at a pressure of 620lb. when strained to 26 tons to the inch.

If, however, we allow for the strength of the ends, we find that only 63 per cent of total strain comes on shell, 37 per cent coming on the ends. On this hypothesis, the strain on shell plates, under a pressure of 620lb., was 16¼ tons to the inch.

Now, Mr. Scott gives the elastic limit of plates, similar to those used in his boiler, as 16½ tons. Mr. Manuel gives the elastic limit of joints as from 14 to 16 tons. This boiler, which all the evidence proves to have been strained just above its elastic limit, sustained a pressure, according to new theory, of 16¼ tons per inch; according to old theory, of 26 tons per inch. The inference drawn by the writer is that the old theory is wrong, and the new one is right.

Let us now conclude this paper with a short summary of the arguments used therein. After noting that practical experience had led many engineers to the conclusion that the rules now in force prescribe an excessive thickness for the shell plates of marine boilers, we examined the theory on which these rules are based, and found that it was a theory only true for open-ended rings, which might be approximately true for long boilers, but for short boilers of the marine type it was manifestly untrue. We then considered the case of a very short boiler, and saw that in such a case the strength of the shell, instead of being the sole consideration, was a small fraction that might be neglected, and the whole strength of boiler to resist rupture might be reckoned as that of the end plates. We then, by reference to the simplest and most elementary facts, showed that the distribution of strain on a given section did not depend on the form of the vessel of which the section was a part, but only on its area and pressure. From this we inferred that in two boilers of which the length of the one equalled the diameter of the other, as these would have a rectangular section equal in all respects to each other, the strain at any point in this rectangle would be precisely the same for both boilers. We then estimated the difference of thickness of shell plates prescribed by old and by new method, and found in three typical proportions of boilers that—

In one case the old rules require a thickness half greater than new theory.

In another case the old rules require a thickness twice as thick as new theory.

In a third case the old rules require a thickness three times as thick as new theory.

We then noted that if the new theory were correct, then our old theory had led us to commit, at least, two other serious errors. And finally, by an appeal to the best and most recent experiments on the strength of a boiler, we found that these experiments were inconsistent with the old theory, and agreed with great exactness with the new one.

LORD ARMSTRONG AND THE 110-TON GUN.

At an extraordinary general meeting of Sir W. G. Armstrong, Mitchell, and Co., held at Newcastle-on-Tyne, Lord Armstrong, who occupied the chair, after referring to a proposed increase by £200,000 in the capital of the company, commented upon the gross exaggerations which had recently been circulated condemnatory of one of the 110-ton guns of the Victoria battle-ship. That gun had undergone trials of extraordinary severity, in the course of which there had been fired from it no less than 10¼ tons of gunpowder and nearly 20 tons of projectiles. Under these tests of exceptional severity the gun had undergone a slight downward curvature, the small amount of which would be appreciated when he stated that in a length of 504in. the deviation from the original axis of the gun only amounted to about three-quarters of an inch. Every artillerist must know that, so far as the accuracy of the gun was concerned, an adjustment of the sights will correct a deviation of the bore, and so far as safety is concerned, he had no hesitation in saying that its security against bursting is wholly unaffected, nor had any attempt been made to prove that danger will result. Lord Armstrong went on to say that whether the use of monster guns was a mistake or not was a fairly debatable question. The monster gun was incidental to the monster ironclad, and he had never advocated either the one or the other; but to say that the whole question was settled, or even materially affected by anything that had occurred in the case of the particular gun in question, was simply an absurdity. The chairman then proposed resolutions authorising the issue of the new capital. Mr. Charles Mitchell seconded the resolutions, and they were carried.

BOILER EXPLOSIONS.

Board of Trade Reports.

Report No. 338 deals with the explosion of a vertical boiler which occurred at Manor Farm, East Rudham, Norfolk, on the 10th April of this year, whereby two men were killed and two severely injured. The boiler was second-hand in 1877—12 years ago—and since that date it passed through several hands before reaching its present owners, and it was not insured or inspected by any competent persons. The explosion was caused by the collapse of the fire box, due to weakness occasioned by wasting. The plates, originally ⅜in. thick, were less than $\frac{3}{16}$in. in many places, and the working steam pressure, 70lb. per square inch, at which the safety valves were loaded, was too high for safety even with the full thickness of plate. This is another fatal explosion due to working under improper conditions and without inspection, which would have at once discovered the weakness.

Report No. 339 describes the explosion of a boiler on board the paddle trawler Tynedale, which occurred on the 13th of May, 1889, while the vessel was in the North Sea, three miles off Amble, and proceeding to take in tow the stranded screw liner Chancellor. No one was killed or injured. The boiler was of a common marine type, and the explosion was occasioned by the collapse of two furnaces for a length of 5ft., due to overheating, through the sea water being allowed to attain too great a density. The man in charge had no sufficient training to enable him to work the boiler safely.

Report No. 340 refers to the fatal explosion of a copper steam pipe at Deptford on the 9th of April, 1889, at the works of the London Electric Supply Corporation Limited, whereby one man was killed and ten injured. We have already dealt fully with this explosion in previous impressions.*

Report No. 341. This report deals with an explosion on board the steamship Auric, which occurred on the 15th April, 1889, while the vessel was lying in Abercorn Basin, Dublin. The boiler is of the ordinary marine multitubular type, is made of steel, and has been regularly inspected by the Engine, Boiler, and Employers' Liability Insurance Company. The occurrence can only be technically described as an explosion; it was really a joint of a manhole-door which blew out and allowed the contents of the boiler to escape into the engine-room. The door was too small for the manhole, and the door and ring were not placed in position with sufficient care. Unhappily one man was killed and another severely scalded.

Report No. 342 refers to a mild explosion of a steam boiler on board the steamship Talisman, which occurred while the vessel was on a passage from Strome Ferry to Stornaway, Scotland, on the 23rd February of this year. No one was killed or injured. A hole about 1in. diameter by ½in. was found in the combustion chamber bottom between a stay and the end of the starboard furnace, due to local wasting of the plate by leakage. The thinning of the plate should have been discovered in time to prevent the accident.

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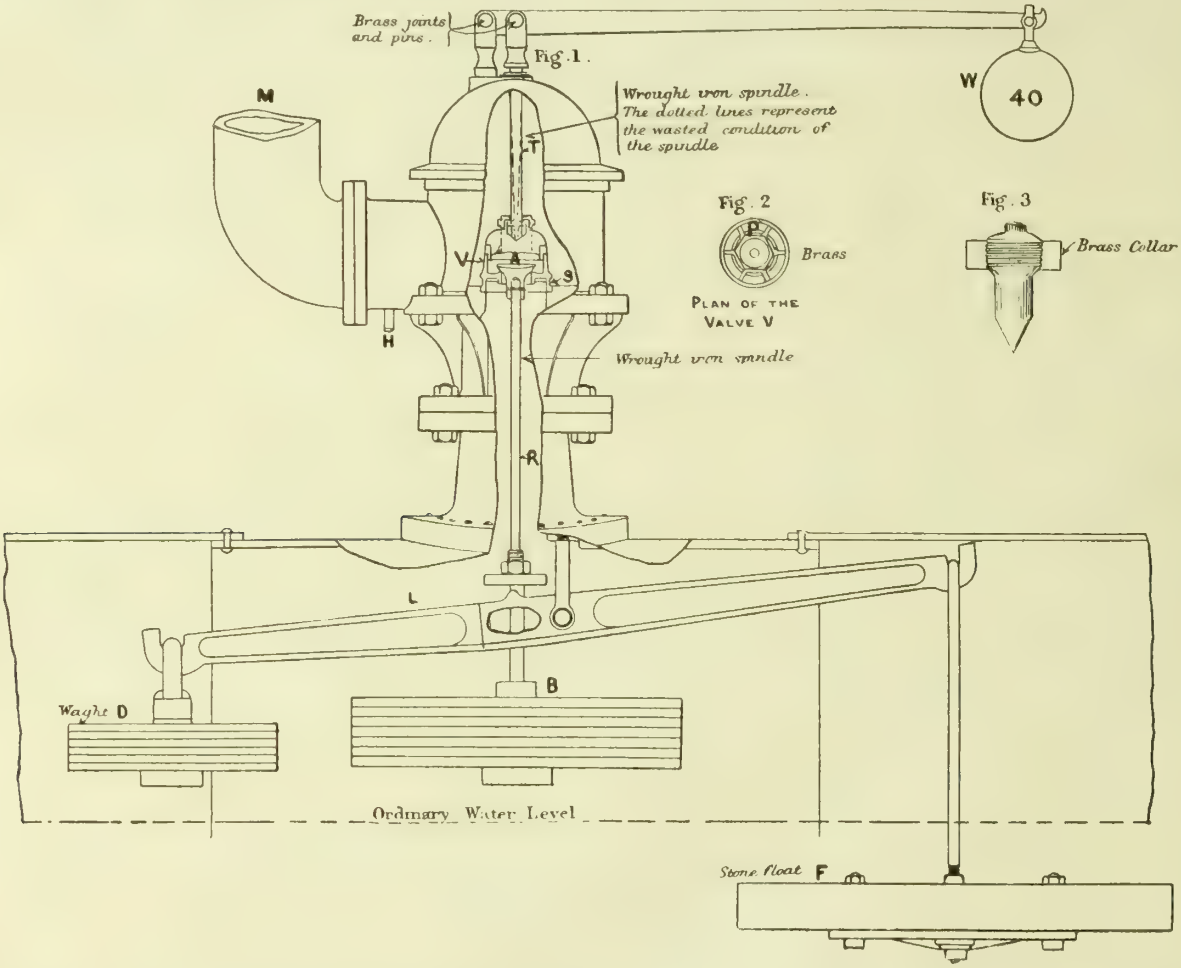
* See *Practical Engineer*, vol. iii., pp. 602, 620, and 636.

Report No. 343 describes the blowing out of a safety valve, which occurred at the Yare Roller Steam Flour Mills, on the 30th May of this year. The construction of the valve and its details are shown at figs. 1, 2, and 3 of the accompanying illustrations. It consists of two valves, the one being placed within the other, and both are enclosed within a cast-iron casing. The large valve V, fig. 1, rests on a brass seat S, let into the cast-iron chest. This seating is 4in. diameter in the base. The valve is loaded by means of the lever and weight as shown, the load, equal to a dead weight of about 770lb., being applied to the valve by means of the wrought-iron spindle T, which appears to have been originally ⅝in. diameter. The small valve A rests on a seating formed by a projection on the upper surface of the large valve. The bore of the seating is 2in. bare in diameter. This valve is loaded by cast-iron weights B, suspended by means of the wrought-iron spindle R, within the boiler. By a suitable adjustment of the stone float F and the weights D, this valve is caused to lift automatically in the event of the water within the boiler falling below the required working level. The escaping steam passes through the spaces P, fig. 2, in the cover of the large valve, into the valve chest, and thence up the waste pipe M, which is led upwards through the roof of the boiler-house; and any condensed water which may form in the valve chest is conducted away by means of the drain pipe H. The usual pressure at which the valve began to blow was said to be about 77lb., but the recognised working pressure of the boiler is stated to be 80lb. per square inch. In addition to the "Hopkinson's" safety valve, which forms the subject of this report, the boiler to which it is attached is provided with two open lever safety valves, besides the other usual mountings. The explosion was caused by the spindle T, which suddenly bent and broke, and the valve was blown from its seat. An aperture of over 12 square inches in area was left open, through which the steam and heated water rushed with terrific violence, but fortunately, in consequence of the valves being enclosed within the cast-iron chest, the issuing contents of the boiler passed up the waste pipe without causing further damage, and no one was injured. The spindle T had wasted until no longer capable of resisting the load acting on the valve. Those spindles should be protected against corrosion.



CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—Seeing that you have published my last letter, I should like to be allowed further to protest against a most objectionable point in connection with compounding locomotives in England. I allude to the absurd amount of puffing which the designers seem to think it necessary to bestow upon their latest engine for the time being.

Omitting what may be called "toys," the first of our present compounds was the North-Western experiment. Concerning this engine Mr. Webb said she could "run like a hare," and "pull 19 coaches at 50 miles an hour;" but in spite of this it soon transpired that she was unequal to even the North-Western work, and early in the following year another class of compound was produced, which was to be absolutely perfection. The success of this type was so marked that within eighteen months Mr. Webb, in despair, made one of the biggest plunges on record, and from being the apostle of light-weight engines, became the builder of the Dreadnoughts, which are amongst the heaviest six-wheeled express engines in existence.

After four years working, even Crewe admits that these latter have not "come up to expectations;" and now we have three further varieties in Teutonic, Oceanic, and that curious hybrid, Pacific.

Meanwhile we have had three types of compound tank engines, all of which, of course, were perfect, but which, strange to say, have not been repeated. Had the North-Western directors six years ago given the order of "one at a time, please," until they were really certain of the advantages of their system, they would, probably, have saved a good deal of money, and might by now have had engines worthy of the line.

Advocates of compounding say they are subjected to bitter criticism for leaving the beaten track, &c. Is it not, rather, their own fault?

When one of their engines is coming out, we are pretty sure to hear of the marvellous things it has done on trial trips, and how it is going to drive the simple engine off the face of the earth; but when really put into work their productions invariably leave matters much about where they were, and surely they have only themselves to blame if a rude remark is occasionally made on their failure to do what was promised. Mr. Worsdell built some compounds on the Great Eastern, but since he left that line the directors have not seen fit to continue his action, which does not look as if they were quite convinced of its advantages. On going to the North-Eastern, he built a six-wheeled engine (1324), about which the most unmitigated nonsense was allowed to appear in the non-technical daily press—something to the effect that she had pulled 64 loaded coal trucks from Darlington to Penrith, over the Westmoreland hills, which was a manifest impossibility, and only made people more cautious about accepting builders' recommendations.

As was to be expected, however, 1324 was *not* perfect; so then Mr. Worsdell returned to the bogie in his 42 class. Still not satisfied, he built the 7ft. singles, 1327, &c., about which more nonsense was circulated; and now we have reached what I may call the Dreadnought period, and a wild plunge has been made, apparently in despair, resulting in the 1520 class of singles, the effect of whose weight on the North-Eastern road will be watched with interest by others besides the permanent way department.

Now, sir, the very fact that so many different types have been tried shows—as, of course, is only natural, considering that the subject is so new—that nothing like perfection has yet been reached; and the builders would earn more respect if they prevented the circulation of these rubbishy stories, which, after all, only remind one of the Yankee company promoter, and deceive no one. Mr. Worsdell has stated with pride that his compounds have given better results than similar non-compounds of the 96 class. He seems to me to misunderstand the situation. Probably, even our best engineers could build an engine to give worse results than a North-Eastern compound; but that is not the point. He has to beat the *best* single engines, not those he may build to be beaten, before he is entitled to declare himself triumphant.

As to the 1517 class, if their power is to be so enormous, no amount of sand blasts or other contrivances will prevent their single wheels slipping, so as to make the engine practically useless; whilst if they are to behave steadily they will not be stronger than most simple engines: but in their case, as in that of other compounds, the rule has been "advertise your greatness, for people may never find it out for themselves."

The South-Western, Great Western, and North British have all compounded in a mild way, but are dissatisfied with the result; and really it seems as if no one but the proprietors of the rival systems believe in them. England is in too great a hurry to be bothered with their complications. Had we trains of 75 trucks strolling along at 12 miles an hour, as we find, for instance, on the P.L.M., compounding would have a much better chance of gaining ground than it has under present conditions.

Trusting I have not exceeded your patience, I am, yours, &c.,
W. B. Thompson.

INDICATOR DIAGRAM PRACTICE.

To the Editor of "The Practical Engineer."

Sir,—The very patent defects in the card (or rather in the distribution as shown by the card) necessitated the making of new valves, for as the cut-off plates and their eccentrics were believed to be necessary, the openings at the back of the main slides were kept as they were, while the increased lap, 1⅜in., could not be made a good job by pinning on. Of course, this increased lap gave a new position of eccentric, and in this case also difficulties arose from the fact of the cut-off eccentric being the driver, with the main valve bolted through and driven from its mate. This, and the raising of the shaft, having been got over, a trial was made with comparatively good results, for it should be mentioned that the working of the engines was very bad—the knocking, especially at the bottom centres, being very heavy. But, while much improved, the knocking was not at first entirely stopped; the centres were turned smoothly enough, but a new shock took place on the up stroke, at a point when the leading crank was near the end, and when the following crank was about half way. Doubtless this always existed, but it was not so noticeable when the greater noise existed. I have mentioned the large unbalanced weight and resistance of the air pump on the up stroke. A little consideration and examination of the first cards at the point of shock showed that the force of propulsion was scarcely equal to the weight of the moving parts and the resistance of the air pump, and when the leading crank had just received the full effect of the entering steam a sharp acceleration took place, with the result already mentioned. After one or two trials of cutting a bit off the cut-off valves, I at last concluded to dispense with them altogether, and the result proved the nature of the defect by giving no shock or vibration whatever throughout the stroke. Card No. 1, new valve with cut-off; card No. 2, cut-off plates shortened; and card No. 3, as the engines are working now. So far there is no loss of coal; in fact, it is rather the other way. Doubtless it may be said that it was a retrograde movement to dispense with the cut-off valves, but it was to be borne in mind that the cylinders are unclothed and unjacketed, and the increased gain of vacuum due to the earlier release, and doubtless less internal condensation, not to mention the smoothness of working, were sufficient reasons. Meantime, the facts of a good card (No. 2) and a bad working engine are not incompatible, while No. 3, although homely and old fashioned, seems to have its place and function in a wretchedly designed tool, by an eminent firm, too—an attempt, indeed, to make a silk purse out of a sow's ear.—Yours, &c.,
Cast Iron.

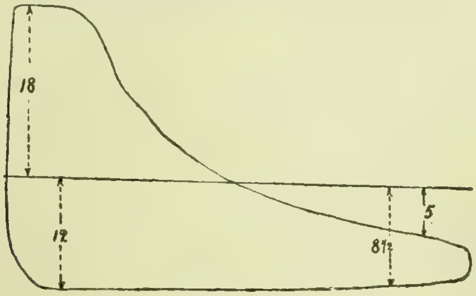


Fig. I.

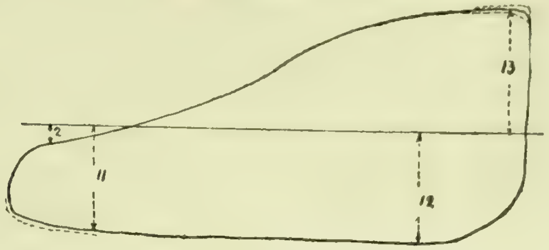


Fig. 2.

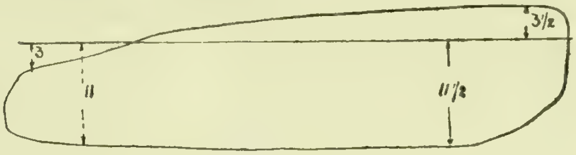


Fig. 3.

BOILER INCRUSTATION.

To the Editor of "The Practical Engineer."

Sir,—Could any of your readers help me out of a slight difficulty, viz.: I have a Cornish boiler driving an engine, with an average pressure of 55lb. per square inch. The feed water is drawn from a well, and is so impregnated with lime, that the glass water gauge continually becomes choked, and appears white within the tube?

I have given a patent non-depositing mixture a trial, and it certainly prevents the adhesion of the lime to the inside of the boiler. Can I get rid of this pest before it enters, or what is the cause of it being so densely impregnated? The well is in a good situation, sunk in clay and gravel.—Trusting I am not occupying too much space of your valuable paper, I am, yours, &c.,
In Trouble.

QUERIES AND REPLIES.

117. Driving Ropes for Engines.—Would some of your readers be good enough to inform me what size of ropes, and how many, would be required for an engine 500 horse power? also what would be about the price of such an engine.—Improver.

Answer.—Ropes are required to work under such varied conditions, that anyone having a practical acquaintance of rope-driving may be pardoned for being somewhat diffident at answering questions with respect thereto, unless the fullest information is given. However, if "Improver" will provide an engine to travel at 4,000ft. per minute—avoid ropes over 5¼in. circumference; obtain pulleys not less than 36 times (40 is better) the diameter of the ropes; drive with the slack on the upper side, and see that the ropes are kept clear of iron filings and other obstructions—he will have ample power with fifteen ropes of the size mentioned above. Of course, I am assuming that "Improver" intends to use cotton ropes. In our Oldham mills, fitted up with ropes by Messrs. Jas. Knott and Co., much better results than these are obtained, so that "Improver" need not doubt that he will be on the right side.—Practical.

127. Distilled Water.—I require 20 gallons of distilled water in 10 hours. I propose to obtain this by means of a coil in a cylinder 1ft. 6in. diameter, and 4ft. high. Please show how I can find the size and length of coil to be used, and how much cold water must be admitted in cylinder. Pressure of steam in coil to be condensed, 40lb. Assistance with above will be greatly esteemed.—Doubtful.

Answer.—As "Doubtful" wishes to condense 20 gallons of water in 10 hours, he will require a coil 84in. long, and ½in. internal diameter = 1·7in. external circumference (a brass coil is assumed), which will be equal to about one square foot of cooling surface. The temperature of the circulating water at inlet should be about 54 deg., when the temperature at the outlet orifice will be about 66 deg. The diameter of condensing water pipe will depend upon the velocity of flow, and as you do not state how you propose to effect this, it is difficult to advise you, but perhaps the difference in temperatures above indicated will be a sufficient guide for you. The above particulars are deduced from experimental data, and may be relied on.—J. R.

128. COMPRESSION AND RELEASE IN ENGINES.—How is the required amount of compression in a steam engine determined, and at what part of the stroke should release commence? An answer will much oblige.—A BEGINNER.

Answer.—The compression is determined almost entirely by practical considerations, and usually begins at about $\frac{8}{10}$ths of the stroke. If there is a persistent knock on the connecting rod brasses a diagram will probably show too little compression. If there is a sharp knock on the valve at the end of stroke, there is probably too much compression. In the former case, the work of stopping the momentum of piston and rods is thrown on the brasses. In the latter case the pressure or compression exceeds the pressure on the back of the valve, and knocks it off its face, to return with a sharp clap. Release should begin as nearly as possible at the same part of the stroke as compression. Designing this beforehand requires allowance to be made for steam and exhaust lap, for lead, and for the expansion of the steam in cylinder.—C.

Answer.—The point at which compression commences is dependent upon the clearance volume between the valve and the piston when at the end of the stroke (c), the initial pressure of the steam in the cylinder (P), and the pressure of the exhaust steam (p); the ratio of compression (R) should be so arranged that p is increased by compression to P, or thereabouts ; hence $R = \frac{P}{p}$. Consider an example, where c = 3in. of the stroke, P = 60lb., p = 20lb. per square inch ; then $R = \frac{60}{20} = 3$, or the total volume of steam in the cylinder and ports when the valve closes must be three times c, or $3 \times 3 = 9$in. of the stroke; and subtracting c from this, we have $9 - 3 = 6$in., the distance of the piston from the end of the stroke at the commencement of compression. If the valve is set correctly for compression, release will generally be right also, except where c is excessive, in which case release is too late, and a less valve must be taken for R to improve the release. Expressing the above in the form of a rule, we have: Point of compression from

$$\text{end of stroke} = \frac{\text{clearance} \times \text{initial pressure}}{\text{exhaust pressure}} - \text{clearance.}$$

ORION.

131. CHANGING PULLEYS ON CRANK SHAFT.—I have a steam engine with a 4ft. 6in. driving pulley, running to a 3ft. 6in. pulley on the main shaft, and the engine making 150 revolutions per minute. Would it be any advantage to replace the 4ft. 6in. driving pulley by a 6ft. pulley, and reduce the speed of engine to 110 revolutions per minute? What difference would the above alteration make in the economy of engine? Information will oblige.—VULCAN.

Answer.—Before making any change of pulleys, the engine should be indicated. If the diagram is good and the engine runs quietly, a change of speed will probably be disadvantageous. Over 400ft. per minute of piston speed is not unusual in modern engines, and a well-proportioned engine, if designed to run at 150 revolutions, will run with less economy at a lower speed. This the diagrams should show before making any alteration.—C.

133. SMALL ENGINE CASTINGS.—Could any of your readers kindly inform me of the best and cheapest form of engine for driving a 5in. centre lathe, and where I could buy castings?—F. J. H.

Answer.—If "F. J. H." writes either to Mills, model steam engineer, Tintern Street, Sunderland, or Bateman, model engineer, High Holborn, London, stating his requirements, they will no doubt forward him catalogues giving full particulars of castings such as he asks for.—ORION.

136. FORCED DRAUGHT.—Will any reader kindly state if the above can be applied to a Lancashire boiler, with advantage, where there is insufficient natural draught, which causes large quantities of soot to accumulate in the flues? Also the best form of the above?—PROSPECT.

Answer.—In carefully considering the advantages to be derived from the use of forced draught, "Prospect" should first ascertain whether his natural draught arrangements are as satisfactory as they might be; and it is found in practice impossible to obtain satisfactory combustion in furnaces arranged so that the whole air supply is drawn up through the fires from the ashpit, but that a collective area of about 5 per cent of the open space between the bars should be allowed for the admission of air direct to the gases, and this area should be made up of holes not greater than $\frac{3}{4}$in. diameter, spread over the furnace fronts, doors, and, if possible, at the bottom of the back bridge. If this is carefully attended to, it may be found that the same rate of evaporation can be obtained with 10 per cent reduction in coal consumption over the boiler arranged for taking all the air through the fire, and, furthermore, the smoke will be reduced both in intensity and duration fully 50 per cent. Assuming, on the other hand, that "Prospect's" boiler is all that can be desired in this way, then he will find it advantageous to use a moderate forced draught, say about equal to half an inch of water column, which should give a rate of combustion of about 40 pounds of coal per square foot of grate area, and I should say some sort of blower such as Koiting's patent would be all "Prospect" would require. FURNACE.

Answer.—Forced draught is sometimes applied with advantage to Lancashire and other boilers. Occasionally a steam jet is used; but perhaps the best method is to have an air-tight fire-door, and to blow air in by a fan or other suitable blower, under a pressure of about half an inch of water. This gives good results.—C.

140. COMPUTING POWER OF COMPOUND ENGINES.—(1) I wish to know how to compute the lift and I.H.P. approximate of compound and triple-expansion pumping engines, and ordinary marine or land engines, having given diameter of cylinders, stroke, piston speed, and steam pressure at H.P. cylinder. I have seen it computed by ascertaining the ratio between H.P. and L.P. cylinders, and by that means finding, from steam expansion table, what the mean pressure of steam would be on pistons; but I do not know exactly how to find this ratio, and, having found it, to ascertain (by steam expansion table) what portion of stroke this is equivalent to cutting off at. (2) What usually determines the relative sizes of steam cylinders in compounds—I mean what ratio do they usually have one to another?—DRAUGHTSMAN.

Answer.—It is not necessary to know the proportional sizes of the cylinders, as the calculation is based on the diameter of the low-pressure cylinder alone. Given the pressure of steam which enters the engines, and the pressure which leaves them, we get the ratio of expansion; and the average pressure may then be found by an expansion table. With either condensing or non-condensing engines the pressure of the atmosphere must be included. 2. The diameter of the low-pressure cylinder is usually made double that of the high-pressure one, and varies from this only within narrow limits. When made exactly double, then a ratio of expansion of 8, as determined by the foregoing method, would mean a cut-off of one-fourth in the high-pressure cylinder. C.

142. IMPACT ON BEAM.—A beam will safely carry a stationary load of five tons with a deflection of two inches. From what height may a weight 200lb. be let drop upon the same beam without deflecting it to a greater extent?—STUDENT.

Answer.—The work done by the falling weight must be equal to the work done by the 5 tons in deflecting the beam. If the 5 tons be gradually applied to the beam, the load would commence at 0, and finish with 5 tons, by which time the deflection would be 2in.; therefore the mean force exerted throughout the 2in. would be $\frac{0 + 5}{2} = 2\frac{1}{2}$ tons ; $\therefore$ work done in deflecting the beam $= 2\frac{1}{2} \times 2240 \times \frac{2}{12}$ ft. lbs. The ft. lbs. of work stored up in a raised weight = weight in lbs. × height raised in feet.

$$\therefore \text{height} \times 200 = 2\frac{1}{2} \times 2240 \times \frac{2}{12}$$

$$\text{height} = \frac{5 \times 2240 \times 2}{2 \times 12 \times 200} = 4\tfrac{2}{3}\text{ft. above joint B.}$$

J.

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134. LIQUID FUEL.—I am told the Great Eastern Railway runs some of their trains with locomotives burning tar and oil, &c., for fuel Can any of your correspondents give me particulars of the burner or sprayer used, and say if it is applicable to ordinary vertical boilers? How do you start the fire, and what about standing? does the fire go out, as I presume, if the burner keeps at work, too much steam would be made? What do they do about draught? Any particulars would be very acceptable.—W. E. D.

138. SOLID-DRAWN TUBE.—I wish to make a number of lengths of solid-drawn copper tube $\frac{1}{2}$in. internal diameter and $\frac{7}{8}$in. external. I shall feel obliged if anyone will give a description of the necessary tools.—L. M.

141. POWER OF HOISTING BLOCK.—It is found by trial that when P is on the point of lifting W by means of a single fixed pulley, $P = (1 + m) W$, where m is a fraction depending on the friction of the parts of the machine. If three such pulleys are combined into a "block and tackle," find the power requisite to raise a given weight by means of it.—STUDENT.

143. CONSUMPTION OF FUEL.—Will any reader kindly supply me with the following information, taken from the most modern practice of our principal engine builders? 1. What is the consumption of coal per I.H.P. for (*a*) ordinary high-pressure steam engines working expansively; (*b*) ditto condensing; (*c*) ditto compound non-condensing; (*d*) ditto compound condensing; (*e*) ditto triple-expansion non-condensing; (*f*) ditto triple-expansion condensing. 2. What difference does steam jacketing make in coal consumption? 3. Is there any material difference in the consumption of coal per I.H.P. shown by engine, in multitubular, Lancashire, and Cornish boilers? Any information relative to the above, also *re* consumption of coal per I.H.P. for direct-acting steam pumps, such as Worthington type, will be esteemed by—F. J.

144. CURVATURE OF RIM OF PULLEY.—How do you find the proper curvature to give to the rim of pulley? Does it simply depend on the width of the belt, or does it also depend on the thickness of belt, speed of belt, and diameter of pulley? A leather belt, about $\frac{1}{4}$in. thick, is to travel at about 3,000ft. per minute over a 27in. pulley of 8in. face. What should be the difference between the diameter of pulley at the centre of the rim and at the edge?—RAW HIDE.

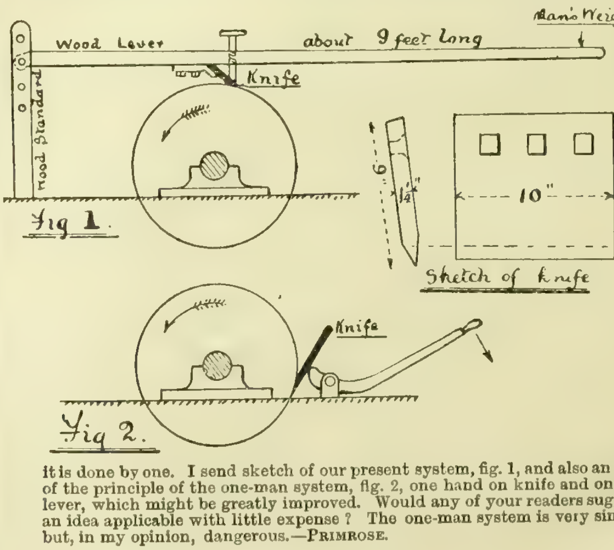
145. THICKNESS OF CAST-IRON PIPE AND PROPORTION OF ENGINE CYLINDERS.—Would any engineer inform me the thickness of cast iron for 8in. diameter steam pipes to be safe from bursting with 80lb. of steam per square inch in the boiler, and what diameter of cylinders would you recommend to work compound side by side? Corliss high-pressure cylinder, short slide valve for low-pressure cylinder, to drive 200 I.H.P., 44 turns per minute, 4ft. 6in. stroke, 80lb. of steam in boiler per square inch. Information will oblige.—J. C.

146. RETURNING CONDENSED WATER FROM STEAM JACKET TO BOILER. What is the best means of returning the condensed steam from the steam jacket of a cylinder to the boiler when the level of the engine cylinder is below the water level of boiler?—ECONOMY.

147. EXHAUST STEAM INJECTOR.—Will any reader kindly inform me if the above could be applied to a condensing engine, or would it interfere with the vacuum? I believe they require very little steam to work them. A. S.

148. AUTOMATIC VACUUM BRAKE.—Can any reader inform me the reason why, when the brake is applied from the engine, it always takes hold of the last carriage first? It always seems strange to me why it should do, and I shall be extremely obliged for any information on the subject.—W. G.

149. GRINDING STEEL KNIVES.—In our establishment we use steel knives, bolted on to a metal pulley, for chopping rope, &c. They have to go through the process of grinding twice a week, which takes two men, one at the end of the lever, and one to stand by the knife; in some mills similar it is done by one. I send sketch of our present system, fig. 1, and also an idea of the principle of the one-man system, fig. 2, one hand on knife and one on lever, which might be greatly improved. Would any of your readers suggest an idea applicable with little expense? The one-man system is very simple but, in my opinion, dangerous.—PRIMROSE.



PATENTS AND INVENTORS' QUERIES.

30. Devices for Raising and Lowering Vertical Spindle.—In a provisional specification I have lodged I describe two methods of raising and lowering a vertical spindle, and in practice both give the desired effect. I only require one method, and wish to know if in my final specification I must describe definitely one form or the other, or can I describe and claim both forms. I enclose sketch.—Alma, Coventry.

Answer.—If the combinations in which both forms occur are novel, then you can describe and claim both forms in the respective combinations. In your final specification you may describe much which is not novel if it assists in giving a clear idea of the practical working out of your invention, but you can only claim, of course, those portions which are novel. The methods of lowering and raising, of which you send sketches, are very neat and effective. Your safest course is to describe both, and claim them in your new combinations.

31. Royalties in Licenses.—What are the usual terms for granting licenses to work a patent ?—C. M. B., Northwich, Cheshire.

Answer.—The terms vary as much as the inventions. Royalties vary from 5 to 20 per cent on the sale price. Send particulars of your invention, and we can advise you definitely.

32. New Cut-off Gear.—I have designed a new form of triple cut-off gear. Is there any commercial field for an invention of this kind ?—L. N. Leicester.

Answer.—Send sketches and description of your invention, and we shall advise you.

33. Patent Opposition.—I have reason to believe that a firm have patented an invention communicated by me to them in confidence. Can I oppose the patent in any way ?—H. W., Newcastle-on-Tyne.

Answer.—You can oppose the granting of the patent at the proper time, either personally or through an agent. The proof of your ownership of the invention must be very complete. It is extremely foolish to communicate inventions to firms without first obtaining provisional protection. The cost is very low now.

34. New Pendulum.—I have invented a compensating pendulum, and, knowing nothing of patent laws, want advice. Would it be best for me to put it before a patent agent for advice as to the utility of the invention, cost, &c. ?—Onward.

Answer.—Send us full details, with your name and address. We shal advise you on all points.

TO CORRESPONDENTS.

Economy, Heaton Norris.—We thank you for your appreciative remarks on our leader, "Steam Jacketing." Your query is duly inserted.

Gossamer, Sheerness.—Rose's "Complete Practical Machinist" is a fairly good work, but it is quite natural that experienced machinists should shake their heads over some of it, as you state. No two machinists are quite agreed upon the best methods, and it is not wonderful that they should not agree with another's experience as given in book form. Cast iron, if closely grained, will take a surface equal to wrought iron, with water to a finishing cut, with a slow speed. Porous cast iron will not do this.

Lelgae, Bury.—Mr. Edison stated that 90 per cent of the heat energy of coal could be converted into electricity experimentally, not practically. This has been known for a long period. It is done by consuming carbon in a battery containing fused nitre as the active liquid at a high red heat, and two plates are immersed in this molten nitre ; one is carbon, the other platinum. A current is then produced by the consumption of the carbon plate. The method is quite impracticable, and Mr. Edison is quite out of his reckoning on that subject. There is no immediate possibility of rivalry to steam from electric power.

J. H., Greenpits, Ross.—The fire box of which you enclosed sketch is known as the "reticulated and perforated fire bar," and is made by Messrs. Clarke and Co., Forest Road, Nottingham, and costs, we believe, about 15s. per cwt.

W. F., Stoke-on-Trent.—"A Course on the Stresses in Bridges and Roof Trusses, Arched Ribs, and Suspension Bridges," by Professor W. H. Burr, price 15s., is published by Messrs. John Wiley and Sons, Astor Place, New York.

MISCELLANEA.

The firm of Krupp, Essen, Germany, has been given an order for 10,000 tons steel rails for the Tehuantepec Railway in Mexico. Another Mexican railway company is negotiating in Germany for the whole iron and steel material required for the building of the line from Minatitlan to Salina Cruz.

The sales of the Westinghouse engines in America for October, 1889, up to and including October 21, were as follow : Juniors, 30 engines, 935 horse power ; Standards, 16 engines, 645 horse power ; compounds, 30 engines, 2,510 horse power ; total, 76 engines of 4,090 horse power.

The new Hawarden Bridge over the Dee, connecting the Manchester, Sheffield, and Lincolnshire Railway with North and South Wales, was tested on Friday, November 15, by Major-General Hutchinson, in the presence of Sir Edward Watkin. Four engines were driven across the bridge, which was also rotated with success.

Ironworks in Mexico.—The *Boston Herald* has a city of Mexico special saying that preparations are going actively forward for consolidating, under one strong company, all the ironworks in the southern part of that country, and a powerful organisation, known as the Mexican Company of London, has concluded arrangements with owners of mines and ironworks and Mr. Richard Povey, of that city, for taking all their properties. Several million dollars will be invested in adding to the existing plant, and in addition a large and costly steel-making plant will be set up.

Smokeless Coal in China.—We hear from Tientsin that large quantities of hard smokeless coal have recently come down from the Sheh Men mines, near Shan-hai Kuan, owned and developed by a native company calling themselves the Sheh Men Anthracite Coal Company. These coals are now stored on the Bund, on the premises formerly occupied by the Chinese Engineering and Mining Company. The price of the coal is Tls. 6·70 per ton for the medium quality, which can be used for household purposes, and Tls. 7·70 per ton for smelting purposes. The proprietors claim that this coal has double the burning power of ordinary coal.

Lord Salisbury, Electrician.—Many may have been surprised to read that the Prime Minister was figuring among the electrical engineers the other evening, and as one of them. It is not so generally known as it ought to be that the Marquis of Salisbury, as Sir William Thompson expressed it, is "a scientific electrician and an electrical engineer." But such is the case, and the extremely interesting and able speech which his lordship made on the subject at the Criterion Restaurant is by no means the first proof of it. Lord Salisbury has been a student of science and a practical worker in scientific pursuits from his youth up.

Patent Case.—The appeal of Haythornthwaite against the decision of the Comptroller refusing to grant him letters patent for an alleged invention of an alarm valve for use with the automatic sprinkler as a protection against fire in mills, warehouses, and other large buildings, on the ground that his valve was identical with that already patented by James O. Jackson and Norman Macbeth, of Bolton, was heard before the Solicitor-general (Sir Edward Clarke), and dismissed with costs, he holding that the two valves were identical, and that Haythornthwaite's alleged invention contained no points of novelty not shown and described in the specification of Jackson and Macbeth's patent.

A Novel Casting.—A curious and noteworthy specimen of expert foundry work has been recently executed. It consists of three plates of cast iron about one-fourth of an inch thick and seven by five inches in surface, covered with writing indented in the iron. This specimen of skilled workmanship was done by John Farrar, foreman at an American foundry, a life-long workman in an iron foundry. The impression on the iron is made by writing backwards on thin paper, pinning the paper in a mould, and then pouring on the iron. The writing thus transferred to the plates, when the iron is cooled, is wonderfully clear and distinct, and is so deeply imprinted as to defy any attempt at erasure.

Magnolia Metal Bearings.—Robert H. Smith, Professor of Mechanics in Mason College, Birmingham, England, has made a series of mechanical tests relative to the durability, friction, and temperature of bearings made of magnolia anti-friction metal when running in bearings on journals of different diameters and lengths. In all, between three and four thousand tests were made, in which the temperature of the bearings and the friction were actually determined. In his conclusion he states the metal to be superior either to Babbitt or gun metal for bearings. The results of the experiments show that the temperature of the bearing and friction was less, and durability of the material considerably greater, than the other materials tried.

Among the the noble metals, or metals of the gold group, palladium is not the least remarkable for the difficulties that have been in the way of getting a perfect determination of its atomic weight. Since Wollaston's discovery of the metal, 86 years ago (he called it palladium because he discovered it just after the planet Pallas was discovered), divers attempts have been made to determine its atomic weight, with varying results. The value obtained by Berzilius's second analysis in 1828 is that given in the books. The elaborate experiments lately conducted by Dr. Keiser, and now explained in the *American Chemical Journal*, result in establishing for palladium an atomic weight almost identical with that obtained from Berzilius's results. Instead of 106·2, Dr. Keiser finds 106·35. Palladium, as the reader may know, has been much used by dentists, the reason being that it does not lose its fine white colour on exposure to sulphuretted hydrogen.

Lord Salisbury's Electrical Contrivances.—It was not said at the Institution of Electrical Engineers, but it is true, nevertheless, that nowhere is the application of electricity to the ordinary uses of life to be seen on a more interesting and extensive scale than at Hatfield House, the seat of Lord Salisbury. The electricity, generated by means of turbines in the river Lea, is transmitted to the house and over the estate for real work's sake. Pumps, ice-making machinery, and an air-propeller fixed in the roof for ventilation, are all driven by the motors at the house. The motors are also used for elevating hay and corn sheaves to the top of the stacks at the farm, for thrashing, grass-cutting, and for cutting chaff for ensilage. His lordship's corn is ground and his fodder made by electricity. He drives piles by electricity, dredges the river, and pumps the town sewage. And it is all his lordship's own scheming.

Edinburgh International Exhibition of 1890.—It is understood that the Engineering Committee of the Edinburgh International Exhibition of 1890 have addressed invitations to the principal locomotive builders of the United States to send a representative American express engine to the exhibition to be shown alongside British express engines of the most modern type, as every effort is to be made to obtain good international exhibits of railway rolling stock and appliances of various kinds. It is also stated that efforts will be made to have one or more American engines tried in actual work in running the trains between Edinburgh and King's Cross, Euston Square, and St. Pancras. As both the Caledonian and North British Railways, which work in connection with the great English lines, will have sidings into the exhibition, every facility will appear to exist for the competition, which, if it can be brought about, will be followed with the most intense interest by railway men on both sides of the Atlantic.

Bridge Across the Hudson River.—It is suggested that instead of wasting its money on a weak imitation of the Eiffel Tower, as an attraction for the proposed exhibition, New York should build a bridge across the Hudson River, and endeavour to make it still more imposing than the Forth cantilever. The proposal is sensible, and such a bridge ought to be constructed, but the work could not be completed, even by the Americans, in time for the exhibition. The engineer's task would be quite as formidable as that which had to be performed in throwing the structure across the Forth. The connection of New York with the New Jersey shore would be a great achievement for the railways, and especially for the Pennsylvania Central Company. At present all goods trains for the routes on the Jersey side have to be ferried over on great steamers, and passengers also have to cross by steamer. A serious sacrifice of time is thus entailed. Since the construction of the Brooklyn Bridge the connection with Long Island has been enormously improved.

Manchester Steam Users' Association.—The annual report of the Committee of Management of this association has been published. The committee state that in presenting the annual statement of accounts for the year they are pleased to report an increase in the amount received for ordinary subscriptions; the total exceeded that of any previous year, and attained the sum of £9,440. The amount received for special fees was slightly below that of the preceding year, whilst the number of members, number of works, and number of boilers remain practically the same as in 1887. This result is regarded with satisfaction, considering the increasing number of joint-stock boiler insurance companies that exist, and with which, to a certain extent, this association has to compete in extending its membership. The net result of the year's working gives a surplus of £371, which has been added to the reserve fund. As in previous reports, so in this, the committee have the satisfaction to state that during the past year no explosion arose from any boiler under the association's inspection.

A New Automatic Block System.—An automatic block system, designed especially for use on single-track roads, has been invented by T. D. Williams and J. S. Lacock, of Pittsburgh, and is now in use experimentally on the track of the Pittsburgh and Western in Allegheny City. Semaphore signals, actuated by electricity, are erected on both sides of the track, one set being for trains in one direction and the other for use in running the opposite way. A battery is carried on the engine, and the current is conducted to the signals through contact pieces laid upon the sleepers at the end of each block. The connections from end to end of block sections are made by line wire either on poles or underground, but are so arranged that a train entering a block will not only set the signal behind it at danger, but will also throw to danger the signal on the other side of the track at the further end of the section, thus protecting itself against butting collisions as well as against rear. The distinctive feature of this system is the employment of polarised relays, by which but one wire is necessary for each set of signals, the equipment for a single-track line with signals on both sides thus requiring only two wires over any part of the road.

The Northern District Telephone Company's System. In a paper entitled "Electrical Notes of a Trans-Atlantic Trip," read before the American Institute of Electrical Engineers, on the 15th ult., Mr. Thomas Lockwood, of New York, said: Long-line telephone work in Great Britain is of course limited by the size of the island and by the peculiar relative position of large towns. I found very good talking between Birmingham and the several towns of Sheffield, Derby, and Nottingham, between Glasgow and Edinburgh and Dundee, and especially fine from Sunderland to points upwards of a hundred miles distant. . . . . The best working long lines which I found were without doubt those belonging to the Northern District Telephone Company. This company is in charge of Mr. C. B. Clay, of Sunderland, the lines are new, and are built of the latest model. . . . The telephone companies had much house-top construction, but the same system of staying prevailed, so that the construction was superb, even though the roofs were all of the pitched variety. In Sunderland only, and the other towns where the Northern District Telephone Company holds sway, are to be found long cross-arms *a l'Americaine*, the idea having been imported by Mr. Clay, who visited the United States a year or two ago, and who is a manager of the most progressive type.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

October 28th.

16976 Safety Bolts, J. Blackburn, Manchester.
16979 Steel Ingots, T. Doughty, Glasgow.
16980 Greenhouse Boilers, H. Jayes, Leicester.
16981 Purifying Water, A. Green, Hollinwood.
16986 Generation of Steam, W. A. Thoms, Alyth, Scotland.
16997 Air Pumps, A. Légé C. A. Remané, and A. T. Job, London.
17008 Motor Engines, H. Haedicke, London.
17018 Vacuum Pans, W. K. Bruce, London.
17023 Valve-operating Mechanism, A. J. Boult, London. (A. Gretschaninoff, Russia.)
17024 Petroleum Motors, A. J. Boult, London. (M. M. Rotten, Germany.)
17034 Hydraulic Riveting Machines, C. A. Piat, London.

October 29th.

17038 Tanks, W. Devoll, Erdington.
17044 Steam Expansion, W. W. Girdwood, London.
17050 Gas Valves, H. Barlow-Massicks and W. Crooke, Manchester.
17065 Moulds, F. D. Taylor, London.*
17067 Wood Screws, C. D. Rogers, London.*
17071 Piston Valves, J. Thom, Liverpool.
17072 Steam Generators, J. Thom, Liverpool.
17077 Steam Boilers, C. Gorton, London.*
17084 Generating Heat, V. W. Blanchard, London.*
17085 Steam Engines, V. W. Blanchard, London.*
17091 Coupling, S. Hayward, London.
17093 Packing Rods, J. Smith, London.
17101 Motive-power Generators, E. W. de Rusett, London.
17106 Steam Hammers, J. A. Facer, London.*
17133 Hooks, A. G. Lower, London.
17135 Valves, J. Wheelock, London.*
17136 Condensing Engine, F. C. Simpson, F. Strickland, and G. Kingdon.

October 30th.

17148 Moulding Cylinders, M. E. Gallon and T. Maxwell, Gateshead-on-Tyne
17152 Furnaces, E. Collinge, Manchester.
17158 Indicators, J. Murrie, Glasgow.
17163 Lubricants, W. Brinck, Manchester.
17167 Moulds, J. Breeden and Co. Limited and F. Breeden, Birmingham.
17169 Bricks, E. Palmer, Sheffield.
17196 Couplings, J. B, Schöner, London.
17199 Saws, D. P. A. Mersing, London.*
17214 Pipe Unions, R. Stange, A. Klinkig, and G. Schilling, London.*
17216 Covers for Manholes, B. Haigh, London.

October 31st.

17231 Lubricators, S. O'Neill, Manchester.
17232 Mineral Oils, N. M. Henderson, Glasgow.
17234 Printing Presses, R. Galland-Mason, Douglas, Isle of Man.
17257 Gas Producers, G. Scott, Glasgow.
17262 Sluices, H. J. Haddan, London. (L. L. Le Breton, France.)
17269 Hydro-metallurgical Apparatus, W. D. Bohm, London.
17287 Steam Boilers, F. C. Winby, London.
17292 Gearing, L. A. E. Hèbert, London.
17295 Gas Motors, P. Niel and A. Janiot, London.*

November 1st.

17338 Flexible Shafts, T. Taylor, London.
17344 Motive-power Engines, R. M. Lowne, London.
17346 Furnace Bars, E. Prime and W. Lee, London.
17358 Steam Trap, W. A. Granger, London.
17369 Casting Metal Articles, W. S. Simpson, London.

November 2nd.

17377 Packing Rings, W. Jowett and G. Spencer, Manchester.*
17379 Removing Scale from Boilers, R. Elliott, Newcastle-on-Tyne.
17384 Wheels, C. Bramall, Sheffield.
17389 Injectors, G. A. Nussbaum, London.
17391 Valves, J. Edge and J. Edge, Liverpool.
17400 Gas Engines, W. E. Crist, London.
17412 Cylinders, W. Sumner, Manchester.
17413 Bearings, T. H. Wharton, Bradford, Yorkshire.
17414 Pincers, W. Hugh, Kent.
17418 Union Joints, R. Snook, London.

November 4th.

17448 Bending Machine, H. B. Tiltman, Hull.
17460 Steam Generators, W. W. Bastow and C. B. Casebourne, Stockton-on-Tees.
17474 Explosives, C. E. Rhodes and A. T. Cocking, Sheffield.
17480 Artificial Fuel, J. H. Wood, London.
17481 Governors, D. J. Murray, Glasgow.*
17483 Electric Rotary Brushes, W. S. Frost, London.
17487 Propellers, J. Haas, jun., London.
17504 Wheel Tires, J. Harrington and J. Hopper, London.
17505 Centrifugal Pump, J. Martinez-Ancira, London.*
17507 Motive-power Engines, T. McCarter and T. Cooper, London.
17516 Fire Extinguishers, C. M. Martin, London.*

November 5th.

17533 Cylinders, T. Norman and E. Coates, Sheffield.
17536 Metal Tubes, H. J. Allison, London. (The Spiral Weld Tube Company, United States.)
17538 Measuring Air, E. B. Badlam, London.*
17540 Propellers, B. Ray, Great Grimsby.
17545 Rotary Engines, G. W. Keep, London.
17554 Hoisting Apparatus, A. B. Brown, Glasgow.
17566 Coal-cutting Machinery, R. Armstrong, London.
17568 Steam Engines, C. Wells, London.
17569 Rivets, R. Miller, Glasgow.*
17572 Fasteners for Driving Belts, A. Tehnik and F. Vàvra, London.
17578 Lubricators, C. R. Winn, Birmingham.

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

NOVEMBER 29TH, 1889.

STEAM-ENGINE GOVERNORS.

The efficient control and regulation of the speed of a steam engine, while subject to variation of load and also steam pressure, is a problem which has occupied many of our most able engineers and inventors ever since the steam engine passed from the function of a mere pump to the dignity and general adaptability of a rotative prime mover. The centrifugal governor of Watt forms indeed the basis of most modern engine governors, but many attempts have been made to depart from that principle and break new ground, without, however, any very substantial success. To-day, accordingly, we find centrifugal governors practically master of the field, to the almost entire exclusion of other forms, just as in the early days of steam. Most forms—indeed we might say all, as there is only one exception—depend for their action upon change of speed in the engine, and in centrifugal governors this change causes an increase in centrifugal force, and the balls or weights move out until they assume a position in which the increased resistances balance the increased centrifugal force.

In the ordinary pendulum governor the increased resistance to change of position is furnished by the increasing action of gravity, due to the movement of the balls further from the centre of rotation, and the consequent assumption by the connecting links of a more horizontal position. The energy available in this way, however, for moving the throttle valve, or variable cut-off gear, is insufficient, and a very slight change in the tightness of the throttle-valve spindle packing or the connection to the cut-off gear gives rise to serious irregularities, as the change in speed requires to be great to give the necessary power to overcome the friction. To overcome this difficulty, and get a governor which will supply considerable power with a small change in engine speed, the loaded or Porter type was introduced, and consists of a pendulum governor, in which the sleeve is loaded with a central weight. The speed of rotation of the governor can thereby be considerably increased, and caused to rotate at many times the revolutions of the engines; and as the centrifugal force is proportional to the square of the velocity of rotation, it follows that a small change in the engine speed causes a considerably greater liberation of energy, and the governor has power enough to vary the valve action with slight change in engine speed.

Ordinary pendulum governors, whether loaded or simple, however, are not isochronous—that is, each succeeding position of the governor balls, as they extend, corresponds to an increased revolution. For every change in the position of the throttle or cut-off gear, therefore, the engine runs at a slightly different speed. By causing the balls to move in a parabolic path, immediately they begin to expand they move throughout their whole range, and the rate of rotation of the engine for every separate position of opening in that range is identical. Theoretically, therefore, such a governor should preserve an unvarying rate of revolution, subject to the practical consideration of friction, which can be reduced to a very small proportion. In practice, however, serious difficulties arise due to the phenomenon of "hunting" which is caused by the overrunning of the required position of the valve cut-off gear by the immediate action of the governor, resulting in the steam being almost entirely cut off whenever the speed is slightly exceeded, and similarly almost entirely opened again when the speed falls slightly. The regulation of steam, instead of being graduated and kept constant in throttle or cut-off for given loads, is constantly changing, now giving full steam and now none at all. This causes serious irregularities on the engine of a far greater extent than those due to want of a completely isochronous governor, and it is better to have a governor which is not entirely isochronous than one which is completely so.

Many attempts have been made to use governors which settle definitely in fixed positions for various fixed loads, and the necessary variation in engine speed is compensated for and brought within any desired limits by a series of very ingenious supplementary contrivances which are now extensively utilised in engines which require to run with the greatest possible uniformity, such as those driving spinning mills in Lancashire. One of the earliest of these compensating contrivances is, we believe, the Knowles supplementary governor as applied by Messrs. Hick, Hargreaves, and Co. to their Corliss engines. The main governor is of the loaded type, and is not isochronous; it consequently settles in a fixed position for every change of speed. Suppose it in such a position, with a speed of two revolutions per minute above the standard rate, it is evident the throttle valve must be more closed than when the engine ran at its normal speed. If, now, the rod or link connecting the governor sleeve and the valve could be shortened, say by turning round a right and left hand screw nut connecting two parts of it by the fingers, then the steam would be further cut off and the speed would fall slightly. By carefully turning this screw the throttle could be closed, so that the governor balls could resume their position at normal speed, and then the engine would be running again at its standard speed with the throttle closed to suit the lightened load. The Knowles supplementary governor performs automatically the operation we have described as being performed by hand, and it consists essentially of a second smaller high-speed governor actuating a sleeve of peculiar construction. This sleeve has friction collars bearing alternately against the top or bottom side of a disc, which actuates by driving cord and pulley a right and left handed nut on the valve rod. The faintest increase or diminution of speed brings into action one or other of the collars, and causes the disc to be rotated in one direction or the opposite, and so adjusts the throttle till it allows the main governor to assume nearly its normal position. When the engine makes a slight momentary increase in speed, the main governor at once sufficiently closes steam, but the speed is a little too high; the supplementary governor now acts, and finally adjusts the valve till the main governor reaches its normal position. In this way any change of speed is only momentary, and the engine is kept at a speed varying within any desired narrow limits from the standard.

Although we have referred to adjustment of the throttle valve for clearness of explanation, the same reasoning applies to variable cut-off gear. Other governor regulators act in the same way upon the connecting linkage between the governor sleeve and the steam valves, but dispense with the secondary governor. Wilby's governor regulator, for example, acts upon the rod or linkage by gearing, and is set in motion by the variation of the main governor only; it is also a most efficient regulator. Higginson's regulator has been recently described by us elsewhere, and it is most ingenious. It depends upon the principle of varying the central load upon the governor by means of an interesting mercury balance, which, with varying positions of governor, causes mercury to flow from one side to the other, and so increases or diminishes the effect of the central load or weight. In this way, without changing the relationship of governor sleeve to throttle or cut-off gear, the speed may be kept very nearly constant for varying positions of the sleeve. This is evident on a little consideration. Suppose a loaded governor to assume a certain position by increased speed: if the load could be diminished, the speed would at once fall; as the speed required to sustain the load in the new position is less, the smaller the load. This is another way of putting the fact that without a central load the governor will act to shut steam at a much lower speed than with it. The apparatus therefore diminishes load for regulating during increase, and increases load for regulating during decrease of speed from external causes acting upon the engine.

The many attempts which have been made to utilise other than centrifugal changes for governing are most interesting and instructive; but meantime we can only refer to a few of them. We inspected, some years ago, a beam engine at work in a large London brewery, which was controlled by means of an air compressing pump. The pump connected to the beam compressed air into a small chamber, from which it escaped at a regulated opening. If the engine ran too fast, the pressure increased in this chamber, as the opening did not allow discharge of all sent in without increase in pressure. This increased pressure was utilised to close the throttle valve by means of a piston and suitable linkage, when the engine slowed down; on the other hand, the weight or spring opposing the air piston tended to open the valve. The regulation was very fairly good, but the adjustment of the discharge opening was rather delicate.

Fan or screw blades acting in water, and raising and lowering a spindle against a spring, have also been used, as well as paddles and turbines, while even air escapements have worked fairly well. Marine governors of special kinds have been designed, which we may discuss in future, and the variation in the tension of a belt or resisting moment of a driving pulley has been adapted to indicate change of load and cut off steam.

THORNYCROFT'S WATER-TUBE BOILER.

Our readers will observe in another part of this impression an abstract of a paper on "Thornycroft's Water-tube Boiler for Marine Purposes," read at the Institution of Civil Engineers last week. We call special attention to it here because of the remarkable efficiency obtained by Professor Kennedy in tests made by him upon it. When working at its most economical rate it evaporated 13·41b. of water under standard conditions for every pound of coal, or gave an efficiency of no less than 86·8 per cent. A boiler in which 86·8 per cent of all the heat put upon the grate in the form of fuel utilised in raising steam is indeed remarkable, and were it not for Professor Kennedy's well-known care, and his thorough experience in testing, we should hardly have credited such an extraordinary result. We are not aware of any previous properly authenticated test giving such results. In this boiler many of the weaknesses inherent in the water-tube system have been got rid of; notably the tubes surround the fire so that radiation loss by brickwork is eliminated, while the difficulties of deposit, it is said, have been satisfactorily combated. We suppose, however, that feed make-up apparatus was used on board the vessels tested, so that the boilers cannot yet be supposed suitable for the hard bad water so commonly used by the Lancashire type. The test, however, indicates possibilities of improvement in the water tube type which seem to have been suspected by few, and this is borne out by a test, at which we recently assisted, of a new modified water-tube boiler in Manchester. The results were excellent, and would stand comparison with any given by the best Lancashire. We hope to publish them soon, together with a description of the boiler itself. Mr. Thornycroft's boiler is somewhat complicated, but great surface in small weight cannot be obtained without some multiplication of parts.

AN INTERESTING PATENT CASE.

The case of Otto v. Singer, upon which Mr. Justice Chitty gave judgment on Tuesday of last week, is one of vital interest to engineers or manufacturers who are actual or prospective licensees. The conditions of the case were somewhat peculiar. Mr. Otto obtained provisional protection for an improvement in the construction and arrangement of elastic rubber tires for bicycle or tricycle wheels, one of the features being the use of a hollow rubber tube internally supported by a corrugated wire coil or spring. This allowed the tube to be sprung over the wheel, and by the power of the spring the edges of the rubber were kept together, and the whole arrangement firmly held in position. Clips holding the tire to the wheel also formed part of the invention. When the final specification was filed and accepted, Mr. Hookham, of Birmingham, opposed the granting of the patent, on the ground that many and the most important parts were covered by an application of his own several months earlier than Mr. Otto. The comptroller accordingly ordered Otto's patent to be amended, and several parts struck out. The patent, as finally granted, therefore, differed considerably from the indications of the provisional specification.

Messrs. Singer, of Coventry, arranged with Mr. Otto to work under an exclusive license granted during the provisional stage, and upon Mr. Hookham's success in opposition they refused to pay under the license, on the ground that they were debarred from using the most important parts of the invention indicated in the provisional. Mr. Otto insisted upon the terms of the license being carried out, as his patent was valid, even if slightly restricted. Mr. Justice Chitty decided that, notwithstanding the amendment of the specification, the defendants were bound by the license, and gave judgment accordingly. This is undoubtedly the law in such cases, as is evident from many previous decisions, and it should act as a warning to engineers or manufacturers taking up inventions in the provisional stage, to make certain that they will be allowed to manufacture the article described in the provisional, at least in its essential details, otherwise they may find that a successful opposition so restricts the value of the patent as to make it practically of little use.

FATAL ACCIDENT WITH WATER GAS.

On Wednesday afternoon, of last week, a fatal accident occurred at the Leeds Forge, Leeds, by which two men lost their lives by water-gas poisoning. The men were discovered quite dead in a tool house, evidently from water-gas poisoning. We have often insisted upon the dangers of water gas, on account of the large volume of carbonic oxide contained in it. There is no reason why the gas should not be used in works with perfect safety when proper precautions are taken, and the men are alive to the dangers of the compound, but all using it should be most careful, especially as to absolutely free ventilation.

HYDRAULIC MACHINERY EMPLOYED IN THE CONCENTRATION AND TRANSMISSION OF POWER.—X.

Hydraulic Press and Hydraulic Weighing.

The baling press, mentioned in our last article, page 777, we illustrate in fig. 45, which represents the ordinary hydraulic press applied to a specific purpose, and having self-contained in its base the cistern and pumps for obtaining the necessary pressure. The first portion of the stroke necessary for baling is effected by means of the larger diameter pump, seeing that but little pressure is then required; and the final, or end portion of the stroke is obtained from the higher pressure or smaller diameter pump. Thus, in the present example, we assume two diameters for our pump plungers, the areas of which represent the differences to be obtained in working: The larger or low-pressure pump, we fix at $1\frac{1}{2}$in. diameter, and the smaller or high-pressure pump at $\frac{3}{4}$in. diameter; the areas being as the squares of the diameters, we obtain by this system one pump which will deliver water at four times the pressure of the other, and, of course, at a proportionately slow rate—that is, one-quarter the amount will be delivered in the same time by the small pump that would have been delivered had the larger pump been worked.

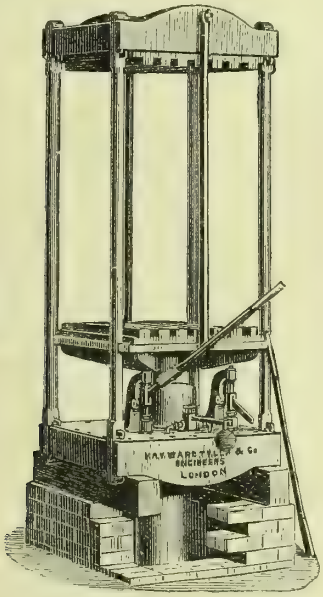


Fig. 45.

If length of the handle be 36in., and length of short end 2in., while the diameter of pressure ram is 12in., then—

Leverage gain on handle = $\frac{36}{2} = 18$.
Say pressure on handle = 50lb.
Area of $\frac{3}{4}$in. plunger = ·44in.
Pressure on plunger = $18 \times 50 = 900$lb.

$$\frac{900\text{lb.} \times \text{area of ram in ins.}}{\text{area of plunger}} = \text{pressure on ram.}$$

$$\text{Pressure on ram in lbs.} = \frac{900\text{lb.} \times 113\text{in.}}{\cdot 44} = 231136\text{lb.}$$

$$\frac{231136}{224} = 103 \text{ tons.}$$

Total power of pressure = say 100 tons net.

The conditions which we have given above give us the power we can actually obtain by hand-working upon a ram having a diameter of 12in. We will now determine the other dimensions which we require to construct the press itself, when the pressure supply is an independent one, and that it is, as stated on page 778, viz., 2,000lb., while the total power of the press is 100 tons.

We first decide that the head and base are to be of cast iron, also the ram cylinder, and table or platten; the columns or bars to be of wrought iron, and to be of circular form, attached to the head and base by means of a nut on each end. It is, then, clear that these four bars or columns must sustain the full power of 100 tons; therefore each bar must have an area of sufficient safety to sustain 25 tons. Thus—

Safe working load on bars = say 5 tons per square inch

$$\frac{25}{5} = 5\text{in. area of bar.}$$

$2\frac{5}{8}$in. dia. = 5·4in.
Dia. of bar = $2\frac{5}{8}$in.

The thickness of the cast-iron cylinder we take from our table, previously explained and set out in pages 159 and 160, *Practical Engineer*, March 8th, assuming that our test pressure is to be over 50 per cent above the working load, viz., $1\frac{1}{2}$ tons per square inch. We there find opposite the diameter 12in., and under the column $1\frac{1}{2}$ tons, the thickness given as 3in., so that our cylinder becomes $18\frac{1}{2}$in. diameter, allowing half an inch as the clearance between the cylinder and ram. The end of the ram is shouldered down to form a thrusting surface at the point of attachment to the platten; and the thickness of metal that may be adopted for the ram is one dependent more upon the quality of the particular metal to be employed than upon any point which we can determine by calculation, seeing that the water pressure outside the ram causes a compressive strain to be exerted upon it. For practical reasons of uniformity and density we make the metal $1\frac{1}{2}$in. thick. The strength of the head and base is to be determined by treating the webs or vertical ribs or walls as so many separate or independent beams, supported by the columns or pillars at each end. Similarly the platten or table is to be considered as a cantilever or bracket, supported at one end and loaded at the other, in order to assume the very worst condition that may possibly arise. The long pillars or columns are secured to the head and the base by means of nuts, as indicated in fig. 46, and the bearing part of the column is turned to fit the bored portion of the boxes upon the head and base.

The platten is sometimes guided up the bars of the press by having little brackets attached to it so as to partly embrace the bars; in other cases the corners of the platten plate are cut out to fit round them, while in many common cases there is no occasion to provide a guide, as no tendency exists to cause motion of any kind of the ram within the cylinder. The leather packing, as indicated, is of the ring U form, made in the manner described in our previous articles. The cylinder hangs loosely from the base, being simply supported by the bearing and by the shoulder formed at its upper part. Sometimes, in short-stroke presses, the cylinder and base are cast in one piece, but this practice is not to be recommended, owing to the trouble which often arises with the settling of the metal in casting. Treating the head and base as beams supported at each end, we adopt the well-known formula—

$$\frac{K\,B\,D^2}{L} = \text{breaking weight in tons of K}$$

B = breadth in inches
D = depth in inches
L = length between supports in feet
K = constant = 1 ton for a bar 1in. square and 1ft. long;

then $\frac{B\,D^2}{L}$ = breaking weight in tons of each rib.

Taking 5 to be the factor of safety, we can readily arrange the thickness and number of the ribs to suit the strain actually induced upon the material. We do not go into the details of this calculation, as it is purely an arithmetical one, and would take more space than we can afford to give for this one hydraulic appliance in view of the more important articles to follow.

HYDRAULIC WEIGHING MACHINE.

The principle of water acting upon a ram or piston is so definite and constant, that it has been applied most ingeniously by Mr. Duckham to suspended weighing machines. The application is one that has special advantages for crane or dock work, seeing that the amount of rough usage generally extended to such appliances is quite sufficient to damage any spring and to damage any lever or elaborate mechanism. The attention given to this class of machinery by the East Ferry Road Engineering Company Limited is such that their gauges or standards are absolutely accurate, and no case has, we believe, ever occurred of an error in marking.

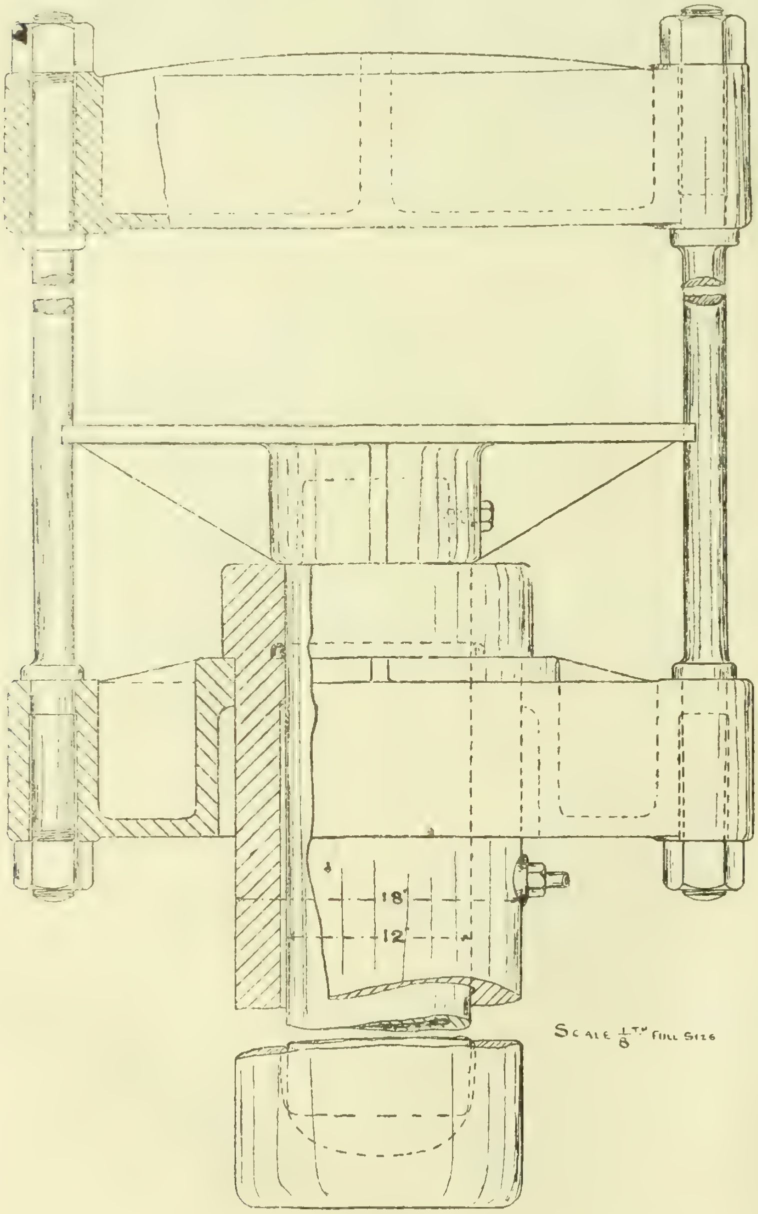


Fig. 46.

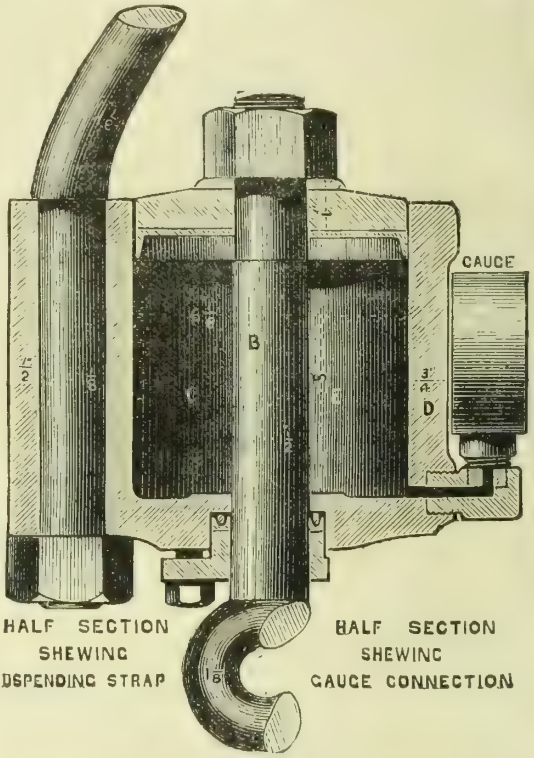


Fig. 47.

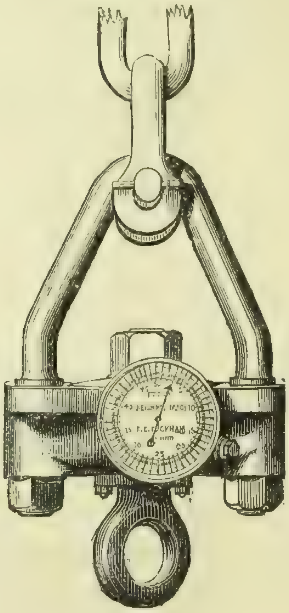


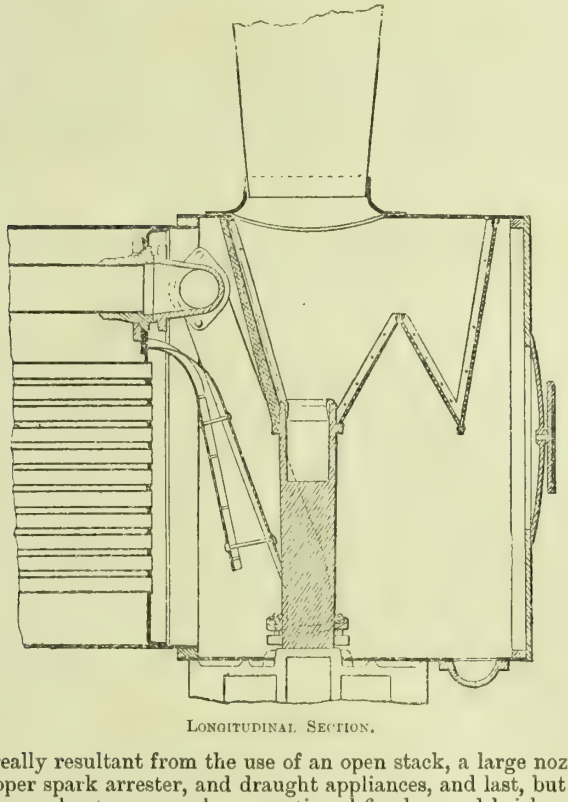
Fig. 48.

We illustrate the machine in figs. 47 and 48, the former being a sectional dimensioned view, and the latter an elevation showing it in actual position and ready for use. The construction of the machine we will now describe in detail. The cylinder is bored out perfectly true and lapped with emery to a fine dead polish, thus ensuring an absolutely smooth surface; the piston rod B, with its plates and leathers, are then fitted. A is the hanging strap, B the piston rod, D the cylinder, C E the space filled by the liquid. The indicator gauge screws into the cylinder, and a filling plug is also inserted in the cylinder, so that it may be filled with the liquid when desired. Oil is generally employed, although in cold climates glycerine is sometimes used. Leakage will not affect the correctness of the indication upon the gauge unless the piston actually comes in contact with the bottom of the cylinder, when it will, of course, cease to indicate until filled. Re-filling is usually necessary about once a month when the machine is in constant use.

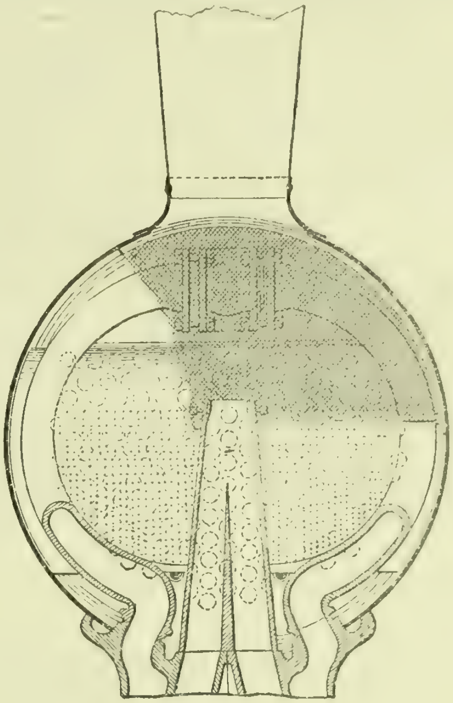
When a load is suspended from the piston rod of the machine a pressure is communicated to the liquid, which pressure is then transmitted to the indicating gauge for registration on the dial. The gauge is of the ordinary Bourdon type, having an elastic steel tube of a flattened form of transverse section at one end, and bent to present the figure of a circular arc. The effect of the pressure is to flatten the curvature of the tube and to cause the free end to move with an oscillatory motion; the free end of the tube has connected to it a rod which gives motion to a rack gearing into a pinion working the hand which indicates the pressure. These suspended hydraulic weighing machines are now used for dead weights requiring indication up to within twenty pounds, such for example as for weighing boilers, heavy goods, and large packages, where they have been found to be invaluable.

EXTENDED SMOKE-BOXES.

Mr. J. Snowdon Bell writes to our American contemporary the *Master Mechanic* on this subject in an interesting fashion, illustrating his remarks by the drawings we reproduce: "The writer has been so long an outspoken and uncompromising opponent of the extended smoke-box as to have doubtless earned for himself, in some quarters, the reputation of a 'crank' on the question, but he at least possesses the courage of his convictions, and since his first practical acquaintance with the extension, which was on the B. & O. Railroad in 1865, he has, notwithstanding the numerous and extravagant assertions of its advantages and absolute success in use, made by many of those who have adopted it under the force of example, and who are disinclined to admit they were mistaken, found no reason to depart from his original conviction of its radical errors of principle and positive disadvantages in practice, a conclusion which he is entirely satisfied it is merely a question of time to affirm. The extended smoke-box was 'primarily designed as a receptacle for the cinders drawn through the tubes,' and no amount of laudation or misrepresentation can make it anything else. It is not a spark arrester, and in the nature of things can never be anything but what it was originally proposed for, viz., a receptacle for so-called 'cinders,' or, in other words, unburnt fuel which an imperfect fire-box fails to consume, and which the cramped nozzle required by such a fire-box pulls through the tubes. The presence of a makeshift of this character necessarily implies and admits the inefficiency and imperfection of the fire-box, and that locomotive designers should be content to allow their work to be obviously subject to such a criticism, and, beginning at the wrong end, to attempt to merely reduce or partially counteract a radical defect, instead of dealing successfully with the conditions to which it is due, is scarcely creditable to intelligent and advanced practice. The advantages unjustly ascribed to the extended smoke-box are really resultant from the use of an open stack, a large nozzle, a proper spark arrester, and draught appliances, and last, but by no means least, a properly proportioned fire-box and brick arch. Because these features have borne their fruit, not by reason, but in spite of, an extended smoke-box, on an engine on which they have been handicapped by it, the extension has until recently been awarded the credit, and the actual features of advantage entirely ignored. The reaction has, however, begun to set in, and the reduction of smoke-box lengths due to it, of which that in the mogul passenger engines of the Chicago, Burlington, and Quincy is one of numerous examples, retains every useful element of the best practice in the extended smoke-box arrangement, and rejects its useless and objectionable feature, the disadvantages of which you correctly state, although you do not note the resultant one of impairing the steaming qualities of the engine. A frequent assertion of the extension advocates, and probably the only one which, if true, would warrant it, is that it is impossible to obtain a sufficient area of netting without materially extending the smoke-box for that purpose, but this is not borne out by the facts. The arrangement used on the Old Colony Railroad with extended smoke-boxes, for which very perfect results are claimed, could be used in a smoke-box of normal length; and a design of the writer, published in the *National Car Builder* of February, 1889, gives a greater area of netting in a 50in. smoke-box. The accompanying illustrations show a construction having a still greater area of netting, and which embodies the additional advantage of presenting inclined instead of horizontal sheets to the currents of escaping products of combustion. The double perforated deflector is a new feature, designed to thoroughly disintegrate the particles of solid matter before they reach the netting. Any engine which will pull more coal through her tubes than can be retained in a smoke-box of the capacity of that shown ought to have a new fire-box, proportioned and worked on modern principles, just as soon as she can be taken into the shop."



Longitudinal Section.



End Section.

WATER-TUBE STEAM BOILERS FOR MARINE ENGINES.

At the second ordinary meeting of the session of the Institution of Civil Engineers, on Tuesday, the 19th of November, the President (Sir John Coode, K.C.M.G.) being in the chair, the paper read was on "Water-tube Steam Boilers for Marine Engines," by Mr. John I. Thornycroft, M.Inst.C.E. Water-tube boilers were those in which the water to be evaporated was contained within the tubes which formed the heating surface. In 1878 Mr. Flannery, in a paper contributed to the institution, showed what progress had been made up to that date with this kind of boiler at sea. That communication and the discussion which followed proved that although considerable saving of fuel had been obtained with them, water-tube boilers as then made were unsuitable, because the tubes forming the heating surface were burnt, owing to insufficient circulation. The author therefore commenced by discussing the kinds of circulation in various forms of tubulous boilers, arriving at the conclusion that circulation, in order to be perfect, must be systematic, under which condition a smaller amount of water could be successfully used, and the weight of this element thereby reduced. By circulation, he intended to convey the idea of motion of the water contained in a steam generator, from the upper surface of the liquid down to the lower part of the generator, and returning again to the upper surface. Motion of water, simply from the point where the feed water was admitted to a point in the boiler where it became steam, he wished to hold distinct from the idea of circulation. Having thus defined the term, the author divided all boilers into classes, depending on the manner in which circulation took place. The first type dealt with was described as the oldest and simplest form of boiler, in which circulation at the outset depended upon small variations of density in its different parts. The action might be energetic when boiling took place, but was wanting in order, being struggling and confused in character, and nowhere acquiring high velocity. The circulation of the earliest water-tube boilers was of this nature. The author then described the boilers of Mr. Perkins, Mr. Herreshoff, Mr. du Temple, and of Mr. Matheson; also giving an account of the Field tube. The boilers of the Peace and of the Propontis were compared, and the most suitable diameter and length of tube were discussed. The author attributed the failure of the upper ends of the tubes of the Propontis to their being of such large diameter, that instead of steam and water passing over in foam, steam alone left the tubes, and that all impurities brought in with the feed water gradually accumulated in the upper part of the tubes, and ultimately led to their destruction. He thought it possible that obstruction from sediment collected in this manner gave rise, at a later period, to the more serious failure of the large water chambers. He next showed that a water-tube boiler might be constructed of less material than one of the ordinary form, and that this result was partly due to the fact that a strong envelope only was required to surround the steam and water, which must necessarily be enclosed in a pressure-resisting shell. In the case of the ordinary form of boiler, there was a strong vessel containing not only the steam and water, but likewise the fire and the products of combustion. These latter, it was pointed out, were again enveloped in a second or inner shell, and thus were covered twice by material to resist the whole pressure contained in the boiler. This was shown to be one evident cause of the great saving of material possible with the water-tube system. The reduction in weight was accompanied by greatly superior steaming power, economy of fuel, and less forcing of the fires. Lastly, the safety of the vessel and crew had been materially increased. The conditions favourable to perfect combustion, and those which tended to satisfactory absorption of the heat of gases produced, were then described, together with a boiler which the author had designed with a view to embody the principles of circulation and of combustion which appeared to him to be the best. Lightness of structure and strength to resist internal pressure had been particularly kept in view, and the evil effects of unequal expansion had been provided for by the curved form of the tubes, which afforded practically the whole heating surface. The tubes were shaped so as to make an arch over the fire, only allowing escape for the products of combustion by a series of narrow openings a little above the surface of the fire. In the upper portion of the arch each tube, by touching its neighbour, formed a continuous roof, and enclosed a large space above the fire-bars extending the whole length of the boiler. The tubes which composed the fire-box, having arrived at a point near the centre of the arch, altered their direction of curvature, and after meeting turned apart again to give room for the largest vessel in the boiler. By keeping in contiguous lines they afforded a protection from the heat to this vessel. In a similar way in which the furnace was formed, two rows of tubes united to make the external casing of the boiler, at the same time constituting a flue in which numerous other tubes were placed. The ends of all these tubes were secured in three horizontal cylinders, two of which served the purpose of supplying water to the tubes. The third was a separator, from which the steam produced was taken and the overflowing water returned to the tubes. For this purpose large external tubes connected the separator to the cylinders forming the base, and between these cylinders the fire-bars were arranged with a fire-brick bridge on either side, protecting the cylinders from excessive heat. The fire-doors were situated at one end of the tunnel or arch of tubes, and the other end was closed principally by blocks of light fire-resisting brick inclined away from the fire to add to their durability. The water level in the boiler was best a little below the centre line of the separator, in which was placed, underneath the points where the tubes entered, a shield to guide the circulating water down to the water surface, at the same time protecting from spray a perforated pipe, in which the steam was collected. The ends of the boiler were covered with plating, and in order to make the casing quite smoke-tight, the outer wall of tubes was also covered with light plating, but this had not to resist any great heat. The first water-tube boiler, put into a torpedo boat by the author's firm, afforded a very satisfactory means of comparison between the new boiler and its locomotive rival, which had been placed in a sister vessel. The result of steaming was eminently satisfactory, and the saving in fuel at equal speeds was sufficiently evident without exact experiment, the boat under natural draught being about 1 knot an hour faster than the other vessel, the full-power trials showing also a difference of 0·67 knot speed in favour of the former. Some evaporative trials were made by the Portsmouth authorities, and the results seemed to indicate that equal duty could be obtained when the proportionate quantity of water evaporated was 2·36 from the water-tube boiler to 1·00 from the locomotive boiler. After this boiler had been at work for three years, several tubes were cut out with the view to ascertain their state. They afforded a sample of tubes under varying conditions. Some were taken from the fire-box, where they had been exposed to the full intensity of the heat, and some from positions in the flue, where the heat was much less. Their condition was eminently satisfactory. The small amount of scale in their interior was a great contrast to the condition of water tubes taken from the boiler of the Propontis, in which the circulation was not so well provided for. The thickness of the tubes had suffered no perceptible diminution. The author then gave the results of some recent trials made by Professor Alex. Kennedy—whose report was appended to the paper—both at natural draught and with different amounts of forced draught, and a full description was given of the method of conducting them. At the most economical rate of working, the evaporation, reduced to standard, amounted to 13·4lb. of water per lb. of fuel, and the following heat balance showed the way in which the heat of combustion was utilised by the boiler:—

	Per cent.
Heat expended in heating and evaporating feed water	86·8
Heat expended in raising temperature of furnace gases	10·8
Heat lost through formation of carbonic oxide.........	0·5
Heat lost by radiation and otherwise unaccounted for	1·9
	100·0

The very high percentage of evaporation, 86·8, represented the efficiency of the boiler, and was simply equal to the ratio between the actual evaporation and that theoretically due to the perfect combustion of the fuel, or $\frac{13\cdot4}{15\cdot4}$. Professor Kennedy stated that it was the highest boiler efficiency he had found upon any trial, and he believed the highest on record in any trustworthy manner.

ELECTRICAL MACHINERY AT A NORMANTON COLLIERY.

At the invitation of Messrs. M. Immisch and Co., electrical engineers, London, and by permission of Mr. Warrington, of Messrs. Locke and Co., St. John's Colliery, Normanton, about seventy mining engineers and other gentlemen interested in mining and electrical science, from the principal mining districts of England and Wales, assembled on Nov. 20th at St. John's Colliery, to inspect the electric pumping and hauling plant recently supplied by Messrs. Immisch and Co., the installation forming the largest electric transmission plant in Great Britain. The power at the surface consists of a pair of engines, 20½in. cylinder by 4ft. stroke, driving a pair of 24in. dynamos, which absorb 66 break horse power each when fully loaded. The current from these two dynamos is let down the shaft by an insulated and lead-covered cable to the motors at the bottom. The armatures of these motors are each 24in. in diameter. These drive a counter shaft which extends across three engine-houses. In the first engine-house there is a pair of 6in. by 4¼in. by 24in. differential pumps. In the centre house is the hauling gear, driven from the same counter shaft, with gearing to bring the speed of the ropes down to about two miles per hour. In the third house is a set of 3-throw pumps, 6in. diameter by 12in. stroke. These are geared for a speed of about 100ft. per minute. The counter shaft is prepared with two pairs of clutches, which can be taken out or put into gear at pleasure, and the dynamos are so arranged with these counter shafts that either set of pumps or hauling gear can be run together or separately as desired, so that if anything went wrong with either motor or either set of pumps the other motor could be utilised for driving pumps or hauling. The machinery is thus in duplicate, and so avoids the possibility of either hauling or pumping having to stand for any length of time by any accident. The pumping plant has been in operation for about two years, and the hauling plant for about two months, and we are informed that there has not been the slighest hitch, and that the plant works very smoothly and satisfactorily. The efficiency of the electrical plant, as tested by Mr. E. Brown, the colliery engineer, and Mr. A. T. Snell (of

Messrs. Immisch and Co.), gives 47¾ per cent as against compressed air probably 20 per cent.—in fact, the engines that were used for compressing air are now utilised to drive the dynamos. About 130 gallons of water per minute can be pumped with either set of pumps. The rising main or delivery pipes are very small, being only 4in. in diameter. These were put in when the feeder of water was only about 40 gallons per minute, and it was not anticipated that the feeder would exceed 60 gallons at any time. The feeder, however, has increased to as much as 130 gallons per minute, and it is intended to replace the 4in. pipes with a set of 6in. pipes, which it is expected will increase the efficiency of the electrical plant to at least 50 per cent. Electrical haulage is used in the Haigh Moor, or east district, and in the Kirkthorpe, or west district of the pit, both being at the same level, namely, 212 yards. From the gear, which is driven by the electrical motor, a main rope is laid on to the main engine plane which makes 2½ turns round vertical shafts. These shafts are about 60 yards apart, and on each shaft two 4ft. pulleys are fixed. The bottom pulleys on each shaft are kept running continuously from the commencement of work in the morning until it ceases in the afternoon. The top pulley is lifted by means of a steel screw which passes up the middle of the upright shaft, which is hollow. This screw is attached to the boss of the top pulley, and by the top pulley being either raised or lowered puts it into or out of gear with the bottom pulley. The hauling ropes on each side go 2½ times round the top pulley, so that to start the ropes all that is necessary is to screw down the top pulley into the friction cones, which are cast on both the top and bottom pulleys of sufficient surface to drive any load that is likely to come upon them. The screens are also lighted by electricity. The motor is one of Parson's steam turbines, driving a dynamo direct on the same shaft without any gearing, at a speed of something like 4,000 revolutions per minute. The majority of the lamps are of 16-candle power, but there are two sunbeam lamps, each of 200-candle power. These light up the screens well, and give every opportunity for dressing the coal in a proper manner. The coal is tipped down a screen on to a set of endless bars at right angles to the screen itself. These bars are driven by an engine, and the coal is fed in a thin stream till it falls on to the endless belts. The picking and sorting is then done, and from the belts the coal drops into a wagon in the ordinary way.

ERICSSON AND THE MONITOR.

Prof. C. W. MacCord has, in the *North American Review* for October, a very interesting article, in which some of the inside history connected with the building of Ericsson's Monitor is, we believe, for the first time given to the public. Prof. MacCord was with Ericsson at the time as a draughtsman, and is, of course, able to give many very interesting facts connected with the inside history of that event. A very high tribute is paid to Ericsson's ability as an engineer, as well as to his character as a man and a citizen, and he is referred to as "the world's most illustrious engineer." Ericsson's indomitable energy and readiness in resources are well illustrated by the manner in which he remedied a difficulty which had arisen with the steering gear, and which the naval authorities proposed to overcome by putting in a new rudder, which would have required about a month's time. The vessel had at that time not been accepted by the Government, and still belonged absolutely to Ericsson. As was natural, he strongly resented this interference, and in three days had the defect remedied. The Government it seems never assumed the least risk in connection with the Monitor, and, at the time of the battle of Hampton Roads, in which she defeated the Confederate ironclad, she did not belong to the United States Navy, but to Ericsson, and that she was there rather in spite of than with the co-operation of the naval authorities.

Professor MacCord says: "It will always be recorded in the history of this country that the building of the Monitor was sanctioned by the authorities at Washington only upon conditions the most arbitrary, and, in the circumstances, the most contemptible ever imposed by a great government upon a great designer. At a price barely sufficient to cover the cost of materials and labour, they would accept his battery, but not until it had proved impregnable under the guns of the enemy at the shortest range; in a most critical emergency, they would take all the profit if he would take all the risk. Twenty years before, these United States had reaped the fruits of his genius and his labour, when the building of the Princeton had also marked a new era in naval construction. During all those years they had refused, as they have refused during all the longer years since, to pay him for his services, although, in the meantime, there had been days when the paltry sum would have been most acceptable. They are willing, it seems, that the memory of their meanness shall be everlasting, since they have allowed him to carry it with him to his eternal rest."

This is well calculated to bring the blush of shame to the cheek of every American citizen who has a particle of regard for national honour, but well illustrates the fact which has been before recognised, and that is, that an engineer who renders an important service to his country must expect far less recognition of it, as well as far less recompense, than would be freely given in the case of a soldier or statesman who had accomplished something of equivalent value.

Referring to the criticism sometimes passed upon Ericsson, that he made many mistakes, Prof. MacCord says that, in considering this, account must be taken of the immense amount of original work accomplished by him, which, of course, is obviously true; he who never undertakes to do anything not done before is reasonably sure not to make many mistakes.

"Mistakes he made, and he knew it; his projects were not always successful. In exploring new fields, errors are often found assuming the garb of truth so effectually that the imposition is not at once detected. In the development of new ideas, perfection is seldom reached without repeated trials, and to say that Ericsson made mistakes is simply to affirm that he was human; but, when they are compared with the total results of his labours, the ratio is so small that no one has yet laid stress upon them who would not, in the caustic words of John Bourne, 'have been a much more distinguished engineer than he is if he had never done anything in his life except to contrive the mistakes of Ericsson.'"

Much insight is given into Ericsson's method of work, and the article is well worth reading by everyone, and especially by engineers and mechanics.—*The American Machinist.*

ARMSTRONG'S ITALIAN WORKS.

A consular report from Naples, just issued, says of the works of Sir W. G. Armstrong, Mitchell, & Co. Limited: This firm, during the past year, has executed orders for war material for the Italian Government. They employ from 900 to 1,200 workmen, chiefly natives of South Italy. The work in hand consists of orders for war material for the Italian Government, and comprises some guns of large calibre, for which the works are specially adapted, and a number of small rapid-firing guns, with their respective carriages. A quantity of revolving carriages are being proved at the works batteries in the presence of a royal commission. They are intended for land service, and will be mounted with 28cm. howitzers. Two gunboats for the Italian Government have been built at the shipyard attached to these works, and are being fitted out with hydraulic machinery, &c.; they are intended to carry one 120-ton gun each. These gunboats have a displacement of 530 tons, with a draught of 8ft. 4in. On their official speed trials they developed 364 indicated horse power.

COMPOUND HORIZONTAL ENGINE.

Perhaps the finest and most elaborately finished engines in the whole of the Paris Exhibition were those of Messrs. Sulzer Bros., of Winterthur, and their compound horizontal engine, which we here illustrate, is an admirable example of their best style. It is intended to indicate at its normal power 400 horse power, but can be worked up to 500 horse power if desired, of course with a less economical steam consumption. The high and low pressure cylinders stand side by side, and drive cranks at the outside ends of the crank shaft, while the flywheel is carried between. The steam pipe connections are carried under the floor, and so leave the visible portion of the engine free from the complication of pipes and stop valves. The cylinders are respectively 500mm. (19·7in.) and 800mm. (31·5in.) diameter, while the stroke of both is 1,400mm. (55·1in.). The low-pressure cylinder is thus 2·56 times the capacity of the high-pressure. The working pressure is 110lb. per square inch, and the working speed is 75 revolutions per minute. The well-known Sulzer automatic variable cut-off gear is used, and at different points of cut-off the engine develops the following at the normal speed of revolution:—

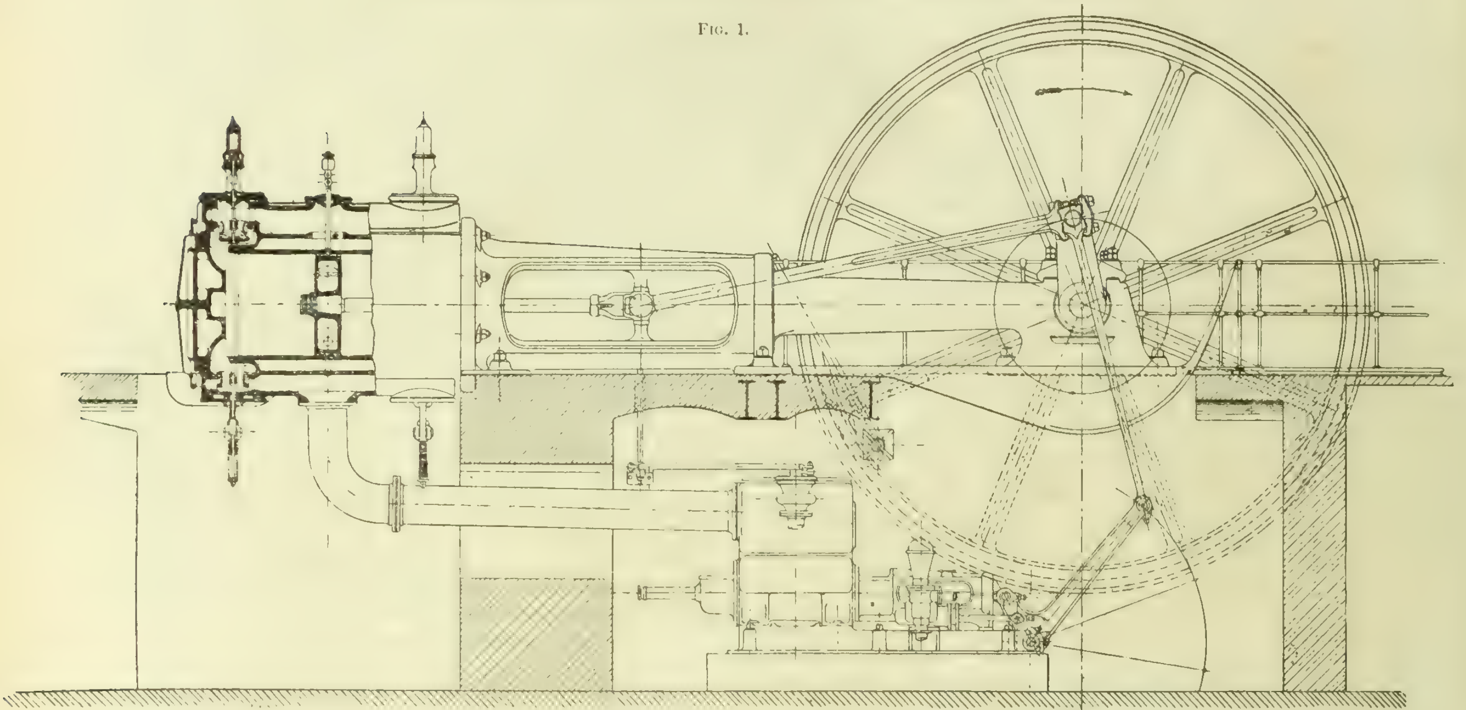
Cut-off……………………	10%	20%	30%	40%
	H.P.	H.P.	H.P.	H.P.
Indicated power about..	315	420	510	585
Or effective power about.	265	360	430	500

COMPOUND HORIZONTAL ENGINE.

(*For description see page* 813.)

CONSTRUCTED BY MESSRS. SULZER BROTHERS, ENGINEERS, WINTERTHUR.

FIG. 1.



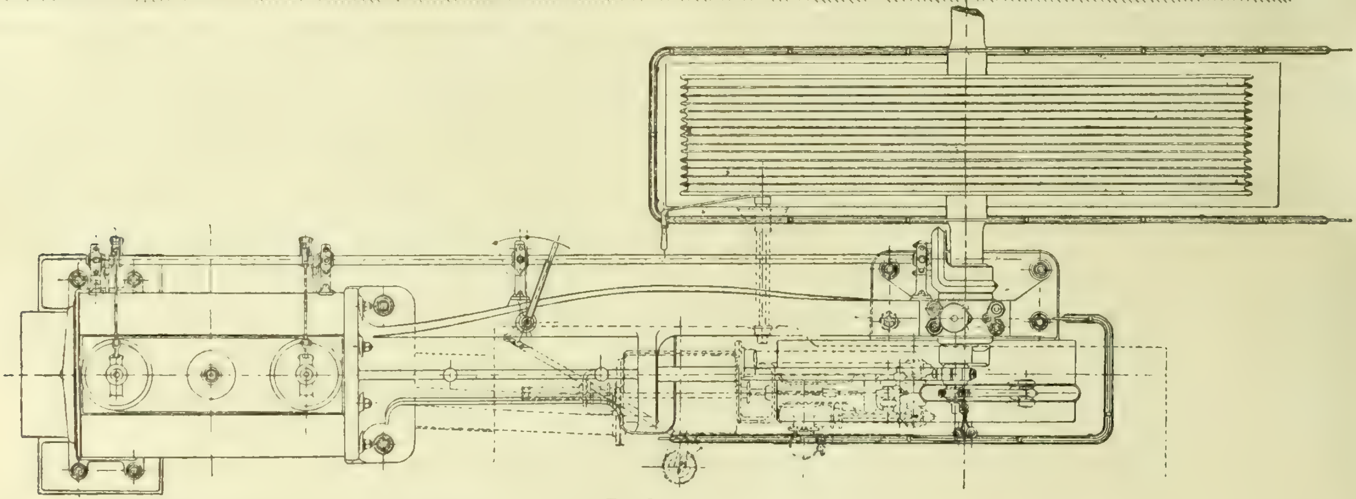


FIG. 2.

Both cylinders are steam-jacketed, and the high-pressure steam passes from the jacket into the cylinder, and thence by the communicating pipe to the low-pressure cylinder jacket, which serves as a steam receiver. It is then admitted to the low-pressure cylinder. In both cylinders the admission and exhaust valves are quite independent of each other, and are of the double-beat equilibrium type. The admission valves of the high-pressure cylinder are opened by eccentrics, and the exhaust valves by cams, carried on the same valve motion shaft, which runs parallel with the engine cylinder, and is driven by bevel gear from the main shaft. The low-pressure admission and exhaust valves are both worked by cams on a similar valve motion shaft.

A small double-acting pump is used for supplying the lubricating oil, which is continuously pumped from a tank or reservoir The piston rings are of the Ram-bottom type, and the piston rods are very strong and stiff, while the crosshead pins, crank pins, and crank-shaft bearings have large surfaces. Throughout the whole engine the rubbing surfaces are large, and pressure per square inch on them low. Referring to our illustration, fig. 1 is a longitudinal section through the low-pressure cylinder, showing an admission and exhaust valve section. Fig. 2 is a half-plan, and fig. 3 an end elevation, showing valve gear and governor. The engine is of beautiful finish, and works with admirable smoothness.

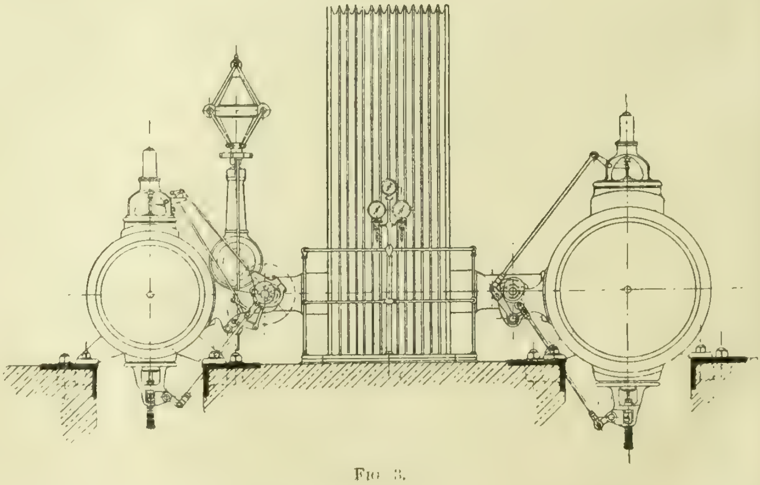
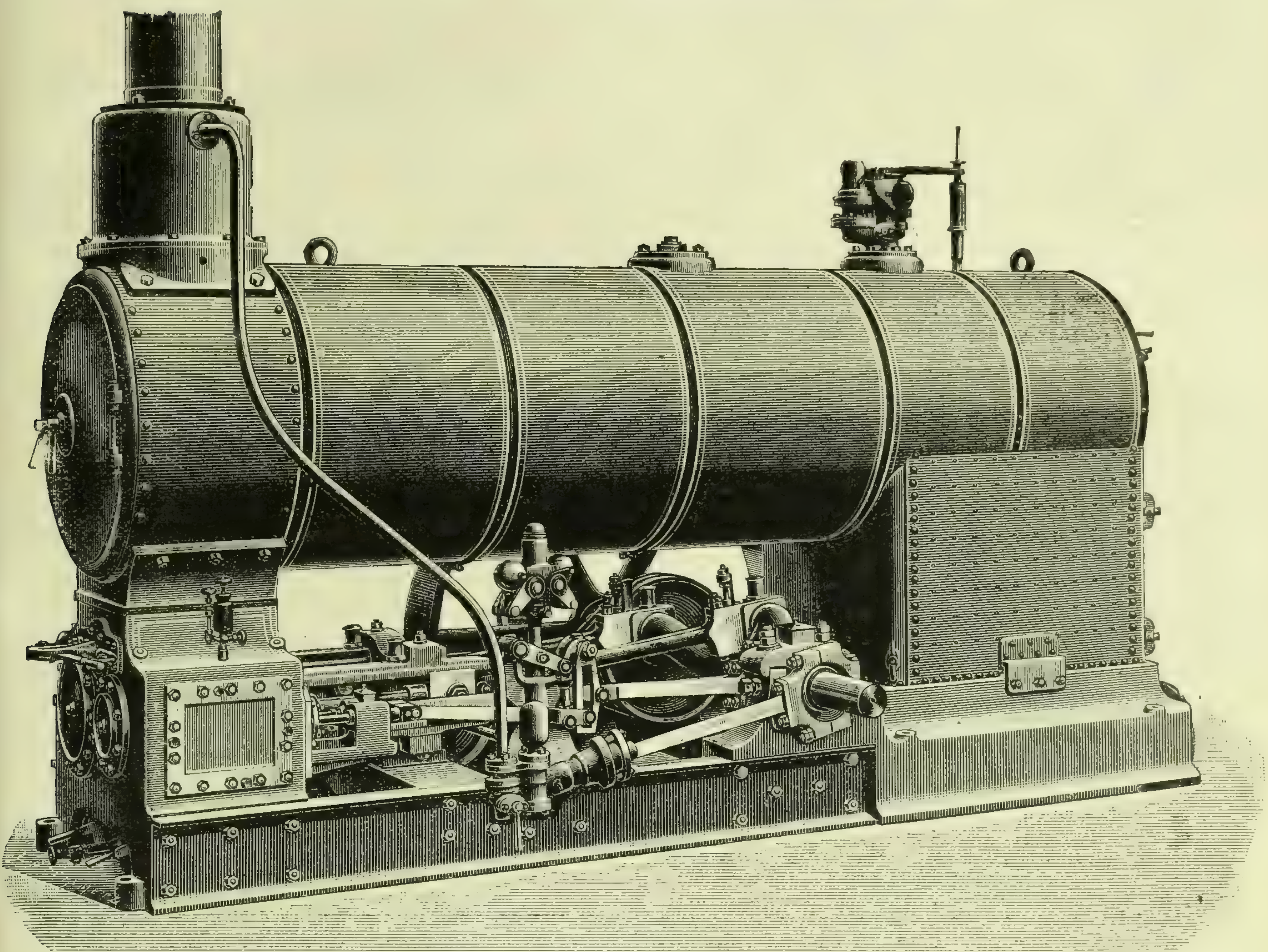


FIG. 3.

20-H.P. COMPOUND UNDERTYPE ENGINE.

CONSTRUCTED BY MESSRS. C. BURRELL AND SONS, LIMITED, ENGINEERS, THETFORD.



We here illustrate a compound undertype engine, constructed by Messrs. C. Burrell and Sons Limited, Thetford, which is of specially heavy construction, intended for long wear and heavy work. It is rated at 20 H.P. nominal, and is built up on a channel iron bed frame, to which the cylinders are bolted at one end, and a substantial casting bolted at the other end carries the main crank-shaft bearings, while a cast-iron cross stay carries the guides. The engine is fitted with Messrs. Burrell's patent feed-water heater and automatic expansion governor. The feed-water heater is situated on the top of the smoke box, and is heated partly by the heat passing up the flue and partly by the exhaust steam, so that the water ultimately finds its way into the boiler at a temperature of 250 deg. Fah. This results not only in the economical use of fuel, but tends greatly to extend the life of the boiler by avoiding unequal expansion.

The boiler pressure is 140lb. per square inch, and the boiler is fitted with lock-up and adjustable spring safety valves, while the water gauge and cocks are Dewrance's patent, asbestos packed. At each end the top of the boiler is provided with a wrought-iron eye, securely fixed for the purpose of lifting the boiler with hooks or chains without slinging, and so avoiding the risk of damaging the lagging and fittings.

The engine is provided with an auxiliary starting valve for admitting steam to the low-pressure cylinder when required, and both cylinders are thoroughly steam-jacketed, and drained with Vaughan's patent ejector to discharge the jacket water automatically. The crank shaft is of mild steel, and all bearings and wearing parts throughout are of ample area.

The engine has been most carefully designed and constructed, and is, we are informed by the makers, made in sizes from 8 H.P. to 50 H.P. nominal. We are indebted to our contemporary *Engineering* for our illustration.

THE COMPARATIVE MERITS OF MAIN DRIVING BY SPUR OR BEVIL GEARING, BELTS AND ROPES.

At a meeting of the Manchester Association of Engineers held in the Grand Hotel, Manchester, a discussion on the comparitive merits of main driving by spur gearing, belts, or ropes was held. The subject was introduced by Mr. Rea, who treated the matter from a practical point of view, as the outcome of an experience of 20 years of millwright work. He said spur or bevil gearing, being the oldest form of main driving, was consequently deserving of the first place in consideration. This principle might be divided into four classes or kinds, namely, wheels made of iron and iron teeth, iron and wood, wood and wood and helical teeth, iron and iron, which was a more modern form of gearing. He might here say that only in two instances on a large scale had he come across a case where the power was transmitted from a prime mover where both wheels were geared with wood teeth, the reason of their adoption being that wheels geared in this manner were almost noiseless. However, in both cases the results were satisfactory.

The principal objections made against wheel gearing with cogs or teeth might be summarised as follow: (*a*) liability to breakdowns; (*b*) expensive foundations and first cost; (*c*) excessive noise in working; (*d*) cost of grease when running; (*e*) limit of speed; (*f*) loss of power in transmission by friction.

With regard to the first objection, he certainly admitted that in years gone by it was not wholly groundless, arising from a variety of causes, which might be classified as follow :—

(*a*) The teeth being made too long and not the proper form.
(*b*) Being often cast of old patterns, out of truth.
(*c*) Bad moulding, the teeth not being a true pitch.
(*d*) The structure of the wheel being faulty in design.
(*e*) The shafts being too light to prevent torsional vibrations, in addition to carrying the loads.
(*f*) Badly proportioned wheels, in diameter or size.
(*g*) Wheels often made too weak for the load, or power transmitted.
(*h*) Shafts getting out of line or level, throwing the strain on one corner of the teeth.

The foregoing were some of the principal causes producing failure in toothed gearing, but in this age of wheel moulding machines and steel, with truer forms of teeth, with more correct ideas in regard to the structure and design of wheels, these objections did not hold good as before. He had here a few sketches showing the best methods of building up main driving wheels, also a form of tooth, both contributing to prevent breakdowns. The first showed the method of building the wheel up of segments attached to an internal rim, by dovetailed projections and wrought-iron keys. The second showed the segments attached to the rim of wheel by hard wood keys and iron wedges. This principle, though old, was by far the best method, as the wood keys absorbed the vibrations arising from the impact of the teeth, really a series of small blows; where the load was of a very irregular character, such as driving a roll train in an iron or steel works, this plan is essential to resist the intermittent shocks from the ever-varying load, and ought to be adopted. Messrs. Buckley and Taylor, of Oldham, had designed and patented a special wheel, where they introduce a rubber cushion on one side of the snug and wood on the other. His fear was that in time the rubber would become vulcanised, and so lose its elasticity, and therefore become useless. In a form of tooth suitable for high speed and heavy driving it would be noticed that the principal point of contact in the teeth was at the pitch line; the rounding of the points of the teeth obviated the sliding motion of the teeth when coming into contact, and the sliding motion of the teeth when receding from each other; it also prevented noise in the wheels when working, in addition to reducing the friction in transmission. According to Professor Willis, the friction is more injurious during the approach of the teeth to the point than when receding from it. To avoid this contingency the teeth should not be made too long. A good proportion was from $\frac{5}{8}$ to $\frac{3}{4}$ of the pitch in length. If the several points noted were attended to, breakdowns would be reduced to a minimum.

It might be admitted that the first cost, including foundations, &c., would be rather more than for rope driving. The noise also, it must be admitted, is greater in toothed gearing. Cost of grease might be placed against the renewals of ropes, cost of splicing, &c. In regard to the question of speed, he had no hesitation in recommending a speed of from 3,000ft. to 4,000ft. per minute. This he had seen demonstrated by years of practice. The loss of power in transmission by a pair of well-made spur wheels will not exceed 2½ per cent.

Before passing from this part of the subject he admitted that helical teeth were not well suited for main driving, arising from the form of the teeth and the inequality of the strain thrown on them by the slight end long motion of the crank shaft, and by a slight rolling motion in it at each end of the stroke. This had a great tendency to fracture the teeth; hence a decided objection to use this form of teeth for main driving wheels.

The principal advantages of toothed gearing were the following: (*a*) positive motion for heavy driving; (*b*) great economy of space between centres; (*c*) less loss of power in transmission; (*d*) suitability for special positions, &c.; (*e*) great durability, if well made; (*f*) not liable to injury by fire in a textile factory.

Turning now to the question of belt gearing, Mr. Rea said this was used a good deal in the manufacturing districts of Lancashire and Yorkshire for the transmission of large powers, but much more extensively in America, especially for driving rolling mills, with very satisfactory results. He had placed belt driving before ropes, because where the load was transmitted to one point by a single belt, instead of a number of separate ropes, there was less loss of power in transmission by the belt than by a series of ropes. This loss arose from the following causes: (*a*) unequal tension in the ropes; (*b*) different diameter or size in the ropes, producing unequal velocity; (*c*) a tendency to get jammed in the grooves; the whole producing a kind of cross action in the motive power, and thereby excessive friction.

(*To be continued.*)

THE MANUFACTURE OF THE ALLOYS OF ALUMINIUM IN THE ELECTRIC FURNACE (COWLES' PROCESS).

(*Concluded from page 798.*)

In the church of St. Germain, Paris, are twelve beautiful candlesticks, six feet high, and a crucifix four to five feet in height, made of 5 per cent aluminium bronze; these have been in position over 20 years, and their colour is still perfect. In Philadelphia, the statue of Wm. Penn, intended to surmount the dome of the new city hall, will be cast in aluminium bronze.

Aluminium brass is another valuable alloy made by combining aluminium bronze with zinc in different proportions. It is a close grained, homogeneous, and tough metal. The torpedo shell before you is cast from this metal (the No. 2 grade).

Al. Brass.	Tensile Strength in Castings.	Elongation.
No. 1	23—27 tons per square inch	10—14 %
No. 2	30—34 tons	6—11 %

This alloy forges hot, and its special casting properties, its resistance to corrosion, its low specific gravity, render it valuable as a material for ships' propellers, stern and rudder frames, pump plungers and rods, valves, wheels, and pinions, and for hydraulic and engineering work generally.

A number of tests were made by order of the Navy Department of the United States of Al. bronze and brass as compared with United States gun bronze, with favourable results.

A blade could be made of it at least one-third thinner than cast iron or any other bronze blade, and would be correspondingly lighter.

For cartridge shells these alloys cannot be equalled; their strength would enable a thinner and lighter shell to be used, with the advantage of not being corroded by the contained explosive. The use of Al. bronze as a material for cannon was the subject of a paper read before the United States Naval Institute in 1887. As early as 1859 a mountain gun of this metal was cast and tested by the Committee of Artillery of France, with very favourable results; the high price of aluminium being then the only thing prohibitive of its widespread use for guns. Numerous tests of aluminium bronze and brass have been made by the United States Navy Department, and a special set has been made to determine the effects of temperature, from which it appears that a bar had the same tensile strength, 108,000lb. to the square inch, at 450 deg. Fah. as at 60 deg. Aluminium brass, however, at that temperature broke at 29,000lb.; when cold the same bar stood 85,000lb. without rupture.

Ferro-aluminium. The alloys of aluminium and iron have long been known. They are referred to by Faraday, who found 0·013 per cent to 0·69 per cent aluminium in "Wootz" steel. Rogers, in an article in the *Moniteur Industriel*, No. 2379, 1859, says a small per cent of aluminium makes steel hard, strong, and brittle, a larger quantity makes it very dense, without impairing its peculiar polish or detracting from its qualities.

The influence of aluminium in small quantity on cast iron is very marked, and was last year the subject of an interesting paper by W. J. Keep, in conjunction with Professor Mabery and L. D. Vorce, of the Case School of Applied Science, Cleveland, Ohio, U.S.A., read before the American Association for the Advancement of Science, August, 1888.

Two bases were used: one a white iron, with composition Si. 0·186., P. 0·263., S. 0·0307., Mn. 0·092; the other grey Swedish iron, marked F. L. M. with Si. 1·249 P. 0·084., Si. 0·04., Mn. 0·187. The ferro-aluminium used was made by the Cowles' process, and contained Si. 3·86., Al. 11·42 per cent. Each base was experimented upon separately, and at the same time a series of blank trials were made, the metals in the two series being subjected to exactly the same conditions.

The following results were obtained :—

1st. Solidity of castings and prevention of blow holes.—The aluminium castings were of a slightly finer grain and of increased solidity, with 0·1 per cent Al. present. The resistance to dead weight was increased about 44 per cent, and to impact 6 per cent.

2nd. Does the aluminium remain in the iron after remelting? The white base after the addition of 0·25 per cent of aluminium was re-melted six times, fresh quantities of the white base being added each time. That the aluminium remains in and improves the iron is shown by the superior and stronger castings obtained in this series, even after the percentage of Al. had become very low, than in those cases where no aluminium was added.

3rd. The effect of aluminium on the grain.—Aluminium seems to enable iron to hold in solution all its carbon until just upon the point of solidification, when it is precipitated in a finely graphitic form. The advantage of this is the uniformity of the mass, and the absence of pockets of graphite, which are generally produced when ordinary grey iron has been cooled slowly. Hence the homogeneity and greater strength of the aluminium castings. The rapidity of cooling makes little or no difference, as the release of the carbon seems to be instantaneous, and only at the moment of crystallisation. A very little aluminium is sufficient to precipitate graphite from white iron—0·25 per cent rendering it perceptibly darker in colour; 0·5 per cent more so; whilst 0·75 per cent renders it quite grey, with no signs of white. With increasing amounts up to 4 per cent (the maximum in all these experiments) the effect is the same, the castings becoming softer and greyer as the amount of aluminium increases. The presence of much silicon does not alter the matter, the grain being the same also in thin, and rapidly cooled, as in thick castings.

4th. Aluminium castings are not affected by chilling; graphite is liberated whether the casting is cooled rapidly or slowly, with the result that the grain is uniform, and there is no chill.

5th. When sufficient aluminium is present to liberate the graphite, a coating is formed on the casting which resists the sand and the heat, and prevents the iron burning the sand into itself.

6th. The fineness of the grain causes them to be more easily cut than cast iron of coarser grain.

7th. The presence of aluminium increases the strength to sustain a constant load, but the strength does not increase uniformly with the percentage of aluminium.

8th. The increase in strength is much greater and more marked than in the preceding. Above a certain percentage the strength diminishes, due to larger amount of graphite liberated.

9th. Elasticity is improved.

10th. The fineness and compactness of iron containing aluminium gives less permanent set than iron equally as soft when that softness is produced by silicon.

11th. The shrinkage is slightly increased with a small quantity of aluminium, due probably to the elimination of blow holes; but with 0·75 per cent, and more, it is much decreased, especially in case of wrought iron.

12th. In case of the white iron fluidity is much increased; with grey base containing much silicon it is not so clear, though it is believed the fluidity is increased.

The fact that aluminium lowers the melting point of iron is utilised in the Mitis castings, the invention of Mr. Peter Ostberg, of Stockholm. In making Mitis castings a very small quantity of aluminium, about ·050 per cent Al, in form of 7 or 8 per cent ferro-aluminium, is added to the charge (about 60lb.) of wrought iron in the crucible the moment this has been melted. The fusing point is at once lowered about 500 deg., and the charge becomes very fluid, and can be cast in the finest moulds. The great difference between its temperature and its fusing point gives all the time necessary for its manipulation without danger of its solidifying.

The tensile strength of Mitis castings may be as high as 27 tons per square inch, with an elongation of 20 per cent.

Another alloy made in the electric furnace is silicon bronze, which, owing to its great strength and tenacity, its resistance to corrosion, combined with high electrical conductivity, is perhaps the best metal extant for electric light, telephone, and telegraph wires.

INSTITUTE OF MARINE ENGINEERS.

A MEETING of the Institute of Marine Engineers was held in the Langthorne Rooms, Stratford, on Friday evening, November 1st, when the first general business meeting of the institute was held, presided over by Mr. A. Beldam. The honorary secretary made the following statement:—

Mr. Chairman and Gentlemen,—It is with a considerable degree of pleasure that I ask you to look back with me over the past nine months, and trace the footsteps of the Institute of Marine Engineers from the early tottering of childhood to the firm tread of youth. I would also ask you to allow your minds to soar beyond the limits prescribed by time present, gaze fearlessly into the future, and behold the institute in the full force and power of its manhood.

In February of the current year, we may say, the institute was founded, when the first public meeting was called, in order to feel our way, and test the feeling of engineers on the subject.

The reading-room was opened about the same time, and the table supplied by voluntary contributions. The loan collection was then added as a library of useful and pleasant books for the use of the members, and has been added to month by month, until now the necessity has arisen for an additional case to contain the volumes.

The collection of objects of interest and specimens is also gradually increasing, and many samples and specimens are being held back for want of accommodation. The seven papers which have been read are now matters of history, and the comments of the press are such that I need not further refer to them, except to express the hope that the papers in preparation may sustain the character earned by their predecessors. I am pleased to note that the attendance at the reading of papers has been steadily increasing.

The recreation committee are now at work arranging for a social meeting, or conversazione, to be held in the Town Hall, Stratford, on the 6th December, for members and their personal friends.

The registration of the institute was completed in July, when Mr. Neely received the charter from the Board of Trade, and forwarded the same to us.

The names of the council and office bearers are printed in the copies of Byelaws and Articles of Association, which may be inspected by members in the reading-room, and, in view of the election to take place at the annual meeting in March, members should examine the list with a view to the election of the new council. Voting lists and notices will be posted in due course, in terms of the articles in the byelaws.

The membership to this date is as under:—

	160	Members.
	8	Honorary members.
	9	Associate members.
	9	Associates.
	4	Graduates.
Total......	190	

With the addition of several applications, which yet remain to be considered, the total will reach 200.

The total receipts up to this date amount to	£321	5	0
The expenditure to	201	17	4
Leaving a balance of............	£119	7	8

There is still a balance of account to be paid to Mr. Neely of about £40.

In connection with this cash statement it may be remarked that there are several annual subscriptions due from members, who have, up to this date, only paid their entrance fees, and I may take this opportunity of asking members to bear this in mind. It should also be remarked that the legal expenses in connection with the registration of the institute has cost, including what remains to be paid, about £100. Mr. Neely, of 25, Old Jewry, who acted as our solicitor in the matter, has our warmest thanks for the manner in which he conducted the negotiations, and the personal interest and trouble he took, and, in addition, for his proferred and courteous offer to act as honorary legal adviser to the institute.

It rests with the members, after what has been done by the present council and office-bearers, to express their views as to the style in which the business has been conducted, and if they are satisfied that the honour and dignity of the institute is safe in their hands till the annual meeting, to move a vote of confidence accordingly. The annual meeting takes place in March. This is merely a formal business meeting, called in accordance with the requirements of law, to give members an opportunity of expressing their satisfaction or otherwise with the office-bearers and what they have done. It is highly gratifying to observe that so many of the leading journals and scientific papers are desirous of reporting our proceedings, and have expressed opinions favourable to the institute; we would thank the various editors and proprietors for their courtesy and kindly interest, as well as for their good wishes. It is not many months since, at our third or fourth council meeting, when the question arose regarding notices from the press, I remarked that the time would come when, in place of our seeking to obtain notice from the press, the press would seek to obtain notices from us. My remark was prophetic; the time I predicted has come, and the spirit of independence which animated me to make the remark has been justified in the sequel. It is more in keeping with our life work as engineers to prove what we are, and demand success by results achieved, than to seek by adventitious means to gain that to which we have not proved our title. In closing, I would seek to act the prophet again. We—I speak as the mouthpiece of the present council—have established the institute on a good sound basis. Some of us have not spared ourselves in seeking to command that success should crown our efforts, and it remains with every member, of every grade, to do his utmost to advance the highest interest of the institute. Doing so, I venture to predict a great future for the institute, and, through it, the whole trade to which we esteem it an honour to belong.

The Chairman commented on the work which had been done since the 12th February, when the inaugural meeting was held, and asked for an expression of opinion from members. Mr. Sage proposed, and Mr. J. W. Dimmock seconded, the motion of a cordial vote of confidence in the present executive of the institute. This, on being put to the meeting, was carried unanimously.

Mr. Leslie, convener, reported that a committee of ladies is working along with the recreation committee in arranging for a conversazione in the Town Hall, Stratford, on the 6th December. The programme is well in hand, and the meeting promises to be a most pleasant one.

The business meeting closed with a vote of thanks to the president, Mr. Beldam.

On the same evening, the president read a paper on the "Progress and Development of the Marine Engine." Mr. J. Mc F. Gray occupied the chair, and introduced the author of the paper with a few appropriate words, when Mr. Beldam proceeded to give a *resumé* of the history of the marine engine, from the first engine, designed by Symington, and fitted in a small vessel to ply on the Forth and Clyde Canal, to the latest powerful and magnificent steamers of the Inman International Line. In the discussion which ensued, some very valuable and interesting information was elicited. Mr. Wymer referred to crossing the Bay of Biscay in the days of his boyhood, in the William Fawcett, in 1834, and related his experiences with the early types of marine engines, the difficulties which had to be contended against, and the great discomforts endured by those who had charge of them.

The experiences and reminiscences of their youth, detailed with freshness and vividness by Messrs. F. W. Wymer, J. Mc. F. Gray, and others of the older members, were exceedingly interesting; and to hear these gentlemen was to partake of a mental feast of a nature such as we have seldom enjoyed. The work of the Napiers, Elder, J. Scott Russell, Caird, Kirk, Bryce, Douglas, and other celebrated engineers was referred to; also the immense importance of that work in the economy of the world. The discussion was kept up with much interest, many members taking part in it with evident relish and enjoyment. The whole proceedings were of a most interesting character.

Mr. Beldam replied to the several points which had been raised in the course of the evening, and the meeting closed with the usual votes of thanks to the author of the paper and the chairman.

EXPERIMENTS ON CONDENSATION AND RE-EVAPORATION OF STEAM IN A JACKETED CYLINDER.

(Continued from page 784.)

Clearance Surface—Whatever view may be taken of the nature of the process which causes condensation in a steam cylinder, it appears to the author that the number of thermal units of heat transferred must vary directly as the area of that portion Sc of the clearance surface which is colder at the moment than the entering steam, whether the surface be that of a film of water or of the actual metal. In assigning the value of Sc, however, it is necessary to deduct from the whole clearance surface any portion which is permanently heated from the outside, as by steam-jacketing the end of the cylinder by other means to a temperature exceeding that of the entering steam, such portions must remain dry throughout the whole cycle, and can produce no effect by contact either on the initial condensation or on the subsequent re-evaporation during the stroke. The effect of the cold portion of the clearance surface in producing condensation must be most marked at the first instant, when the difference of temperature is greatest; and must diminish as the surface is brought up to the same temperature as the steam in contact with it. The number of units of heat transferred at each stroke cannot, therefore, be assumed to vary directly as the time of exposure, or inversely as the number of revolutions in a given time; and every experiment made by the author tends to show that it varies, at any rate approximately, as the square root of the time of exposure, or as $\frac{1}{\sqrt{N}}$, where N is the number of revolutions per second. This result, as pointed out by Professor Cotterill (Proceedings, 1857, page 536), is also to be expected on theoretical grounds. The effect of clearance surface will therefore be represented by the factor $\frac{S_c}{\sqrt{N}}$.

Temperature.—Next, as to the effect of temperature, it is frequently assumed that the condensation must vary directly as the range of temperature in the cylinder; but this view appears to the author to be based upon a fallacy. It is true that there is experimental evidence, obtained by Forbes and others, to show that the rate of transmission of heat through a metallic plate depends on the difference of temperature of the media on either side, and that therefore the condensation of steam, in long-continued contact with metal, should vary as the difference of temperature of the two sides; but in that case there is a steady flow of heat, and the temperature of the side of the plate in contact with the steam must be uniform, and sensibly the same as that of the steam. But the condition of things when steam is entering a cylinder appears to the author to be entirely different; the steam is brought into sudden contact with a surface sensibly colder than itself; and to say that the condensation will depend upon the range of temperature is equivalent to saying that there would be no condensation at all after the temperature of the inner surface of the cylinder is raised to that of the incoming steam, a result directly at variance with both theory and practice. It appears to the author, that in a steam cylinder there will be a nearly constant rate of condensation due to conduction through the metal, and depending in amount on the mean temperature; and that to this should be added a variable rate due to the proportion borne by the range of temperature above the mean in the cylinder to the absolute mean temperature of the metal; so that if the absolute temperature of the incoming steam be denoted by T_1, and the absolute mean temperature of the inner surface of the cylinder by T_m, the maximum rate of condensation will vary as $1 + \frac{T_1 - T_m}{T_m}$, or as $\frac{T_1}{T_m}$. Also that in cylinders which are jacketed, or in which the flow of heat to the outside is prevented by any other equivalent means, T_m will approach T_1, and the effect of the range of temperature will become negligable.

Density of Steam.—Next, all the author's experiments, and all others which he has had an opportunity of analysing, tend most conclusively to show that the initial condensation varies directly as the density of the incoming steam; and it appears to him that this result is also one which must be expected on theoretical grounds. For whatever may be the nature of the action between the steam and any given portion of the condensing surface, it cannot be sensibly affected by the precisely similar actions going on simultaneously on other portions of the surface; and whatever be the rate of condensation, whether it be the same or different on each portion, it must depend directly on the number of particles of steam brought into contact with a given area, or, in other words, it must vary directly as the density.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—In reply to "Loco." in your issue of the 1st November, I would remind him that many of my figures are given to the public by the directors of the North-Eastern Railway Company, so that if wrong he must blame them.

I must repeat that it is a question of economy, and economy only, and I would ask "Loco." to consider the matter calmly, and give in figures what the cost per mile is of those 80 compounds against 80 of those obsolete engines he speaks of, built by Mr. Fletcher. I think he will have plenty of choice out of 1,426 engines. I presume that the 901 class and the Tennant express are included in the number 1,426 useless engines. It is well known on the North-Eastern what part the 901 class and Tennant express took in the late railway race, on the East and West Coast, from London to Edinburgh, compared with the compounds. Now, in order to give the compounds fair play in the future, let "Loco." select 80 of the obsolete non-compounds of the North-Eastern, and give your readers figures and data to form their unbiassed opinion. "Loco." seems to evade the question at issue—*i.e.*, a comparison of the cost of consumption of coal, repairs, and other general charges of the compound engines as against the non-compound (of the best type). When he gives data and proves his case, I shall be most willing to acknowledge myself at fault. However, let "Loco." give all the cost of maintenance of the two classes of engines, and not single out cost of coal only. Again, how does "Loco." account for the heavy increase of expenditure in the locomotive department if, as he states, the compounds have not been in the shops for two and a half years, and the saving of coal is what he would have us believe, notwithstanding that 80 of the obsolete engines have been dispensed with, and compound engines are working in their places so successfully? How is it that the locomotive department expenses are so excessive, and higher in this half-yearly report, than at any period of the history of the North-Eastern Railway Company? And especially may this question be asked when we take into account the additional machinery and plant that have been introduced at the Gateshead, Darlington, and York locomotive shops, and consider that the new plant was laid down in the best condition it is possible for a superintendent to have, and everything made smooth for the economical production of new engines, renewals, and repairs.

It cannot be said that it is for want of facilities to do the work expeditiously and cheaply. The task of selecting and arranging the machinery and plant as described was done by the present superintendent's predecessor, who did not remain to see the results of his labour. If he had, I have no doubt they would have been a credit to him. The engines he built speak for themselves by the work they do, which is not excelled by the engines on any other railway. Mr. Fletcher had to build his engines with the old plant, and yet in no time of his management have the expenses of repairs come anything near what they have been since the years of 1885 and 1889.

Mr. Fletcher left the service of the North-Eastern seven or eight years ago. Taking the life of a locomotive at fifteen years, the North-Eastern, at the present time, should turn out one hundred new engines per year; with the extension of plant no doubt they could do it, and this is what is required to keep up the locomotive power to its proper standard. "Loco." informs us that Mr. Worsdell has only made eighty compounds. Would "Loco." give us the number the present superintendent has made of other class since he came to the North-Eastern? then your readers would see for themselves whether a sufficient number of engines have been built by the North-Eastern for the last four or five years. The predecessor of the present superintendent was only with the North-Eastern about two years. The greatest portion of his time was taken up by re-arranging the Gateshead, Darlington, and York shops, and putting everything in the shops in good condition; the number of new engines under these circumstances, made and bought and added to stock of the North-Eastern, was very much in excess of what has been done since. Perhaps "Loco." will favour us with the number built for the last 4½ years, compound and non-compound. I feel sure that if "Loco." will oblige us with this information, we shall see that the 1,426 useless engines are worked to death, and I think that 80 of the obsolete engines will be able to hold their own in reference to cost of charges, all things equal, and especially so if "Loco." should venture to take those made, say, within the ten or twelve years.

Now, take the gross cost of expenses for locomotive power for 1877 and 1884 down to June 30th, 1889, which is as follows:—

December, 1877	£495,842 17s. 3d.
„ 1884	£527,135 14s. 0d.
„ 1888	£532,092 16s. 5d.
June 30th, 1889	£543,913 0s. 0d.

The difference of gross cost of locomotive power in the years 1877 and 1889 is £48,070 in favour of 1877.

Passenger miles run half-year December 31st, 1877 and 1888:—
December 31st, 1877, 4,032,528.
„ „ 1888, 5,427,242; increase, 1,394,714.

It is evident that the cost of locomotive power was £48,070 more in the half-year ended June 30th, 1889, than what it was in the half-year December 31st, 1877, and 1,394,714 train miles more were run in 1889 than were run in 1877, and it has cost £48,070 to do it. I think "Loco." will see from these figures that, with the addition of 80 compound and other non-compounds, there is not much to boast about over the obsolete engines running eleven years ago, with coal 10 per cent dearer in 1877 against 1888.

The sum of £53,000, out of a total of £107,000 additional expenses in the last half-year—*i.e.*, June 30th, 1889—was spent in the locomotive department (I think there must be some dead stock somewhere in the locomotive department). I am afraid "Loco." will figure to a disadvantage if he steps out of his present groove. I should advise him to leave off praising compounds unduly.

"Loco." charges me with coupling renewals and repairs together, so as to make out a nice case in favour of the non-compounds. Mr. Editor, I send you a copy of the half-yearly report of the North-Eastern Railway Company, of June 30th, 1889, which I shall be glad if you will insert here for the benefit of "Loco." and your readers. It is as follows:—

Half-yearly report North-Eastern Railway Company, June 30th, 1889. Submitted to the 71st half-yearly general meeting of the shareholders, at York, on the 9th of August, 1889:—

REVENUE.

	Half-year ending June 30, 1889.	Half-year ending June 30, 1888.	Increase.	Decrease.
	£	£	£	£
Passenger Traffic	711,031	651,820	59,211	
Parcels, Mails, &c.	143,376	133,833	9,543	
Goods Traffic	1,033,265	953,666	79,599	
Cattle Traffic	49,676	50,771	....	1,095
Mineral Traffic	1,160,099	1,079,181	80,918	
Miscellaneous Receipts	86,150	89,063	....	2,913
Gross Receipts	3,183,597	2,958,334	225,263	
Expenditure	1,703,305	1,595,816	107,489	
Net Receipts	1,480,292	1,362,518	117,774	
Miles open for Traffic	1,578	1,560		

EXPENDITURE.

Maintenance of Way—	£	£	£	£
Works and Stations	236,014	211,711	24,303	
Locomotive Power	543,913	491,019	52,894	
Carriage and Wagon Repairs	269,908	262,913	6,995	
Traffic Expenses	472,040	450,941	21,099	
General Charges	52,811	52,022	789	
Stationary Engines, Inclines, &c.	10,555	11,656	....	1,101
Law Charges	3,516	2,981	535	
Parliamentary Expenses	2,000	....	2,000	
Compensation	10,537	11,225	....	688
Rates and Taxes	96,378	96,113	265	
Government Duty	5,633	5,235	398	
Total	1,703,305	1,595,816	107,489	
Train Mileage	12,144,216	11,675,459	458,757	

"Loco." tells us that none of the compounds had been in the shop for repairs up to December 31st, 1888, but that a few have since that date. I think he is incorrectly informed. He seems to me to be guided by hearsay, which is sometimes, no doubt, convenient. Besides, repairs can be done elsewhere outside the shop, as there is such a place as the running shed. Perhaps "Loco." will find, if he goes to the trouble, that there are non-compounds running on the North-Eastern system with 26lb. of coal per mile daily, and would run with less (all other things equal) than the compounds. I think the "Practical Engineer," referred to in your issue of April 20, 1888, would find it difficult for the compounds to show better results than this. Some of these engines have not been in the shop for four years.

I am pleased to inform "Loco." that I have all the back numbers of *The Practical Engineer* he refers to, and I intend to have them bound for the years 1888 and 1889, and I have also the *Newcastle Chronicle.*

I think "Loco.'s" advice to me, to read the comments of a "Practical Engineer" on the merits and demerits of compound and non-compound engines, in your issue of April 20, 1889, goes for very little. It is, no doubt, a very able article, and, no doubt, by a very able man, but I think it was written a little too soon. Probably he is a friend of "Loco.'s;" if so, I am glad of it. It may come true some day, but up to the present we have not sufficient data to lead us to the conclusion "Loco." would have us believe; at least the shrewdest engineers do not seem to be in a hurry about compounding locomotives.

"Loco.'s" remarks about the boiler explosion which occurred during Mr. Fletcher's time, are very uncalled for, as the explosions are not the cause of those excessive charges for repairs; it is to be found somewhere else. Perhaps Mr. Fletcher was a little lax in the matter of boiler inspection, but that does not go to prove that he is not an engineer. Mr. Fletcher was engineer for over 40 years to the North-Eastern Railway Co., and the reputation and respect with which he is held by the directors of the North-Eastern will never be tarnished by the pen of "Loco." Perhaps "Loco." is not aware that it was the predecessor of the present superintendent who instituted an efficient boiler inspection department and staff to prevent boiler explosions, and I am not aware that a single boiler explosion has occurred since on the North-Eastern, and no engineer in the kingdom was more alive to the importance of this department than he was.

I will give "Loco." my word I have no desire to rush into print, but when I read such statements as his, it is time someone should speak and correct him and his American cousin. He stated that the 7ft. 6in. new passenger engine (compound) took 30 carriages with as much ease as a simple or non-compound would 18. Now, will "Loco." inform your readers whether this identical engine took six carriages (not 30) on a trip a few days after the one referred to, and when it got to Bilton it stuck and would go no further, and that one of the obsolete engines had to be called into requisition to pull the lame dog and his carriages over the stile, and give it another start, and send the engineers home again who had gone with it to see its performance.

"Loco." speaks of the locomotive department being troubled with the dead stock of the traffic department. This engine, with its 30 tons of dead weight, might be referred to by the traffic department in similar terms. "Loco." asks me if I think that the superintendents of other railway companies who are building non-compounds are so foolish as not to make their boilers carry 175lb. and 180lb. of steam to the square inch, if they found better results by so doing. Here "Loco." displays deplorable ignorance of what other railway companies' superintendents are doing. Using his own words, he is unconsciously condemning what is being adopted—*i.e.*, making boilers of non-compound engines carry higher pressure.

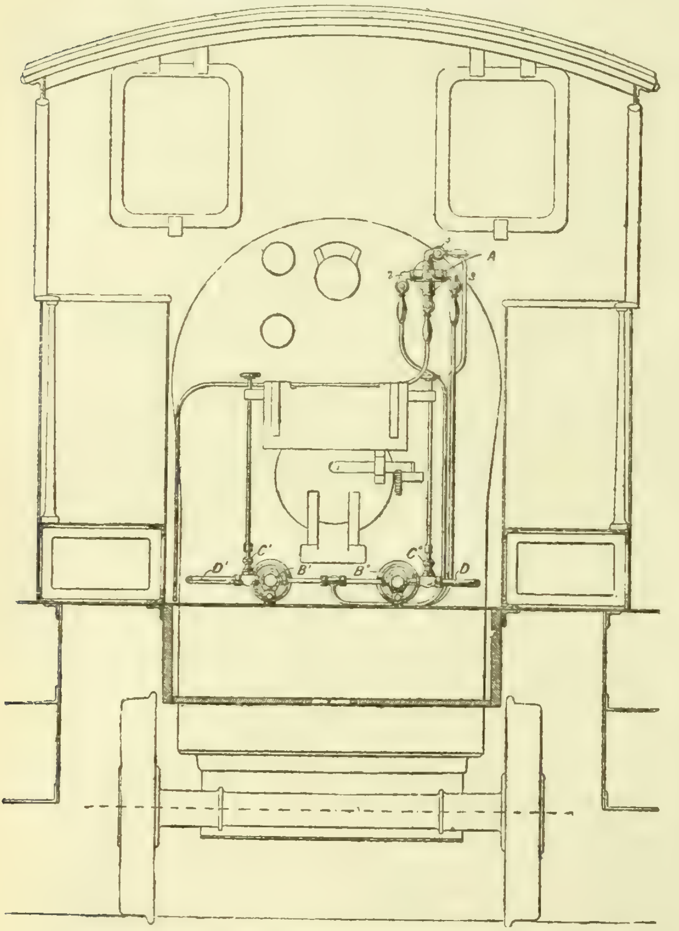
In conclusion, Mr. Editor, I shall not consider it my duty to reply again to "Loco." unless he gives facts and figures in support of his statements.—Yours, &c.,

FAIRPLAY.

QUERIES AND REPLIES.

134. **Liquid Fuel.**—I am told the Great Eastern Railway runs some of their trains with locomotives burning tar and oil, &c., for fuel. Can any of your correspondents give me particulars of the burner or sprayer used, and say if it is applicable to ordinary vertical boilers? How do you start the fire, and what about standing? does the fire go out, as I presume, if the burner keeps at work, too much steam would be made? What do they do about draught? Any particulars would be very acceptable.—W. E. D.

Answer.—As this subject of liquid fuel is just now engaging so much attention, and in the near future is likely to become a successful competitor with coal, I will, with the editor's permission, give some account of the particular system referred to. The apparatus used on the Great Eastern Railway is the invention of Mr. Holden, the present locomotive superintendent, and is, I believe, the only one of its kind having a practical and extended application in this country. The arrangements on a locomotive are very simple, no alteration being made to the ordinary fire-box. The drawing herewith shows very clearly the fittings arranged on a Great Eastern Railway tank engine. A represents a fitting for supplying steam to the injectors, &c. The liquid fuel is fed to the fire-box or furnace by the two injectors shown at B^1B^{11} with nozzles pointing through holes about 5in. diam., provided in the fire-box front. These injectors are of novel construction, and form one of the chief features of the invention. An internal steam jet (regulated at 2 on fitting A) delivers the liquid fuel, the quantity being adjusted at the valves C^1C^{11} through a nozzle with two or more holes, where it comes in contact with a current of air induced by a number of small steam jets issuing from a hollow ring provided at the front end of each injector (this steam is admitted and controlled by 3 on fitting A). This arrangement of ring blower for air ensures the perfect combustion found wanting in so many other liquid fuel injectors and burners. The cock 1 is provided for warming the liquid, if thick, in the tank, and 4 is for clearing the pipes and injectors. An ordinary fire-brick arch in the fire-box receives the impact of the flame. A coal fire on the usual fire-bars raises the steam at first, and when the liquid injectors are started and burning, the fire is made up with broken brick, chalk, cinders, &c., to form a base and cover the bars. When standing at stations, &c., the liquid can be entirely shut off, and the remaining incandescent base of coal and refractory material will ignite the liquid when the injectors start again. As to draft, as your correspondent evidently assumes, very little is required, and the blast pipes of the engines burning liquid fuel have been increased in area at the mouth to reduce the velocity of the escaping steam. A cap or ring of the ordinary (coal burning) area is, however, provided, and is hinged to the top of the blast pipe in such a manner that it can be closed down over the larger orifice from the foot plate should coal only be used and a sharper draft required. Respecting fitting to vertical boiler, one of the patent injectors with steam and liquid fuel supply, directed through a hole cut at side of the fire-door, with a few fire-bricks opposite to it in the furnace, are the only requirements, the boiler being as readily fired with coal after the addition of apparatus as before. A. M. B.



140. **Computing Power of Compound Engines.**—(1) I wish to know how to compute the lift and I.H.P. approximate of compound and triple-expansion pumping engines, and ordinary marine or land engines, having given diameter of cylinders, stroke, piston speed, and steam pressure at H.P. cylinder. I have seen it computed by ascertaining the ratio between H.P. and L.P. cylinders, and by that means finding, from steam expansion table, what the mean pressure of steam would be on pistons; but I do not know exactly how to find this ratio, and, having found it, to ascertain (by steam expansion table) what portion of stroke this is equivalent to cutting off at. (2) What usually determines the relative sizes of steam cylinders in compounds—I mean what ratio do they usually have one to another?—Draughtsman.

Answer.—The method referred to by "Draughtsman" for ascertaining the power of compound engines is one in which the total expansion of the steam throughout the system is first calculated from the formula—

$$R = \frac{AL}{al};$$

in which R = the ratio of expansion;
A = the area of the large cylinder;
a = the area of the small cylinder;
L = the length of stroke;
l = distance travelled by the piston before steam is cut off in the small cylinder.

Then, knowing R, we are able to ascertain the mean pressure referred to the low-pressure cylinder; that is to say, if
M = the mean pressure in the large cylinder;
m = the mean pressure in the small cylinder;
and $\frac{A}{a} = r$;

then the mean pressure referred to the low-pressure piston will be

$$M + \frac{m}{r},$$

and will be the same as if the steam were cut off at $\frac{1}{R}$th of the stroke. Then if P represent the initial pressure of steam in small cylinder, including atmosphere, the mean pressure referred to the low-pressure piston will be given by the formula—

$$p = P\frac{1 + H}{R} - \text{back pressure in large cylinder};$$

H being the hyperbolic logarithm of R, the hyperbolic logarithm of any number being found by multiplying the common logarithm of the number p 2·3026. So that, having found p, we can proceed to calculate the horse power, which will be—

$$\text{I.H.P.} = \frac{A \times p \times \text{piston speed}}{33{,}000}.$$

In determining the relative size of cylinders in compounds, three things should be striven for, viz., (1) the power developed should be as nearly as possible equally divided between the two cylinders; but whatever the ratio of the cylinders, it is a comparatively easy matter to so set the valves that the power shall be thus divided, but in doing this we must aim at (2) keeping the initial loads on the pistons as nearly equal as possible, and (3) also the range of temperature in each cylinder.

Mr. Seaton, in his "Manual of Marine Engineering," gives the following rule for the size of cylinders of triple-expansion engines, which fairly represents the practice of some of our leading marine engineers:—

$$\text{Area of high-pressure piston} = \frac{\text{Area of low-pressure piston}}{\text{cut-off in high-pressure} \times \text{rate of expansion}}$$

$$\text{and area of intermediate piston} = \frac{\text{Area of low-pressure piston}}{1{\cdot}1\sqrt{\text{ratio of low to high pressure piston}}}$$

The following ratios of the cylinders of compound pumping engines are from actual practice, viz., 1 : 3·9; 1 ; 4·3; 1 : 4·45; 1 : 3·08; 1 : 4.—I. H. P.

142. **Impact on Beam.**—A beam will safely carry a stationary load of five tons with a deflection of two inches. From what height may a weight 200lb. be let drop upon the same beam without deflecting it to a greater extent?—Student.

Answer.—If the full load W be applied to the beam direct, producing a deflection of a feet, the work done upon the beam will be W a foot-pounds; the work stored in a moving body of weight w lbs., and velocity v ft. per second $= \frac{w\,v^2}{2g}$; equating these, we have $\frac{w\,v^2}{2g} = W\,a$. Now, a body will acquire a velocity of v ft. per sec. in falling a distance of h ft. $= \sqrt[2]{2g\,h}$, so that the value of $v^2 = 2g\,h$, and substituting this value in the above equation, we have $\frac{w}{2g} \times 2g\,h = W\,a$; reducing, we get $w\,h = W\,a$, or $h = \frac{W\,a}{w}$, and applying this to the query $h = \frac{2240 \times 5}{200} \times \frac{1}{6} = 9\frac{1}{3}$ft. If, however, the weight increased gradually from a minimum o to the maximum of 5 tons, then the work done would be $\frac{W}{2}\,a$, and consequently the height found above must be reduced to one-half the distance. The above holds so long as the stress does not exceed the elastic limit.—Orion.

143. **Consumption of Fuel.**—Will any reader kindly supply me with the following information, taken from the most modern practice of our principal engine builders? 1. What is the consumption of coal per I.H.P. for (a) ordinary high-pressure steam engines working expansively; (b) ditto condensing; (c) ditto compound non-condensing; (d) ditto compound condensing; (e) ditto triple-expansion non-condensing; (f) ditto triple-expansion condensing. 2. What difference does steam jacketing make in coal consumption? 3. Is there any material difference in the consumption of coal per I.H.P. shown by engine, in multitubular, Lancashire, and Cornish boilers? Any information relative to the above, also *re* consumption of coal per I.H.P. for direct-acting steam pumps, such as Worthington type, will be esteemed by—F. J.

Answer.—"F. J." asks for the consumption of coal per I.H.P. for different classes of engines without stating what class of boiler he has behind them. More properly, the engine is spoken of as consuming steam, and, for purposes of comparison, this is measured as so many pounds per horse power per hour; from which, knowing the evaporative efficiency of our boiler, or the pounds of water evaporated per pound of fuel, we can obtain the pounds of coal burnt for every 1 horse power indicated in the engine, which, I take it, is what "F. J." means. Then again, for comparison of boilers it is necessary to reduce their performance to a common standard, which is done by stating the equivalent to their actual evaporation, under their particular working conditions, in the pounds of water the boiler would evaporate from, and at a temperature of, 212 deg. Fah. This equivalent value is found as follows: To the total heat of the steam generated at the given absolute pressure add 32 deg., and from the sum subtract the temperature of the feed water, and divide the remainder by 966. Multiply the given weight by the quotient, the product being the equivalent weight of water evaporated from at 212 deg. Fah. Now, the performances of boilers are expressed in this manner, and the following are some values taken from actual trials of the class mentioned:—

Class of Boiler.	Water evaporated from and at 212 deg. Fah. per lb. of coal.
Lancashire	8·2 to 10·8
Cornish	8 to 10
Locomotive	8 to 11·2

Now for the engine performance—that is, the lbs. of steam used per I.H.P. per hour. This again depends on a great many varying conditions, the principal being the steam pressure and rate of expansion; so that in giving values from trials it is necessary to state the initial steam pressure and the rate of expansion, as in the following table, which is compiled from actual results obtained.

TABLE GIVING LBS. OF WATER PER I.H.P. PER HOUR IN DIFFERENT CLASSES OF ENGINES, TAKEN FROM ACTUAL PRACTICE.

Absolute initial pressure of steam	75	90	110	135	160	175
Rate of expansion	3	3·6	4·4	5·4	6·4	7
High-pressure engines	30	27	26	—	—	—
Simple condensing	25	—	23	—	—	—
Compound non-condensing	—	24·2	21·5	20	19	—
Compound condensing	—	22	19	—	—	15
Triple-expansion non-condensing	—	—	—	—	18	—
Triple-expansion condensing	—	—	—	—	18	17·3

Then, having this table, we proceed to find coal consumption, in lbs. per H.P. per hour, thus—

$$\text{Coal per H.P.} = \frac{\text{lbs. water per H.P. per hour}}{\text{lbs. of water evaporated per lb. of coal.}}$$

TRIAL.

144. CURVATURE OF RIM OF PULLEY.—How do you find the proper curvature to give to the rim of pulley? Does it simply depend on the width of the belt, or does it also depend on the thickness of belt, speed of belt, and diameter of pulley? A leather belt, about $\frac{1}{4}$in. thick, is to travel at about 3,000ft. per minute over a 27in. pulley of 8in. face. What should be the difference between the diameter of pulley at the centre of the rim and at the edge?—RAW HIDE.

Answer.—As the object of giving a pulley curvature is to retain the belt in a central position on the rim, practical experience has determined the amount necessary, and it is found that if the radius of the pulley is made equal to from three to five times the width of the rim the belt will run well upon it. If your pulley has a rim 9in. wide, the radius should be about 36in.—J. R.

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138. SOLID-DRAWN TUBE.—I wish to make a number of lengths of solid-drawn copper tube $\frac{3}{8}$in. internal diameter and $\frac{7}{16}$in. external. I shall feel obliged if anyone will give a description of the necessary tools.—L. M.

141. POWER OF HOISTING BLOCK.—It is found by trial that when P is on the point of lifting W by means of a single fixed pulley, $P = (1 + m) W$, where m is a fraction depending on the friction of the parts of the machine. If three such pulleys are combined into a "block and tackle," find the power requisite to raise a given weight by means of it.—STUDENT.

145. THICKNESS OF CAST-IRON PIPE AND PROPORTION OF ENGINE CYLINDERS.—Would any engineer inform me the thickness of cast iron for 8in. diameter steam pipes to be safe from bursting with 80lb. of steam per square inch in the boiler, and what diameter of cylinders would you recommend to work compound side by side? Corliss high-pressure cylinder, short slide valve for low-pressure cylinder, to drive 200 I.H.P., 44 turns per minute, 4ft. 6in. stroke, 80lb. of steam in boiler per square inch. Information will oblige.— J. C.

146. RETURNING CONDENSED WATER FROM STEAM JACKET TO BOILER. What is the best means of returning the condensed steam from the steam jacket of a cylinder to the boiler when the level of the engine cylinder is below the water level of boiler?—ECONOMY.

147. EXHAUST STEAM INJECTOR.—Will any reader kindly inform me if the above could be applied to a condensing engine, or would it interfere with the vacuum? I believe they require very little steam to work them. A. S.

148. AUTOMATIC VACUUM BRAKE.—Can any reader inform me the reason why, when the brake is applied from the engine, it always takes hold of the last carriage first? It always seems strange to me why it should do, and I shall be extremely obliged for any information on the subject.—W. G.

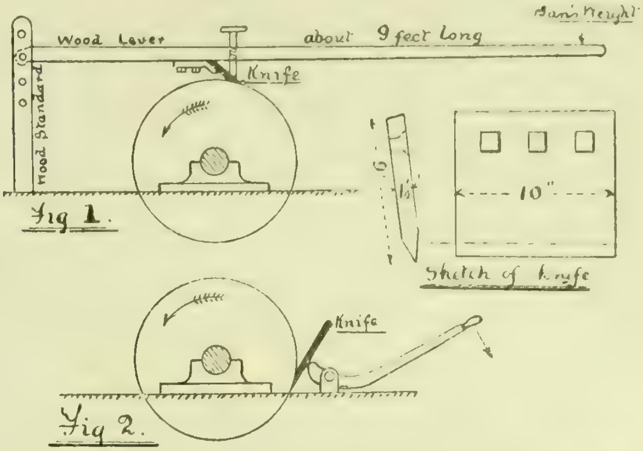
150. LEATHER BELTING.—I wish to know the width of double leather belt to transmit 200 I.H.P. Belt flywheel 14ft. diameter, 72 revolutions per minute; driven pulley 10ft. diameter, 30ft. centre to centre. Please give formula.—ANXIOUS,

151. MARINE GOVERNORS.—Could any reader tell me whether there are any marine governors that work independently of the engine—that is, do not derive their motion from the engine. If there are any, I should be very much obliged for a short description of each.—MARINE ENGINEER.

152. HYDRAULIC SWIVELLING JOINT.—Will any of your readers kindly describe by the aid of sketches the construction of a swivelling pipe joint by which water pressure may be transmitted to a crane which revolves or has a limited travel?—HYDRAULIC.

153. SATURATED STEAM.—Why does its pressure rise in a ratio which slowly increases, referred to the temperature? And why does the amount of total heat slowly increase with the increase of temperature?—S. B.

149. GRINDING STEEL KNIVES.—In our establishment we use steel knives, bolted on to a metal pulley, for chopping rope, &c. They have to go through the process of grinding twice a week, which takes two men, one at the end of the lever, and one to stand by the knife; in some mills similar it is done by one. I send sketch of our present system, fig. 1, and also an idea of the principle of the one-man system, fig. 2, one hand on knife and one on lever, which might be greatly improved. Would any of your readers suggest an idea applicable with little expense? The one-man system is very simple but, in my opinion, dangerous.—PRIMROSE.



154. INJURY TO EYES BY ELECTRIC LIGHT AND LUCIGEN LIGHT.—I should be very much obliged if any of your readers could kindly tell me which is the most injurious to the eyes, a strong electric light (without globes) or the Lucigen light?—J. S. S.

155. POWER AND COAL CONSUMPTION OF ENGINE.—Would any reader kindly inform me what I.H.P. engine ought to drive the following dimensions: diameter of cylinder 14in., stroke 24in., revolutions 80 per minute, automatic cut-off valve, boiler pressure 50lb., belt driving from flywheel 6ft. 6in. diameter; also what amount of coal (slack) should be used for the amount required, to work at best advantage?—YOUNG MAN.

156. TRIPLE EXPANSION.—Can you or any of your readers advise me as to the best proportions of cylinders for 150lb. boiler pressure? We have a pair of horizontal condensing engines, with cranks at right angles, now working with 60lb. boiler pressure, and we propose putting in new boilers for 150lb. pressure, and converting the engines into a triple expansion by substituting for one of the cylinders two smaller ones, placed tandem fashion. Present cylinders 40in. diameter, 6ft. stroke, to run when altered at 35 revolutions, horse power about 600. As the first cylinder will be of very small diameter for the stroke, should any difference be made in the ratios? What is best point of cut-off? How about jacketing?—J. R.

PATENTS AND INVENTORS' QUERIES.

35. ROYALTIES.—The article for which provisional protection has been obtained is a reservoir or fountain pen. What is the usual royalty for such articles?—SCRIBO, Cheshire.

Answer.—10 per cent on net selling price if the invention is completely worked out and acts well.

36. COMPRESSION IN AIR ENGINES.—Who first explained the theory of compression in air engines such as Ericsson's?—H. S., Peckham.

Answer.—Joule's paper on the constant-pressure type of engine, referred to by Rankine in his great work, "The Steam Engine," is, we believe, the first indicating the theory of the subject.

TO CORRESPONDENTS.

VALVE GEAR, Cheltenham.—We shall describe the three engines you mention very soon.

EN ROUTE, Stockton-on-Tees.—Write to the Secretary of the Institution of Mechanical Engineers, A. Bache, Esq., Victoria Street, Westminster, London. He will forward you the forms. It is necessary to get the signatures of several members recommending you.

ANXIOUS, Motherwell.—Kindly repeat your query. We have prepared blocks for it.

NEW PENDULUM.—The new pendulum, of which you send sketch, seems novel, and worth patenting.

J. W. C., Vauxhall.—Thanks for expressions of approval. We make our leaders as practical as possible. The articles on Mechanical Drawing will shortly be published by us in book form, going most fully into the subject.

MISCELLANEA.

It is reported that a discovery of salt has been made near Middlesbrough. The thickness of the seam has proved, so far, 65ft., and is met with at a depth of 1,680ft.

The "most powerful tug in the world" is believed to be the Dalhousie, built of steel by W. Denny and Brothers for a company at Calcutta. She has two sets of compound surface condensing engines, each driving a three-bladed screw, the total I.H.P. being considerably more than 2,000. The boilers are double-ended, working at 100lb. pressure. The vessel is 215ft. long, 32ft. broad, and 16ft. 6in. deep.

Proposed Electric Lighting at Morecambe.—Application has been made to the Board of Trade by Messrs. Andrews and Preece, electricians, Borough Mills, Bradford, for a provisional order, empowering them to construct and maintain electric works and appliances, and to produce and supply electricity for private and public lighting and other purposes, within the Morecambe Local Board district.

The attempt which one of our great English railways is making on a small scale to use petroleum as fuel is being practically made in Russia on a large scale. All the steamboats in the Caspian Sea are using naphtha residuum and oil as fuel. In Moscow the factories are also taking to it; and on the Volga steamboats are beginning to use it. Cheap petroleum for some purposes may check the advance in the price of coal.

A Berlin manufacturer is offering for sale an oil can with a small lantern attached, and a reflector, which is intended to enable the oiler to do his work without carrying a lantern in one hand and an oil can in the other. The lamp burns colza oil (a vegetable oil which still competes with petroleum on the Continent, and especially in France), and the oil holder is inserted in the oil can, and serves to keep the lubricating oil warm in cold weather.

A Large Hydraulic Press.—At the ironworks at Croyet-Fourneyroy, in France, there has just been constructed for the Lyons arsenal a hydraulic press, which is one of the largest in the world. The sole plate on which the press rests is a solid mass of iron weighing 35,000 kilos., and the weight of each of the columns supporting the top part (which is of steel, weighing nearly 12 000 kilos.) is 8,270 kilos. The total weight of the press is given at 3,000 tons.

Electric Light in Carriages.—Several wealthy Chicagoans are having their carriages wired for incandescent lighting, placing two or more battery lamps in the interior and one on each side of the driver's seat, the necessary current being supplied from a set of storage cells placed beneath the carriage seats, and recharged at one of the local lighting stations as often as required. The great convenience thus afforded has but to be once enjoyed to be thoroughly appreciated.

Portable Tramways in India.—The following note appears in the Calcutta *Englishman* (overland mail) in its edition of the 8th October: One of the first experiments in India in the use of a portable tramway for the carriage of forest produce is now being tried in the Anamalais, where a line has been laid down under the orders of the Madras Government. A line of about three miles will shortly be laid on a section of the Chittagong-Demagiri road.

Newcastle Steam Boiler Insurance Company.—The *London Gazette* announces that, at an extraordinary general meeting of the Newcastle-on-Tyne Steam Boiler Insurance Company Limited, held at the offices of the said company, 34, Grey Street, Newcastle, 19th Oct., it was resolved: "That the company be wound up voluntarily under the provisions of the Companies Acts, 1862 and 1867, and that Mr. Thos. Gillespie, of the city and county of Newcastle-on-Tyne, chartered accountant, be and he is hereby appointed liquidator for the purpose of such winding up."

Blackpool Electric Tramway Company.—The fifth annual meeting of the shareholders in this company was held on Saturday, November 23rd, Mr. Alderman R. Horsfall, Halifax, presiding. The chairman moved the adoption of the report, which showed that the profits of the year had been £2,983, out of which it was proposed to pay a dividend of 7 per cent, making £1,401; to pay £1.350 to the depreciation and reserve funds, and to carry the remainder forward. The dividend of 7 per cent was declared, and Messrs. T. H. Morris and J. Oddie, Halifax, were re-elected directors.

The company working what is called the Mediterranean system of the Italian railroads (owned by the Government) at the beginning of its last year had 205 locomotives, 527 passenger cars, 123 baggage cars, and 148 freight cars equipped with the Westinghouse brake; while 41 engines, 465 passenger cars, and 73 freight cars were equipped with the Smith-Hardy brake. Both together form but a small part of its equipment; it has 3,282 passenger cars. It ordered 80 new passenger cars this year, 40 of them with the Westinghouse brake, and 392 new freight cars, 50 with the Westinghouse brake.

A requisition was presented to the Mayor of Manchester (Alderman J. Mark) on Monday, the 18th inst., by a deputation from the Council of the Literary and Philosophical Society, to convene a public meeting to consider the desirableness of raising a public memorial of the late Dr. James Prescott Joule. The deputation consisted of Professor Osborne Reynolds, Alderman Thompson, Mr. C. Bailey, and Mr. F. J. Faraday. The Mayor said he had no hesitation whatever in acceding to the request. He was entirely in accord with the deputation as to the desirableness of perpetuating the great name of Dr. Joule.

Large Printing Frame for Photo-Tracing.—A very large blue printing frame has been recently completed by Clifford M. Batchellor, foreman draughtsman at the Rhode Island Locomotive Works. It is built of wood, with brass corner pieces, trunnions, and fittings. The capacity of the glass is 72in. by 32in The frame is first mounted upon a turntable, normally latched, so that the frame is run out and in parallel with the side of the building, but which can be adjusted to suit the position of the sun, and held in place by a sliding jointed brace rod. The glass is adjustable to any angle in its trunnions, and a gauge is provided so that a number of prints may be taken at exactly the same position. When the frame is run in the backing is lifted by a set of counterweights, and the print and tracing may be removed with ease.

Wharton McKnight, of the Anchor Foundry (Pittsburgh, Pa.), has a block of Bessemer steel, 10in. by 10in. by 7in., 5in. of which has been treated by the Redeman-Tilford Steel Company, being rendered virtually drill-proof, the remaining 2in being soft. This is made as a specimen of the plates the Redeman-Tilford Steel Company are preparing for the cruisers of Uncle Sam. Mr. McKnight could make no impression with chisels or ordinary tempered drills upon the hardened portion of the block, although he tried several kinds of tool steel salt water hardened, with some of Park Bros.' special tool steel lead hardened; after an hour and a quarter's drilling he managed to penetrate three-fourths of an inch into it.—*American Manufacturer.*

Red Phosphorus.—Backed by the recommendations of the Academy of Medicine and the Hygienic Council, a bill is about to be introduced into the French Chamber to make the substitution of red for yellow phosphorus in the manufacture of lucifer matches compulsory. It is now four-and-forty years since Shrotter discovered red or amorphous phosphorus; and, considering how long it is since its safety in match-making was recognised, the wonder is that its enforced use has been so long delayed. The red phosphorus cannot be dissolved in a draught; it is not poisonous; introduced into an animal, it is excreted as it entered; it undergoes no alteration by exposure to the air; it is not ignited by friction; it has to be heated to 260 deg. in order to take fire; and when it alone is used in match factories, there can be no deadly phosphorus disease.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

November 5th.

17596 Couplings, H. Bayley, London.
17599 Valve Handles, J. B. Heighington and W. Heighington, London.*
17604 Hydraulic Elevators, P. A. Newton, London. (Otis Brothers and Co., United States.)*
17605 Connecting Pipes, C. Barnett, London.
17608 Oil Caps, J. W. Cunningham, London.
17609 Steam Engines, C. Wells, London.
17612 Tubes, W. E. Hill, London.*
17624 Oil Cups, E. D. Bangs, London.*
17625 Launching Torpedoes. (Hotchkiss and Co., France.)*

November 6th.

17637 Composition for Boilers, T. Duggan, Liverpool.
17641 Fastening Pulleys, W. P. Thompson, Liverpool. (F. W. Killing, Prussia.)
17648 Spanners, W. Dowland, Southampton.
17651 Pulley Blocks, J. Swalwell, Newport, Monmouthshire.
17654 Pistons, P. Frodsham, jun., Bolton. (P. Frodsham, sen., Russia.)
17655 Rotary Blowers, D. Steffano and A. A. Garside, Barnsley.
17660 Governors, R. F, C. Keats, Portsmouth.
17669 Bolts, J. Wiley and G. Wiley, Birmingham.
17675 Governors, W. A Higginbotham, Dublin.
17687 Bearings, H. J. Haddan, London. (M. Mavet-Metcalf, France.)
17694 Electrical Meter, E. Wilson, London.
17697 Gas Mains, D. Irving, London.*
17699 Ingots, C. Davy, London.

November 7th.

17713 Water Regulator, W. Slatter and W. J. Watkins, London.
17714 Lathes, D. Barnett, Birmingham.
17717 Water Heating Apparatus, H. Ward, Birmingham.*
17726 Couplings, T. Cooke and J. H. Wilkinson, Astley.
17739 Water Gates, F. G. M. Stoney, Glasgow.
17745 Valves, T. Downie, London.
17755 Bearings, R. W. Atkinson, London.
17764 Axles and Bearings, J. Stone, London.
17778 Economy in Fuel, H. H. Lake, London. (G. W. Wilcox, United States.)
17782 Valves, J. Hübner and I. Mayer, London.

November 8th.

17789 Bicycles and Tricycles, T. J. Thompson, Birmingham.*
17802 Cylinders, W. Sumner, Manchester.
17825 Pumping Apparatus, B. Latham, R. E. von Lengerke, and A. Rigg, London.
17835 Belts, F. W. Barker, London. (F. W. Nichols and J. E. Ingersoll, United States.)
17836 Packings, W. A. Bennett, London.
17840 Wire-twisting Machines, J. Atherton, London.*
17846 Valves, J. A. Hopkinson and J. Hopkinson, London.
17847 Water Gauges, J. A. Hopkinson and J. Hopkinson, London.
17849 Locomotive Engines, F. C. Winby, London.
17850 Coupling Links, L. C. H. Mensing, London.

November 9th.

17863 Engine Packing, W. Ames, sen. and C. Gaul, Bradford, Yorkshire.
17877 Furnaces, L. Gardner, London.
17886 Couplings, J. Evans, London.
17891 Tubular Boilers, A. F. Yarrow, London.
17914 Steering Gear, W. Clark, London.*

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

DECEMBER 6TH, 1889.

THE MANCHESTER STEAM USERS' ASSOCIATION.

WE print, in another column, an account of the annual meeting of the Manchester Steam Users' Association, which was crowded out of our last week's issue by press of other matter. The subjects touched upon in the report of the committee of management, and in the address of the chairman, Mr. J. Ramsbottom, C.E., to the members present at the meeting, are of such importance at the present time to steam users, who comprise so large a proportion of our readers, that we make no apology for considering them at some length.

We think it may be conceded that few things have contributed more to the present state of perfection of boiler engineering than the inauguration by Sir William Fairbairn and his colleagues, in 1854, of the Association for the Prevention of Boiler Explosions and for the Attainment of Economy in the Use of Steam, followed as it was so soon afterwards by the establishment of other companies, which led to the work of boiler inspection and insurance being energetically prosecuted. The investigation of boiler explosions, and the valuable practical information which was for so many years published in the Association's monthly reports respecting the causes which most commonly led to boiler explosions, did probably more than anything else to dispel the once commonly held notions which used to attribute these disasters to mysterious agencies, and demonstrated that the prevention of boiler explosions was well within the range of practical engineering. Next to the prevention of explosion, another object which we believe the founders of the Association had in view at the outset, was that of averting official or governmental interference with the businesses of private firms, by attempts to regulate the working or inspection of their boilers. It was clearly recognised by the pioneers of boiler inspection that any interference with the working of their boilers might lead to the imposition of harsh and arbitrary regulations which would entail serious inconvenience and hardship on many steam users; and hence the desirability of establishing a voluntary system of periodical examination by which such disasters as boiler explosions would be prevented, and all necessity for any arbitrary rules or regulations on the part of Government or other authority would be obviated. Bearing this in mind, it is not easy to understand why of late years the Association's officials should have been so persistently endeavouring to induce Government to legislate on this question, and to persuade Parliament to decree the compulsory registration and inspection of all boilers within the United Kingdom. It is, of course, well known that "The Boiler Registry and Inspection Bill," introduced into the House of Lords some two years ago by Lord Stanley, when President of the Board of Trade, but afterwards abandoned, really emanated from the Association, and the recently issued report of the Committee of Management above referred to informs us that the more recent "Steam Boilers' Insurance Bill," introduced into the House of Commons by Sir William H. Houldsworth in February last, was "very carefully prepared" by the Association's committee or officials. Under these circumstances, we can scarcely agree that "the fundamental principles and objects of the Association had been maintained," as stated in the report, if it is the fact that one important object which the founders of the Association had in view at the outset was the avoidance of any compulsory interference with the working of their boilers, by voluntarily submitting them to competent supervision.

The Association has never been very tolerant of its rivals in the business of boiler inspection and insurance (whether reasonably or wisely so we are not prepared to say), and in the report before us the fact that, after 35 years' existence, the number of boilers under the Association's inspection is less than 5,000—no more in fact than at the end of 1877—whilst several of its younger rivals have many times that number under their supervision, is attributed to the increasing number of "joint-stock boiler insurance companies" with which the Association has to compete in extending its membership. Possibly this may account for the zeal manifested by the Association in later years to promote legislation, and, looking at some of the clauses in the Association's latest bill, which lays down certain well-defined conditions under which boiler insurance companies only shall be empowered to insure boilers or issue "certificates of safety," it is not surprising that the chief engineer of the Engine, Boiler, and Employers' Liability Insurance Company (Mr. Michael Longridge) should, in his last annual report, define Sir W.

Houldsworth's bill as "a bill for the regulation of steam boiler insurance by the Association's rivals in business."

As we have already stated, boiler engineering owes much to the Association, which in the past has done excellent work, the importance of which cannot be over estimated. It is capable of doing much more, and of solving effectually many problems in practical engineering of the greatest importance to steam users which are urgently pressing for solution. The chairman, in his address the other day, stated that "in spite of the keen competition which now existed from the number of boiler insurance companies plying for dividend," the reserve fund at present stood at £11,631, a higher amount than it had ever before stood at, and £371 had been added to the fund during the past year. Great things could be done with such a fund properly applied in the interests of steam users, and it is satisfactory to note from the chairman's remarks that the Association is prepared to do something towards assisting its members in reducing the smoke nuisance, a subject which is again being brought prominently forward.

It is to be greatly feared, however, that the zeal displayed during late years in effectively endeavouring to bring about boiler legislation, which at best may only yield a questionable advantage, has paralysed or absorbed the energies formerly devoted to useful engineering work. For several years the monthly reports of the Association's chief engineer, which formerly contained so much useful and interesting matter, have been discontinued. Experiments were made many years ago in bursting experimentally a full-sized Lancashire boiler, but nothing more than one or two spasmodic references, so far as we are aware, have ever been made to the result. Later still, also, we believe attempts have been made by the Association to determine how far it is safe to inject cold water into a red-hot internally-fired boiler; to note the behaviour of furnace tubes under various conditions of shortness of water, &c., and many interesting experiments are said to have been carried out with such a boiler; but, although years have elapsed since these experiments were made, no report, so far as we know, has yet been published. Instead of frittering away its resources in abortive attempts at amateur legislation, could not the Association do better and more useful work with the splendid facilities at its command, if its skilled and trained engineers were allowed to devote their surplus energies to the determination and solution of practical engineering problems, which would be of benefit to all the Association's members?

It is no part of our province to defend boiler insurance companies, most of whom are doubtless well able to take care of themselves, and we deprecate as much as anyone the degradation of the service of inspection, which is likely to result from the lowering of rates, &c., caused by the keen competition which at present exists for this class of business. We believe, however, we are right in saying that the Association itself owes something to these companies, for it was only when the competition of insurance companies forced it upon them, that the Association undertook any pecuniary liability; and we are credibly informed that up to the institution of the "guarantee," making it pecuniarily liable in the event of damage to boilers occurring, the work of the Association was performed in but a perfunctory sort of manner. It now covers damage from explosion, from overheating of furnace tubes from shortness of water, injury to economisers, &c. (which cannot possibly be thoroughly inspected), and it is consequently, to all intents and purposes, an insurance company, although it professes to "guarantee" and not "insure."

The principle of "no inspection, no insurance," referred to by the chairman, is undoubtedly a good one, and we commend Mr. Ramsbottom's remarks on this point to the earnest consideration of boiler insurance companies generally. Space will not permit of our dealing further with this subject at present, but we would point out in conclusion that the Association has the pick of the boilers in the country, and will not "guarantee" many types of boilers which insurance companies include in their risks. It is in a better position than any other company for dictating to its members, and the failure of boiler insurance companies to get "thorough inspection as often as is desirable" results more from the well-known unwillingness of many boiler owners to stop their works and prepare their boilers for examination, than from any remissness or shirking of their duty on the part of the insurance companies.

A GREAT RAILWAY CONTRACTOR.

It is with extreme regret that our readers will have learnt of the death of Mr. T. A. Walker, the eminent railway and dock contractor, which took place at his residence near Chepstow last week.

Few men of our time have been engaged in such large works, involving such heavy expenditure; and few men, indeed, are they who can compare with the happy manner in which the late Mr. Walker maintained his great and well-won popularity with all classes and conditions of the many thousands of persons directly under his control. It is quite refreshing to know that characters which are sometimes conceived to be idealistic when portrayed in fiction are actually far surpassed by the personal actions of this great commander of men.

Mr. Walker's health had been failing for twelve months, and all necessary arrangements for the completion of his contracts, and the general continuance of his large business, had been made. Mr. Walker, who was sixty-one years of age, was trained as a civil engineer, and was throughout his career a member of the Institute of Civil Engineers. As a young man he made an important survey through Russia, and for the ex-Khedive he surveyed the valley of the Nile up to within a dozen miles of Khartoum. For the South-Eastern Railway Company he made the Dover and Deal, the Elham Valley, and the Lydd Railways; and he won a great reputation as the contractor who so successfully carried out the heavy work of making the underground railways in the metropolis. He will be even better remembered, probably, as the contractor for the Severn Tunnel, which great work he completed for the Great Western Railway, after striking hazards and many difficulties, the tunnel having been on one occasion inundated. Mr. Walker's two chief contracts now pending are the Manchester Ship Canal and the Buenos Ayres Harbour works, both of which are well advanced. The works at Salford Docks are in charge of a son-in-law, Mr. Nott; and those at Buenos Ayres (the transformation of the mud banks of the River Plate into a series of docks) in charge of another son-in-law (and nephew), Mr. Charles Walker. At present Mr. Walker's firm employs upwards of 12,000 men on the Ship Canal works, 2,000 at the Barry Docks, near Cardiff, and 10,000 on the works at Buenos Ayres.

Mr. Walker was a member of the Church of the Plymouth Brethren, and ever manifested great interest in the welfare of his workmen. In every one of the seven sections of the Manchester Ship Canal he had provided church and chapel and coffee and reading room accommodation, and the needs of the injured and sick were also remembered. While he was constructing the Severn Tunnel a church capable of holding 1,200 people was destroyed; within a month he had raised another building in brick, capable of holding a couple of thousand persons. At the opening of the Barry Docks last summer he failed to put in an appearance at the railway company's banquet, and was found dining with his 2,000 navvies at an entertainment which he had provided in honour of the occasion. The deceased gentleman had a house at Manchester, another at Mount Ballan, South Wales, and another at Chepstow, where he died.

WEIGHING MACHINE INSPECTION.

The recent Act relating to weights and measures is a step in the right direction for properly checkmating common and inferior scales and weighing appliances imported so largely from foreign parts. These cheap and nasty productions of the Continental maker have already received one great restraint by the conditions of the Merchandise Marks Act, which has rendered it impossible for foreign-made machines to be sold as genuine English manufacture.

On and after the first day of January, 1890, it will be an offence to sell any weighing machine, appliance, steelyard, or balance of any kind without first having obtained the Government imperial mark or brand, which will establish its correctness and in a measure guarantee its accuracy. We think this is a much better system than depending upon the brand or trade mark of any eminent firm, seeing that the tendency to copy a private mark, or to imitate it, is not so likely to be created by making a Government mark imperative. Few persons would attempt to copy such a mark, and therefore we welcome the action. There is remaining, of course, the spirit in which the Act and its provisions are to be carried out, and we see no evidence which will enable us to expect that it can be properly carried into effect on the day named. To inspect a weighing machine in use for all kinds of domestic purposes will not require any great degree of technical experience; but to inspect and pass as correct or otherwise the complicated weighing machines controlled by electricity, as made by an eminent firm, viz., Messrs. Avery, together with all kinds of automatically indicating, printing, recording, and delivering machines, will require a man of some knowledge and with some mechanical experience. If the Board of Trade propose to appoint, as they have the power to do, certain inspectors for certain districts, we can well understand that those inspectors will have to deal with questions about which the makers of the machine know far more than those new officers possibly can. It is not right that it should be left to the knowledge of any one person, however qualified, to determine a limit for the ingenuity of the great weighing machine firms. There should be established a council, or a commission, the members of which should be elected by the trade in part, and by the Board of Trade in part, so that the practical points that must inevitably constantly arise may be fully and carefully considered.

We need but to examine the delicacy of the chemical balance, with its lightness and yet stability, together with the massive dock weighing platform, to at once concede that an industry is to be controlled by this new measure which affects an important branch of trade, giving employment to workmen in various branches. Thus we are not at all surprised that the weighing machine manufacturers have adopted a memorial at a meeting recently held under the presidency of Mr. W. B. Avery, asking that a commission be formed to discuss all matters pertaining to the manufacture and approval of weighing machines. From our own experience, we aver that this industry is a most complicated one, seeing that mathematical questions, chemical and electrical questions, in addition to the ordinary mechanical points, involving strength and fitness of materials, have to be every day decided by those controlling large firms. And after whole lives have been spent in the same firm or family in perfecting weighing machines and appliances, we can well understand that there is a degree of apprehension expressed lest future development should be crippled by decisions from those having but little experience in this work.

The Mannesman Tubeworks, Swansea.—The long and costly work of converting the celebrated Landore-Siemens Steelworks—the works where Sir William Siemens carried his great experiments to a successful issue—into a steel-tube making manufactory, under the patent of the Messrs. Mannesman, is now nearly completed, and a first instalment of German and Swiss operatives have been brought to Swansea to start the work.

BOILER INSPECTORS AND THEIR WORK.—I.

By One of Them.

There are several species or kinds of boiler inspectors. We have boiler-makers who inspect and report on boilers generally to their own advantage We have also Government inspectors, who hold a kind of coroner's inquest on a boiler which has too suddenly departed this life. The Government makes little or no attempt to prevent explosions, and stands aside while a man may be putting a dangerously unsafe boiler into the basement of a crowded tenement or into the midst of a populous neighbourhood, while at the same time its officials punish one who, without a license, keeps a keg of more harmless gunpowder on his premises. In justice, however, it must be said that its inspectors are quick to appear on the scene after destruction has been wrought, in order to pick up and put the pieces of the boiler together, and to inquire why it exploded, which is, after all, its legitimate province.

To these classes must be added that of the inspector who examines boilers for an insurance company in the interests both of his employers and of himself. His primary object is to prevent explosions, and to see that every boiler under his care is in the best possible condition. It is with this class of inspectors that we have here to deal.

To a worthy inspector, the only object which he allows to take precedence of the efficiency of his boilers is the efficiency of himself and of his comrades. He knows that the weakness and strength of any boiler can only be detected by the man who is able to fall back upon himself, and can produce from his own consciousness, corrected by his experience, an ideally perfect boiler with which to compare the one before him, and he knows also that exactly in proportion as he himself is able or unable to do this will his value rise or fall as an inspector. Therefore, if "the proper study of mankind is man," the proper study of a boiler inspector is his fellows and himself.

These studies begin, consciously or unconsciously, from the moment that he accepts service, and his early mental experiences are not always pleasant. When he first sets about his duties he seems to be surrounded with dangers. Several of his first boilers he judges to be in a critical condition, and he feels surprised that they have lasted so long. He therefore mentally congratulates himself and everyone else that he was sent for just in time. After he has delivered his verbal warning to the firm, and sent off his report, he then complacently regards himself as a preserver of his brother man. But he discovers afterwards that no repairs have been urged upon the firm by his company, and, somewhat crest fallen, he begins to modify his ideas about boilers, and his curiously distorted and inverted views gradually become clearer and in better perspective, though for this time and patience are required. He finds that not only what he thought to be dangerous defects turn out to be trifles, but that what he considered comparative trifles are more serious than he supposed, and may require instant attention. Practice will soon teach the intelligent observer these essentials of his work, and it may safely be said that there are few, or none, of any other stamp of men permanently on the staff of inspectors. The risk to boiler insurance companies, both in money and in reputation, is too great to allow of any indifference to the qualifications of those whom they employ.

Our inspector will at last, after due experience, be able to view with equanimity many cases of seam-rips or edge-cracks, of grooving or of distortion, of corrosion or of pitting, which if he were new to the work would have made him feel a heavy burden of responsibility if he had omitted to send off an alarming report at once. His spirits would sink by day whenever he thought of that boiler, and at night, during the hours when he slumbered restlessly, pictorial views would present themselves to him of dense columns of steam, with fragments of exploded boilers on the wing, accompanied by what remained of their attendants. As these panoramic views and the meditations thereon have a depressing effect, the first few weeks of a boiler inspecting life are not particularly happy ones. Of course there are men of stolid temperament, to whom such an experience is almost unknown; but as such bluntness of sensibility is usually accompanied by dulness of reflective faculties, such men are few in number among the ranks of inspectors, and their stay there is usually of the briefest.

The typical inspector is alert and active, mentally and physically, quick to observe, ready to act. He should be of medium height or below it, without excessive width of shoulder or abnormally large bulk to drag toilsomely through the narrow flues. Any extra size or weight, however, due to previous luxurious living, he is likely to lose in his inspecting career. The model inspector must have a tranquil temper, or he may be ruffled by the pretensions of the ignorant. He must exercise tact and firmness to both masters and men, meeting each on the same terms of perfect equality, for in this way only can he gain the confidence of the former or the respect of the latter. Strong self-reliance an inspector should have, but undue self-assertiveness will prove a snare and a stumbling-block to him, though he may be supremely unconscious of it at the time. The self-assertive inspector has more than once lost a boiler to the company which he represents, and this will certainly result in loss to himself.

The chief duties of an inspector are to observe in one place and report to another. He represents the eye of his employer, an eye gifted with locomotion, whose duty is to convey faithful impressions of things seen to the central brain, where his chief engineer sits supreme. Though this is his true function theoretically, he will find that it cannot be undeviatingly adhered to in practice. He will soon discover that, whether he likes it or not, he will be constantly forced to give brief informal reports to the firms whom he visits, even if it be only a forecast of what the official report is likely to be. His information, therefore, should be of a wide range, so that he can readily and intelligently discuss the merits of the boiler, design and construction, including materials and fittings, whom he should be able to express a sensible opinion on any steam or other motive-power engine that may be before him. When such a perfect boiler inspector shall have been found, then we will have a perfect engineer. The search for him still continues.

MARINE ENGINE GOVERNORS.

A MEETING of the Institute of Marine Engineers was held in the Langthorne Rooms, Stratford, on the 18th November, presided over by Mr. J. McFarlane Gray, when a paper on "Marine Engine Governors, and the Benefits derived from their Use," was read by Mr. J. D. Churchill.

The Chairman introduced the author of the paper as an engineer who had not only devoted a good deal of attention to the subject of governors, but had given a practical illustration to show that he had not spent his time in vain. In the paper it was pointed out that, as a rule, the governor was looked upon as merely an assistance in heavy weather, when the engines are racing, due to the pitching motion of the ship; whereas, in the opinion of the writer, it ought to be considered an integral portion of the machinery, and always kept at work. It was legally binding on railway companies to fit brakes on trains, and on steamship owners to fit safety valves on boilers; so also should it be imperative to fit governors on the engines. If a thoroughly efficient governor were to be fitted on every marine engine, and engineers brought to see the usefulness of and the additional safeguard derived from it, the percentage of losses due to machinery breakdowns at sea would be materially lessened. Cases were cited where shafts had broken suddenly, causing an excessive damage, due to the engines running away at an abnormal speed; whereas, had a governor been in use, this would have been prevented. Many steamers were lost on account of a portion of the machinery giving way, and resulting in a general disablement of the vessel. Steamers were posted as "missing," and ultimately as "lost," without a record to see what had happened. Doubtless not a few of these were lost in the same way as those referred to; as, being disabled for want of a governor or brake to check the engines, when, say a propeller shaft had given way, and the portion coupled to the engine, revolving at great speed, without being automatically checked, had broken through the stern tube and ship, leaving a passage for the sea to enter and swamp the ship, unless stopped by the prompt closing of the water-tight bulkhead door. Although the three-crank engine is better balanced, and is considered less in need of a governor than the two-crank engine, it stands really in the same position so far as the real service is concerned. Some data were given showing the number of breakdowns, and the immediate causes of them; and Mr. Churchill drew conclusions from the information he had tabulated as evidencing the great desirability of having a governor connected to every marine engine, not merely for the purpose of preventing racing due to heavy weather, but always connected and at work, so that it was attached to the vital principle, ready for any emergency, foreseen or otherwise.

The discussion which ensued elicited considerable expression of opinion. The general tone of the speakers showed that the leading argument advanced by Mr. Churchill was sustained, and we do not doubt that those engineers who were present would look upon the governor as a machinery detail of much greater importance in the outfit of the engine-room than they had formerly. The discussion was maintained by Messrs. Richardson, Shorey, Conbro, Adamson, Rowe, Scobie, Craig, Wilson, Blair, Thomson, Brett, and A. W. Robertson.

The Chairman gave some valuable hints in the course of the evening, and at the special request of several speakers desired Mr. Churchill to give a brief description of his own governor, the merits of which had been referred to by a few of the speakers who had sailed with it. After the closing remarks, and reference to the principle on which the Churchill governor is based, the proceedings terminated with the usual votes of thanks to the author of the paper and the chairman, moved and seconded by Messrs. Rowe and Craig, and Messrs. Conbro and R. Adam respectively.

PAPER-BAG MAKING.

AT the meeting of the members of the Institute of Mechanical Engineers, held at Westminster recently, a paper was read, descriptive of a rotary machine for making paper bags, by Mr. Job Duerden, of Burnley. The author stated that during the past 20 years, and perhaps more particularly in the last two, rapid strides had been made in bringing the industry of paper-bag making to the high state of excellence it had attained, especially in Great Britain and the United States of America. Previously bag making was carried on by hand, almost identically in the manner followed centuries ago, and it was astonishing to find that almost without exception that primitive method still prevailed throughout the whole European continent. In bag making by hand, the paper, having been cut to the particular size and shape required, was sent to the bag makers, who folded it with the aid of blocks, after which it was passed on to be pasted, and then to be dried. The highest rate at which the bags could be so produced was about 300 per hour, as compared with an average of 7,000 per hour by the new machine. Although the improvement of the bag machine had exercised the mechanical skill of many celebrated men, yet until quite recently the essential qualifications had not been realised which such a machine ought to possess in order to become universally applicable—namely, economical production, small cost of construction, together with a simplicity not beyond the intelligence of the child who had to work it. Numerous machines were in existence, most of which deserved commendation for their simplicity and high productive power, but none of them, it was believed, had been capable of making on the rotary principle bags of different widths and lengths on the same machine. A separate machine had been required for every size made in the mill, and not infrequently more than one machine for making the same size of bag, but of a different quality of paper. When it was considered that from 20 to 30 different sizes, and perhaps not less than the same number of varieties in quality of paper, were turned out in a mill of ordinary capacity, it would be readily seen that the original outlay necessary for providing the machines required would be prohibitive of their general adoption. The machine invented by the author was capable of producing bags from any description and quality of paper, no matter how soft or how stiff. The bags varied in width and length from 4in. by 5½in. to 10½in. by 14½in., and all sizes were made, both light and heavy, thick and thin. For all these kinds, as well as for block-bottomed or oblong bags, varying both in length and width, it was only necessary to have two machines, the smaller producing bags varying in width and length from 4in. by 5½in. to 6½in. by 9¼in., and the larger from 7in. by 9½in. to 10½in. by 14½in. Between the foregoing dimensions any size of bag could be produced, the successive sizes varying by $\frac{1}{16}$in. in width and ¼in. in length. This was an exceptional and important advantage. Undue or superfluous pressure on the sides or folds of the bags, which had hitherto been a serious and unsurmountable objection, causing a tendency to split and burst when being filled with goods, was entirely obviated. The working of the machine was practically noiseless. It had a continuous feed, no folding plates or blocks were required, and the size and shape of the bag could be altered at pleasure by the boy or girl attendant by simply substituting a different change wheel, whereby the cutters, paster, and folders were simultaneously altered. The machine being on the rotary principle, the wear and tear of its parts were reduced to a minimum. Less than quarter horse power was sufficient to drive the machine, and either gas or steam might be used for this purpose.—A brief discussion followed the reading of the paper, in the course of which Mr. Pearson, on behalf of Mr. Duerden, stated that the machine would make bags from all kinds of paper, whether made from rags, straw, or wood pulp.—Mr. Chapman stated that he had seen the machine at work at the Paris Exhibition, where it had obtained the highest award in the face of competition of both French and American machines, and he had actually seen it work at the rate of 141 bags per minute.—A vote of thanks was accorded to the author of the paper, the President (Mr. C. Cochrane) saying that the members of the institute were greatly indebted to Mr. Duerden for bringing before them a most ingenious invention.

Shipbuilding on the Clyde appears to be in a very prosperous condition. During the last month 18 vessels, with an aggregate tonnage of 30,000, have been launched, making the total for the 11 months 300,000 tons, against 212,000 tons in the corresponding period last year. Further orders have been booked very extensively; in some of the yards the work contracted for will take from one to two years to get through.

ENGINE PATTERNS.—X.

Slide Valves.

In the common form of slide valves the pattern is either cut from a solid piece of stuff, or from two or three pieces, which are afterwards glued together. But these examples are so simple that they hardly require illustration in this series, and I shall therefore only illustrate and describe valves whose forms are such that the use of cores becomes necessary.

Figs. 80-84 illustrate the casting of a double-ported slide valve. Here J J are the outer steam ports, communicating with the exhaust arch K; L L are the inner steam ports, opening on the sides of the valve. In figs. 82-84, M is the hole for the valve rod, made of elliptic form, to allow of free fitting as the valve face wears down; N N are the guide blocks, which slide against the steam-chest covers. The design and construction of this type of valve is so well known, and so clear from the figures, that we may at once proceed to the description of the pattern work.

Half Plan (Back).

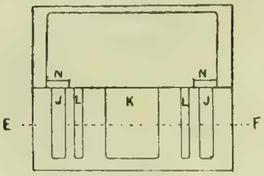


Fig. 80.—Half Plan (Face).

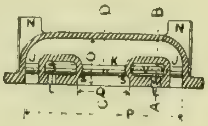


Fig. 81.—Section E E.

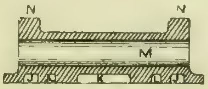


Fig. 82.—Section H.

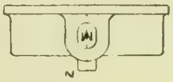


Fig. 83.—End View.

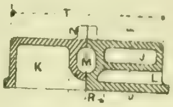


Fig. 84.
Half Sec. C D. Half Sec. A B.

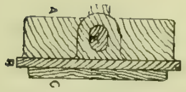


Fig. 85.—End View.

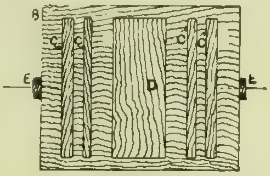


Fig. 85.—Plan of Face.

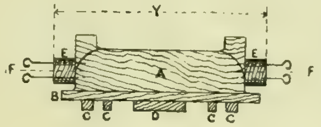


Fig. 85.—Side View.

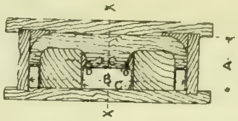


Fig. 86.—End View.

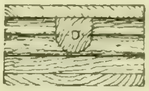


Fig. 86.—Sec. H H.

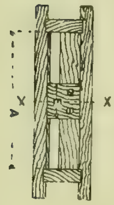


Fig. 87.—Plan.

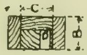


Fig. 87.—Sec. X X.

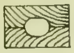


Fig. 88.

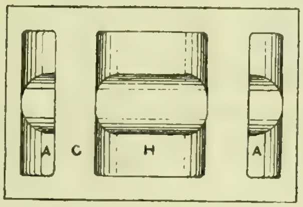


Fig. 89.—Plan of Face.

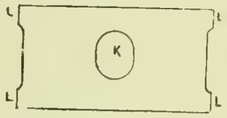


Fig. 90.—End View.

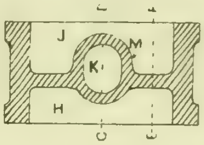


Fig. 91.—Section A B.

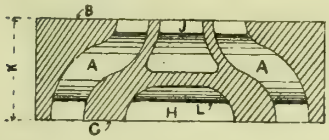


Fig. 92.—Section E E.

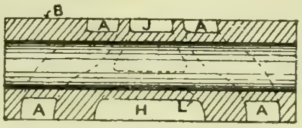


Fig. 93.—Section C D.

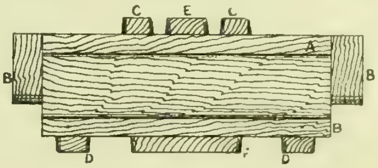


Fig. 94.—Side View.

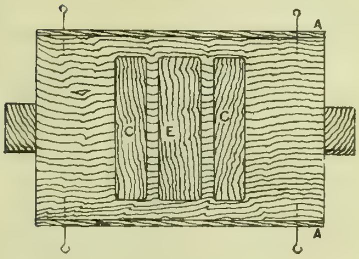


Fig. 94.—Plan.

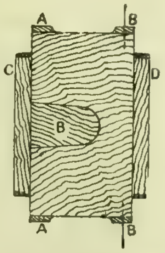


Fig. 94.—End View.

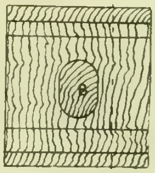


Fig. 95.—End View.

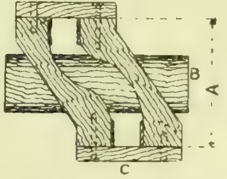


Fig. 95.—Section X X.

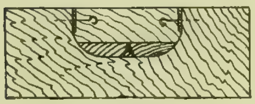


Fig. 96.—Section X X.

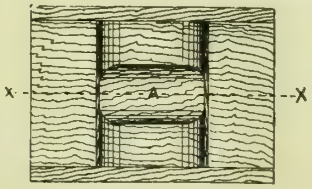


Fig. 96.—Plan.

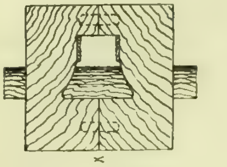


Fig. 97.—End View.

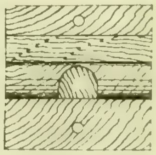


Fig. 97.—Joint Face X X.

The pattern itself is shown in fig. 85. Here A is the body, B the flange, C the prints for the inner and outer steam ports, D the print for the exhaust arch, and E the prints for the oval hole for the valve rod. The pattern moulds, with face B downwards to ensure sound metal there, and the prints E, are skewered loosely on. The skewering on of these requires that a joint be made in the mould along the line F F; but there is an advantage as regards the placing the cores in the mould in this method, otherwise the prints E would have been of the pocket form.

There are three core boxes wanted for this valve, one (fig. 86) for the outer steam ports J, and the exhaust arch K, in figs. 80-84; another box (fig. 87) for the inner steam ports L, in figs. 80-84; and the third (fig. 88) for coring out the hole M for the valve rod, in figs. 80-84.

In fig. 86, the distance A corresponds with the distance O in fig. 81, plus the print thickness C in fig. 85; and the length B in fig. 86 corresponds with the length P in fig. 81; and the distance C in fig. 86, with the distance Q in fig. 81. The width of the piece D in fig. 86 is equal to the width R in fig. 84, and, of course, forms the metal around the cored hole M for the valve rod. In this box everything delivers except the pieces D, which form the extensions at S, in fig. 81, and these are therefore skewered in. The other portions are fastened to the outsides, and draw directly with them.

The box (fig. 87) which forms the inner ports L (figs. 80-84) extends in its length A to the middle T in fig. 84, cutting through the valve sides to give inlet to the steam from the steam chest. The depth B of this box extends to the depth U in fig. 81, plus the print thickness C in fig. 85; and the width of the portion C in the box is equal to the width V in fig. 81. The edge D of the bridge piece E in fig. 87 corresponds with the edge W in fig. 81, and its width E with the width R in fig. 84. It will be observed that there is no provision in this box for the formation of the curves seen in fig. 81. As is often the case, these are left to be rubbed off the core after it is dried.

The section of the box (fig. 88) for the formation of the valve-rod hole M is a plain ellipse, and its length is equal to the length Y in fig. 85, and it is jointed and dowelled longitudinally in the plane seen in fig. 85.

An example of a main slide valve—that is, one in which expansive working is provided for by means of a cut off valve sliding on its back face—is shown in figs. 89-93, and the pattern work in the figures following.

In figs. 89-93, A A are the steam passages passing through the valve from the back B to the face G; H is the exhaust arch, J the lightening recess, K the hole for the valve rod, L facing guide strips, sliding against similar strips within the steam chest.

The pattern, fig. 94, is a plain rectangular block, with facing strips A B upon the sides, the lower ones B being skewered on. There are prints B B in this case of the pocket form for the valve-rod hole; and also prints C D both at top and bottom for the steam-passage cores. Prints are put upon the top, as well as upon the bottom, because the exact position of the ports is of great importance; and in the absence of the top prints the cores would be liable to tip out of truth, one way or the other. Prints are not as a rule used in the top of a mould if they can be avoided, because there is always a risk of the sand in the top becoming more or less crushed thereby. There are prints E for the lightening recess, and F for the exhaust arch.

Fig. 95 is the steam-passage core box. Its width A equals the width K in fig. 92, plus the thickness of the prints C D in fig. 94. The block B, which is slid through holes cut in the sides of the box, forms the metal around the hole for the valve rod, and corresponds in size and section with the portion marked M in fig. 91. When the core is made the block is drawn out endways, the sides C C unscrewed, and taken away from the core.

The box (fig. 96) forms the arch of the valve, and the block A forms that portion of the metal seen at L in figs. 92 and 93. The chipping strips for the cut-off edges are necessarily skewered on.

The box (fig. 97) cores out the recess J in the back of the valve (figs. 92, 93), and has its block also, to form the necessary metal around the valve-rod hole.

The box for the valve-rod hole, of elliptic form, is similar to that shown in fig. 88. J. H.

BRITISH COLONIES AS FIELDS FOR THE EMPLOYMENT OF THE CIVIL ENGINEER.

At the first ordinary meeting of the session of the Institute of Civil Engineers, on Tuesday, the 12th of November, the president (Sir John Coode, K.C.M.G.) delivered an inaugural address, it being the first occasion of his occupying the chair at an ordinary meeting since his election as president.

After referring to the growth of the institution, from about six hundred when he joined it as a member in 1849, to approximately six thousand at the present time, the President alluded to the visit of the American Engineering Societies soon after the close of the last session, and the leading part taken by the institution in their reception and entertainment.

When considering the question of a topic for his address, it appeared to him that the experience gained during three lengthened professional visits to distant parts of the British Empire might not be unsuitably drawn upon, the visits involving journeyings of more than 75,000 miles. The text of his subject was: "British Colonies as fields for the employment of the Civil Engineer." By the term colony was strictly meant a country, or portion of a country, inhabited by a people who had gone forth from their mother land and had made that country their home, though remaining more or less directly under the government of the country from which they or their ancestors had originally emigrated. These might be said to be British dependencies, held mainly for strategic purposes, in which the British element in the population was very small, such as Gibraltar, Malta, Cyprus, and Heligoland; dependencies under the British Crown chiefly used as trading stations, but also serving as coaling stations, and for repairing steamers of the mercantile marine, or ships of the Royal navy, such as Singapore and Hong-Kong; colonies which were exporters of their own produce on a large scale, such as the West India Islands, Mauritius, and Ceylon; and colonies proper, as Canada, Australia, South Africa, and New Zealand. The keynote to the colonial question was best represented by the single word "transport." Wherever there was trade there would of necessity be a demand for the means of transport, and where there was a demand for the means of transport there would be found a need for the works of the civil engineer. Whilst the population of the world had increased by a little less than 10 per cent between 1870 and 1880, the increase in transport within the same period had been fully 53 per cent. The connection was obvious between transport and the several engineering works comprehended under the construction of railways, tramways, roads, canals, harbours, docks, steamships, locomotives, bridges, viaducts, aqueducts, tunnels, waterworks, gasworks, sewage works, and irrigation channels; breakwaters and lighthouses might be included within this same category, and he ventured to affirm that this factor of transport pervaded the domain of electric telegraphy. Harbours and docks assumed a special importance in connection with our colonies. As respected external trade, they formed the terminal links of the great chains of communication which served to bind them to the mother country. As regarded our larger colonies, the practice had been to extend the roads and railways from the seaports back into the interior, with the result that the land lines of communication parallel to the coast had been as yet but little developed, and much the larger proportion of the traffic between different parts of the same colony was sea-borne. Hence in most of our colonies harbours and navigable rivers assumed greater importance in the matter of transport than was generally assigned to them in the mother country.

Dealing next with the means of reaching the colonies, the question of oceanic transport by means of steam navigation was of paramount importance. The first crossings of the Atlantic by steam propulsion alone were accomplished by the Sirius, of 700 tons, starting from Cork, and the Great Western of 1,340 tons, from Bristol, both reaching New York on the 23rd of April, 1838, the time occupied by the latter vessel having been fifteen days and six hours. It was in this same year that the English Government first invited tenders for the conveyance of mails to the American Continent by steam, which led to the establishment of the Cunard Line, of which the first vessel, the Britannia, of 1,155 tons and 850 H.P., left Liverpool on the 4th of July, 1840, and took 14 days to complete the voyage to Halifax. At the present time the passage between Liverpool and New York had been accomplished within six days. The Peninsular and Oriental Company afforded a striking example of the progress of ocean steam navigation between the United Kingdom and the colonies. The first contract with the Government for the conveyance of mails by sea-going steamers was entered into in August, 1837, by the company at that time called the "Peninsular." The steamers ran from Falmouth to Vigo, Oporto, Lisbon, Cadiz, and Gibraltar. In 1840, the company was expanded into the Peninsular and Oriental, and the mails were conveyed by steamer from England to Alexandria; in September, 1842, the service was extended to India; a further contract was undertaken by the company, in 1844, to carry the mails to Ceylon, Singapore, and Hong-Kong; and from March, 1852, a service had been established with Australia, and conducted with punctuality, safety, high speed, and comfort. Meanwhile the tonnage of the vessels had increased from some 600 to 800 fifty years ago, to 2,500 tons of 2,500 H.P. twenty-five years ago, and to 6,500 tons in the latest additions to the fleet, which maintained a regular sea-going speed of 15 to 16 knots an hour on the 12,000 miles run from London to Australia. This increase of size and power had been specially marked within the last five or six years. One result of recent improvements in steamship building was a reduction in the cost of ocean transport. The cost of the freight of heavy goods, such as unmanufactured iron, say to Sydney, a distance of nearly 12,000 miles from England, was about £25 per ton twenty years ago, whereas recently it had been as low as £1 10s. a ton, or a little more than $\frac{1}{32}$d. per ton per mile, and the saving in distance by the Suez Canal route as compared with the route by the Cape was only about one-ninth of the whole distance. Sir John Coode then referred to two recent examples of modern passenger steamships—the Teutonic, belonging to the White Star Line, 582ft. in length, with a gross tonnage of 9,685, provided with accommodation for 1,200 passengers, and, by arrangement with the Admiralty, intended to carry in time of war twelve 5in. guns, having a maximum range of over five miles. The other example was the City of Paris, belonging to the Inman and International Steamship Co. This was the only vessel which had hitherto made the passage between New York and Liverpool in less than six days, her mean speed on a voyage in May last having been 23·73 statute miles an hour. This vessel was of 10,500 tons burden and 18,000 H.P., being eight times the tonnage and forty-five times the H.P. of the Great Western. She had 54 furnaces, and her boiler tubes exceeded 13 miles in length. With regard to the possible future development of steam navigation, the question of hydraulic propulsion by jets of water at a high velocity was engaging the attention of many engineers.

(To be continued.)

NEW MACHINE TOOLS.

We illustrate below two forms of machines made by the Britannia Co., Colchester.

Fig. 1 is this firm's new double-geared milling machine. The headstock is cast in one with the column or body and the base, which is broad and substantial. The body is a hollow box casting with door, fitted inside with shelves for cutters and tools. A shelf or tray for tools and cutters is also fitted at the left-hand outside. The spindle of the headstock is steel with conical neck running in hard gun-metal bearings, and constructed with loose back cone to take up wear; and the front is coned and screwed internally for fitting and holding firmly the chucks and cutter mandrels, and is fitted with a cone pulley having four speeds, which, with the back gearing, gives eight changes of speed, and great capacity for varied work. The back gearing is put in and out of gear by eccentric motion. The headstock is also fitted with a top arm (which is removable at pleasure), carrying an adjustable centre, to steady the end of a long cutter mandrel when using extra large, or groups of cutters. The knee slide is accurately fitted to the front of the body or column, and rises and falls 14in., giving 15½in. from top of work table to centre of spindle when at its lowest, and is adjusted by a vertical screw and conveniently placed hand wheel. The longitudinal slide is 24in. long, and 7½in. wide, and has a transverse traverse—*i.e.*, parallel with axis of spindle—of 7½in., adjusted by hand wheel and screw. The work table is 14in. long, and 8½in. wide, with T slots planed out for fixing the work, and has a longitudinal traverse of 18in., self-acting by worm and wheel, and friction cone. The belt cone pulley for self-acting feed has three steps, which give, with the back gearing, six changes of speed. All the slides are accurately scraped and fitted, and have loose angle strips to adjust for wear. All traverse screws are steel, and all material is of the best.

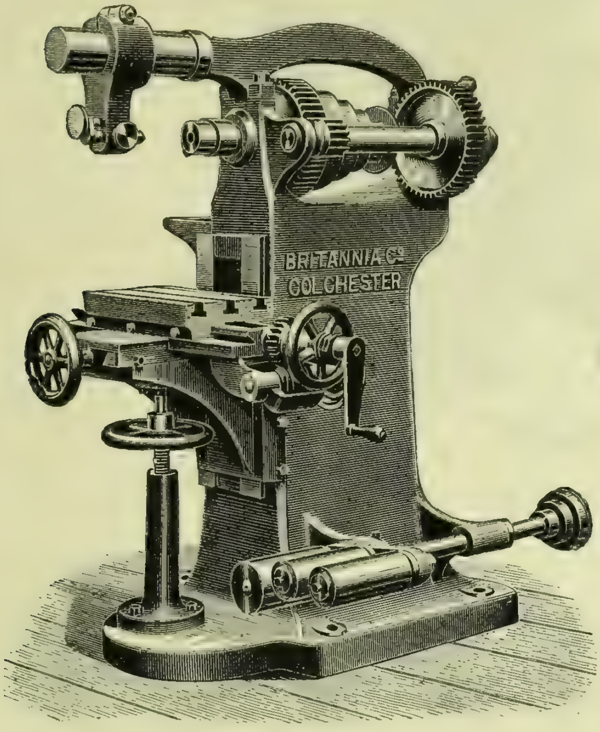


Fig. 1.

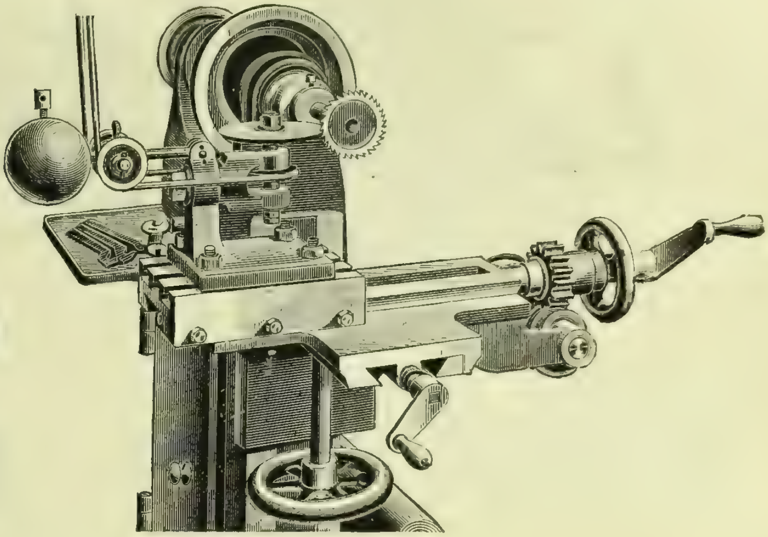
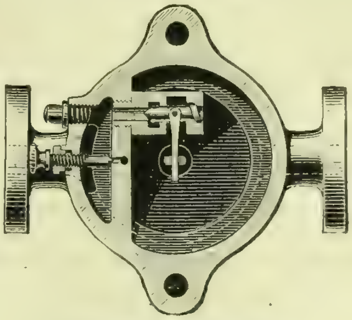


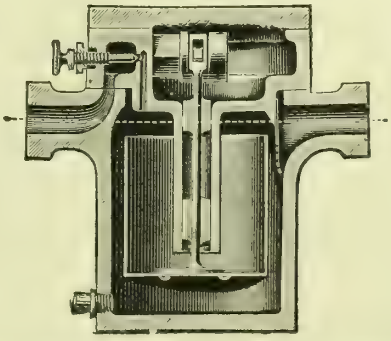
Fig. 2

Fig. 2 shows an appliance for sharpening cutters for milling machines, which has been designed as a handy device to fit on to the table of an ordinary milling machine, to sharpen its cutters. It is intended to be driven from the countershaft of the machine, and adjusted to correct position for grinding by the slides of the machine, the cutter to be sharpened being meantime held in its usual position as for cutting, in the mandrel of the headstock, the driving belt of the latter being of course thrown off for the time. The appliance is constructed with a firm base to bolt to machine table, and has a swivelling head carrying a steel spindle, with driving pulley fitted, and arranged to hold an emery wheel at its end. It has a pair of guide pulleys, which swivel and slide upon a hinged lever, with a heavy weight at its end to keep the driving gut tight. When in operation the emery wheel is brought into contact with the cutter, and the latter is turned by moving the cone pulley by hand, bringing each successive tooth in contact with the emery wheel. The emery wheel, being fitted to swivel, can be arranged to suit cutters having teeth cut square across or obliquely, and can also be used with a square-edged emery wheel, to run in a vertical direction and sharpen the cutter by grinding the tops of the teeth, which is sometimes preferable. The attachment is also useful for backing off taps, reamers, and flute drills. These machines are well-finished and thoroughly up to the standard of the Britannia Co.'s work.

SIMPLEX STEAM TRAP WITH OPEN FLOAT.

The accompanying illustrations show a very simple, reliable, and efficient form of steam trap, constructed by Messrs. Schäffer and Budenberg, of Deansgate, Manchester, of which a large number have been sold and are now working very satisfactorily. The water collecting in the trap forces the float upwards so as to close the outlet screw valve. When the water overflowing into the float causes the latter to sink, the outlet valve is opened, and the water is forced away through the central tube, which also serves





THE PAMPHLETT-FERGUSON DISTILLER.

CONSTRUCTED BY MESSRS. G. WAILES AND CO., ENGINEERS, LONDON.

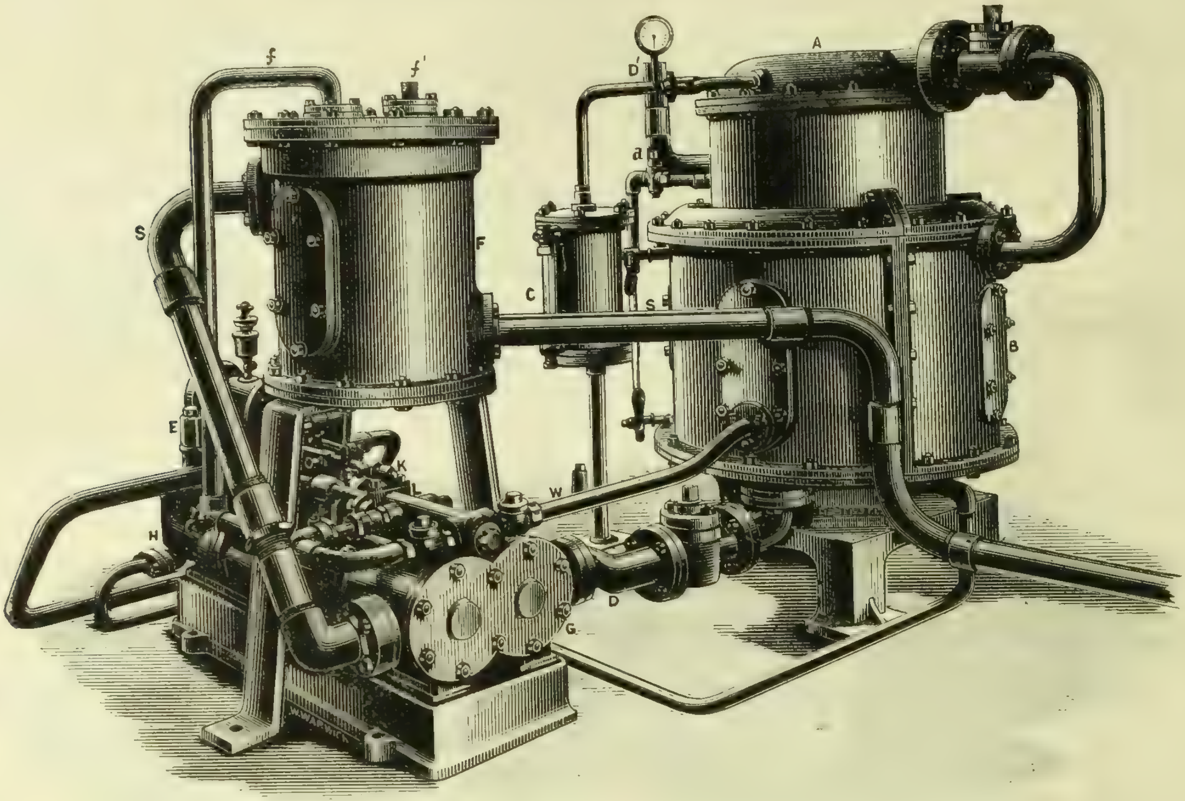


Fig. 1.

A. Chamber for steam, forming the upper part of the evaporator, the high-pressure steam from the boiler being admitted at the bottom.
B. Condenser fitted with vertical tubes.
C. Automatic feed regulator, supplied by the pipe *d* from the warm circulating water D^1 as it leaves the condenser.
D. Circulating water from pump entering the bottom of the condenser B, and emerging warm at D^1.
E. Steam pump for the following purposes: (1) Circulating water pump G. (2) Brine pump H. (3) Condensed (high-pressure) steam pump K. (4) Double-acting pump for forcing the condensed water W and air L through the cooler F.
F. Cooler and filter combined, the aërated distilled water entering hot at *f*, and leaving at the same temperature as the circulating water at f^1.
SS. Suction pipe of circulating water, leading through the cooler F to the pump G.

to guide the float. The air contained in the trap and pipe can be discharged by opening a small screw valve, which closes a passage of communication between the interior of the trap and the water outlet, as shown in the illustrations. The apparatus must be sufficiently filled with water to close the outlet valve before starting it. By loosening the screws the whole mechanism, with float, can be taken out without removing the trap from its working position. The small valve, which is the only part subject to wear, can be easily replaced. It would certainly be difficult to imagine anything much simpler to comply with the required conditions.

THE PAMPHLETT-FERGUSON DISTILLING APPARATUS.

An apparatus has recently been invented by Messrs. Pamphlett and Ferguson for the production of pure fresh water, in which interesting departures have been made from ordinary practice. The chief object of the inventors is to make a thoroughly mechanical apparatus that would meet all the requirements of the engineer in charge of it for economy and simplicity, and convenience in running, cleaning, and repairs.

The principal parts are shown in the accompanying illustrations, in which fig. 1 is an external view, and fig. 2 a longitudinal section and plan. In the evaporating chamber, in the lower part of A, fig. 1 and 2, high-pressure steam from the boiler surrounds a nest of vertical copper tubes, about 1½in. in diameter. The upper part, which is the only portion visible in fig. 1, forms a steam chest and separator combined, so that any water in the steam is thrown down by two inclined baffle plates, or driven outside, as the steam travels round the circular passage on its way to the pipe which leads to the condenser B.

A difficulty which causes much trouble in all evaporators, and especially in these in which the pressure varies from 0 to 15in. of mercury on the vacuum gauge, is to keep the water automatically at a constant level. This is here effected by a float in the chamber C, so proportioned that on board ship the rolling would have little or no effect on it. To this is attached a small double-beat valve that admits, through the pipe *d*, the warm circulating water that leaves the condenser at D^1, and thus keeps the water in the evaporator at a constant level, without requiring any attention. As on the reliability of this automatic feed the regularity in the working of the condenser largely depends, particular care is given to its construction, and every facility is afforded for easy inspection. The condenser B is of annular form, and contains about 120 tubes, ¾in. in diameter and 20in. long, of the ordinary Admiralty pattern. They are expanded into the tube plates, this being found quite sufficient to make a perfect joint that will stand under all conditions of ordinary work. The circulating water that enters at the bottom of the condenser, and leaves at the top at D^1, flows through the tubes, the steam from the evaporator condensing outside, so that if any incrustation is formed it will be on the inside of the tubes, whence it may be easily removed by a tube cleaner. The steam pump E was specially designed by Mr. G. H. Wailes to meet the requirements of this distiller, and consists of—(1) The circulating pump G, consisting of two gun-metal cylinders connected at one end by a passage; the two pistons are driven direct from the crosshead, and each is fitted with merely an indiarubber circular valve. By this means a double-acting pump is obtained that gives an even flow of water, and the parts likely to get out of order are reduced to a minimum. (2) A brine pump H, to pump the brine out of the evaporator. (3) A condensed high-pressure steam pump for pumping the condensed steam from the boiler out of the evaporator, either to the hot well direct, to make up the boiler feed, or through the filter, to be cooled and ærated for drinking purposes. A double-acting pump for pumping the fresh water from the condenser B through the filter and cooler F, and also for forcing air into the water to render it fit for drinking. The steam cylinder is of usual type, the valves being actuated by tappets; and all the above pumps are worked from one crosshead.

The filter and cooler F contains vertical tubes, which are filled with the filtering medium—*i.e.*, charcoal—and through which the condensed fresh water passes, going down one set and up the others, entering hot at f and leaving at the same temperature as the circulating water at f^1. The cooling is done by the water on carried on under a vacuum, so as to reduce the deposition of solid matter to a minimum, and the scale unavoidably deposited is under these conditions rendered much more easy of removal.

The evaporator itself is so arranged that high-pressure steam can be safely admitted without fear of priming; the tubes are straight, short, and of large diameter, easily either cleaned or replaced. For apparatus of this description it is the evaporator which, as a rule, gives the most trouble; the tubes, &c., in it quickly become covered or filled with a solid hard scale, even under the most careful management, this deposit being in every

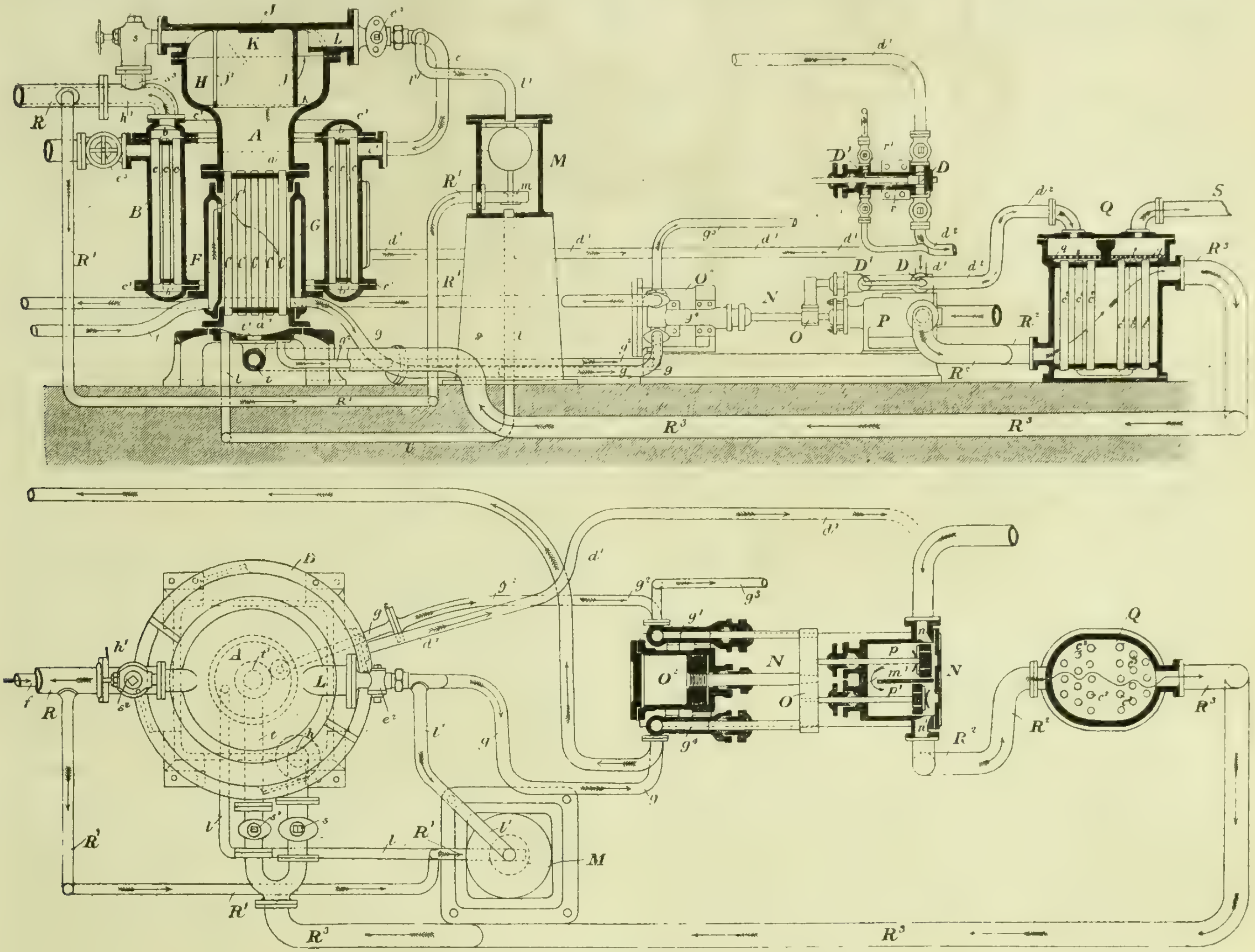


FIG. 2

A	Evaporator.
B	Condenser.
C	Tubes of Evaporator.
D	Fresh Water Pump.
D^1	Aerating Pump.
EE	Return Water Passages.
F	Hollow Door.
G	Hollow Door.
H	Stillhead.
J	Top Cover of Stillhead.
KK^1	Baffle Plates.
L	Steam Exit in Stillhead.
M	Regulating Chamber.
N	Steam Pump.
O	Crosshead.
O^2	Steam Cylinders.
P	Circulating Pump.
Q	Filter.
R	Circulating Water Delivery Pipe
R^1	Regulating Chamber Feed.
R^2	Circulating Water Feed to Filter
R^3	Circulating Water Delivery from Filter.
S	Fresh Water Delivery from Filter.
aa^1	Tube Plates in Evaporator.
bb^1	,, ,, Condenser.
c	Tubes in Condenser.
c^1	Covers of Condenser.
c^2	Tubes in Filter.
c^3	Return Tubes in Filter.
d	Evaporator Tube Chamber.
d^1	Pipe connecting B to D.
d^2	Pipe from D to Q.
ee^1	Pipe connecting Evaporator to Condenser
e^2	Steam Stop Cock from A to B.
e^3	Circulating Water Cock from A.
f	Live Steam Pipe.
f^1	Steam Outlet in F.
g	Pipe for drawing off Condensed Heating Steam.
g^1	Brine Pump.
g^2	Brine Pipe to Pump.
g^3	Brine Delivery Pipe.
g^4	Boiler Feed Pump.
hh^1	Inlet and Outlet of Circulating Water in B.
j	Circular Baffle Plate.
j^1	Slot in Circular Baffle Plate.
k	Space between j and H.
l	Communication Pipe from M to B (water).
l^1	Communication Pipe from M to e (steam).
m	Self-acting Valve.
m^1	Passage between p and p^1.
n	Circulating Water Feed Inlet to Pump P.
n^1	Circulating Water Delivery Outlet from Pump P.
pp^1	Chambers in P.
q	Perforator Plate in Filter Q.
r	Annular Space at Back of Piston in Pump D.
r^1	Suction Valve on Ærating Pump
r^2	Delivery Valve ,, ,,
s	Cock Controlling Feed of Circulating Water to B.
s^1	Cock Controlling Feed of Circulating Water to A.
s^2	Cock Controlling delivery of Circulating Water from A.
s^3	Branch connecting R with s^2.
t	Circulating Water Pipe to A.
t^1	Inlet for Circulating Water to A.

its way to the suction inlet of the circulating pump passing outside and around the tubes in which the fresh water passes. SS is the suction pipe. From this description and an inspection of figs. 1 and 2, the apparatus will be readily understood, and we may now state the advantages claimed for this form of apparatus.

The fresh water is supplied pure and cool, filtered and aerated, suitable for drinking at once; or, if required, it can be supplied hot and unfiltered, to make up the loss of fresh water to the boilers. It can also be used as a simple condenser, to produce fresh water from steam evaporated in another boiler.

The evaporation, when drinking water is being produced, is case difficult to remove, and involving the disuse of the whole apparatus while the removal is being effected. The evaporator in the Pamphlett-Ferguson condenser is made very small and simple, is easily replaced, so that a spare one can be carried, which may be put in quickly, and the cleaning, &c., of the other effected without hurry, or the loss of the services of the apparatus.

The condenser, like the evaporator, can be tested, to make sure of the tightness of the tubes, before being put into position, so that, with ordinary care, no loss of time or trouble can arise from leaky tubes. Practical engineers who have had charge of various apparatus for distilling, will appreciate the absolute value of this advantage.

Mr. Maxwell Williams, C.E., who lately carried out a series of tests, found that of the total heat contained in the steam from the boiler 94 per cent was usefully applied, leaving only 6 per cent for loss due to radiation, &c.

It is contemplated making specially light and compact distillers for special purposes where size and weight are of importance. The large sizes will make 100 to 200 gallons per hour.

A demonstration of an apparatus of a capacity of about 50 gallons per hour took place recently at the works of Messrs. G. Wailes and Co., in the presence of several marine and other engineers, the results of which were considered extremely satisfactory.

MANCHESTER STEAM USERS' ASSOCIATION.

THE annual meeting of this association was held on the 19th of November, at the offices, 9, Mount Street, Albert Square; Mr. John Ramsbottom, C.E., presiding. The report of the Committee of Management, which was read by the secretary (Mr. Robert Tonge), stated that the number of members of the association on the 31st December last was 1,672, and of boilers under inspection 4,850; the subscriptions, special service fees, &c., amounting to £11,066. The committee were pleased to report an increase in the amount received for ordinary subscriptions; the total exceeded that of any previous year, and attained the sum of £9,440. The amount received for special fees was slightly below that of the preceding year, whilst the number of members, number of works, and number of boilers remained practically the same as in 1887. This result was regarded with satisfaction, considering the increasing number of joint-stock boiler insurance companies that existed, and with which, to a certain extent, this association had to compete in extending its membership. The net result of the year's working gave a surplus of £371, which had been added to the reserve fund. A reference to the tabular statement of services will show that the fundamental principle and object of the association had been maintained, viz., the securing of an annual entire examination of the boilers of its members as a means of preventing steam boiler explosions, and the statements made in previous reports might be repeated that every facility was afforded to the members for obtaining these examinations. The committee noted with satisfaction that members continued to avail themselves of the assistance afforded to them when laying down new boilers. As in previous reports, so in this, the committee had the satisfaction to state that during the past year no explosion arose from any boiler under the association's inspection. In the case of boilers not under its inspection they had records of 54 explosions, which killed 26 persons and injured 53 others, whilst in addition they had records of 18 miscellaneous explosions arising from kiers, &c., which killed six persons and injured twelve others, making a total of 72 explosions, 32 deaths, and 65 cases of personal injury. At the last meeting a resolution was passed requesting the committee to persevere in their endeavour to secure the introduction of a suitable measure in Parliament to bring every boiler in the United Kingdom under competent periodical inspection, but at the same time that such inspection shall not be carried out by the Board of Trade. In furtherance of this object a good deal of attention had been given by the committee to the subject, and the assistance of Sir W. H. Houldsworth, Bart., M.P., Manchester, was sought and kindly given. A bill was very carefully prepared, entitled "Boiler Insurance and Regulation Bill, 1889," and at the opening of the session of Parliament on 21st February, 1889, Sir W. H. Houldsworth gave notice of motion for introduction of such bill. The same was presented and read the first time on the 22nd February, but owing to the press of Parliamentary business no opportunity occurred for second reading, and the order for the second reading was discharged and the bill withdrawn on the 30th July, 1889. At present that was where the matter rested.

The Chairman, in moving the adoption of the report, referred to the loss which the association had sustained since its last annual meeting through the death of its president, Mr. Richard Peacock, M.P. He then reviewed the work of the association during the past year, especially with regard to the special service rendered to members when laying down new boilers. On the subject of steam boiler inspection and insurance, he had to say that no policy of insurance should be granted until a boiler had been thoroughly examined and certified as safe, and that no policy should be continued in force unless the thorough examination was renewed year by year, and the certificate of safety was renewed also. The practice of the association was—no inspection, no guarantee: and the practice of boiler insurance companies should be—no inspection, no insurance. The subject of smoke prevention, he proceeded to say, appeared to be coming to the front. The opinion seemed to be spreading that the time had now arrived when the smoke nuisance should be no longer allowed, and there was every prospect that more stringent legislative measures with regard thereto would shortly be enacted. The subject of smoke prevention was one to which the association had paid great attention. It conducted an extensive series of smoke-prevention trials at Wigan some years since, and after their completion sent a trained stoker to the works of as many of its members as desired it, to educate their firemen in smokeless hand-firing. There was, however, but little response on the part of boiler owners, and the services of the trained stoker had shortly to be discontinued. Now, however, attention seemed aroused to the subject afresh, and the association would be happy to assist its members in endeavouring to put a stop to the smoke nuisance. It was not necessary for boiler owners to go to the expense of a mechanical stoker to prevent smoke, or at all events to materially reduce its amount. Smoke could be reduced so as to be no practical nuisance simply by careful hand-firing, and the following recommendation might be offered: Adopt the system of "alternate side firing" introduced by Charles Wye Williams many years ago. Instead of scattering the coal all over the fire at every charge, throw it to one side only, say to the left-hand side, on one charge, leaving the right-hand side bright; and to the right-hand side on the next charge, leaving the left-hand side bright. After each charge admit a little air through the fire door. By no means fire in heavy, irregular charges, but fire regularly and lightly. Be sure and keep the bars covered at the back. Do not rouse the fires with the rake. Fit each fire door with a ventilating grid for introducing air. Sometimes air was introduced at the bridge by means of what was termed a "split bridge." The split bridge was by no means a modern invention. It was patented by Josiah Parkes in the year 1820, and had been revived on many occasions. Mr. Parkinson, of the firm of J. and E. Waters and Co., Talbot Mills, Hulme, Manchester, had taken a great interest in this subject, and had introduced a split bridge in his own boilers. This he had found most successful. It prevented the emission of smoke, and did this without wasting coal. He had been very generous in giving to others the result of his experience, and the association had furnished drawings of his arrangement of bridge to many of its members. Some firemen seemed to fear lest a constant admission of fresh air at the bridge should lead to waste of fuel. This fear, however, was groundless. It was found, at the experiments at Wigan, that the constant admission of air above the bars through an aperture of two square inches per square foot of fire grate did not reduce the economy, and as the aperture at the split bridge had less area than this, it would be seen that waste of fuel need not be apprehended. With careful hand-firing and the admission of a little air either at the fire door or at the bridge, if the draught be fairly good and the boiler not unduly pressed, smoke might be so reduced as to be no practical nuisance. He was happy to be able once more to congratulate the members on the continued immunity which they enjoyed from explosions. As already stated in the report which the secretary had read, no explosion arose during the past year from any boiler guaranteed by the association, thus showing the protection the guarantee system afforded. Outside the ranks of the association, however, 54 steam boiler explosions occurred, killing 26 persons and injuring 53 others; while in addition 18 miscellaneous explosions occurred, killing six persons and injuring 12 others, making a total of 72 explosions, 32 deaths, and 65 cases of personal injury. To this he might add that from the passing of the Boiler Explosions Act, on July 12, 1882, to the close of the year 1888, as many as 366 explosions occurred, killing 248 persons and injuring 406 others. More explosions arose during the past year from the vertical class of boiler than from any other. Vertical boilers were now very numerous, and were not so safe as they were generally supposed to be. A number failed from collapse of the fire box, and the cross-water pipes did not appear to afford the support that was generally supposed. More explosions arose during the past year from defective condition, such as corrosion, both internal and external, than from any other cause. In conclusion, he might congratulate the members on the general prosperity of the association. Its members were guarded from explosions by careful periodical inspection. They received competent advice from time to time with regard to the reinstatement of their boilers, the working of their engines, and many other points; while, in spite of the keen competition that now existed from the number of boiler insurance companies plying for dividend, the reserve fund made steady and satisfactory progress, and now stood at £11,631, which was a higher amount than it had ever stood at before.

HEAT ENGINES OTHER THAN STEAM.—III.

(Continued from page 787.)

You will see on fig. 20 the turning effort on the crank shaft characteristic of each of these engines is shown graphically. These diagrams, which are taken from those given by Professor Kennedy in his paper on the motor trials, represent by the height of the curved line above the horizontal base line the "turning effort" exerted upon the crank shaft at every portion of each revolution of that shaft, the vertical dividing lines representing complete revolutions.

You will see that the steam engine, with two cylinders and with cranks at right angles, gives you a regular rise and fall of curve twice in each revolution; and without labouring this any further, I will just point out that among the gas engines, as you would expect, the "Atkinson" has, when the work it is doing does not vary, the most regular turning effort. For some purposes, especially for those of electric lighting, there is no doubt that this is an advantage thoroughly well worth having.

In addition to those engines which I have described, there are many other gas engines, such as the "Beck," the "Stockport," and others, all of them having certain advantages and certain disadvantages; but as I have given you, in pretty full detail, a description of the three principal gas engines of the present day, I do not think it is necessary for our purpose we should occupy further time in discussing these other forms of gas engine.

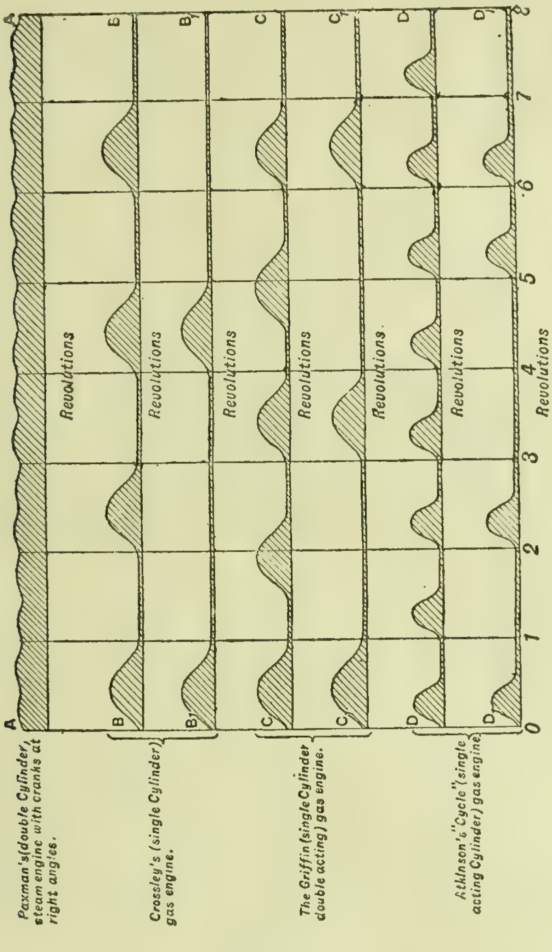


FIG. 20.

Let us now consider what is the theoretical efficiency to be obtained from a gas engine; that is to say, let us endeavour to see what would be the efficiency of an ideal engine according to the doctrine of Carnot, where the working agent was at the temperature developed by the combustion of the gaseous mixture at the commencement of the cycle, and where, when the working agent was exhausted from the engine, its temperature had been reduced to something slightly in excess of that of the atmosphere; assuming, as we must for an ideal engine, that all the heat represented by this difference of temperature is turned into mechanical work.

Mr. Dugald Clerk, to whose book I have already referred, made a series of most important and elaborate experiments on the heats and pressures of various strengths of mixtures of atmospheric air and Oldham coal gas. These mixtures consisted of 1 volume of gas and 14 of air, 1 of gas and 13 of air, and so on, down to 1 volume of gas and 4 volumes of air. He burnt these mixtures in a closed vessel, with the result that (calculating the temperature obtained from the observed pressure) he found the temperature ranged from, say 1,600 deg. absolute to nearly 4,000 deg. absolute, depending upon the amount of gas in the mixture—*i.e.*, upon its richness in gas. He also found that the more he diluted the mixture the lower was the maximum temperature.

Further, he found, on trying experiments with a mixture compressed before combustion, that the temperatures which are reached, or the pressures which are produced from any given mixture, are proportional to the pressure initially given to the mixture by compression.

This is what we should expect to find as the practical result, when we remember the two laws governing the expansion of gases, which we considered in the last lecture.

Let us assume, however, that which is generally admitted to be true, viz., that the initial temperature of explosion in a gas engine is, practically, somewhere about 3,500 deg. above absolute zero. The efficiency, according to the Carnot theory, of an ideal engine such as I have suggested above would be represented by

$$\frac{\text{Initial absolute temperature.} - \text{Final absolute temperature.}}{\text{Initial absolute temperature.}}$$

Or stated in figures—

$$\frac{3{,}500\text{ deg.} - 530\text{ deg.}}{3{,}500\text{ deg.}} \text{ (roughly) } 84\tfrac{1}{2} \text{ per cent.}$$

Remember that, as I told you in the first lecture, the Carnot efficiency is an imposible efficiency in any engine, because, among other reasons, it is impossible to construct an engine which shall not demand for itself and to keep it in motion some portion of the power obtained, because we know of no materials of which to construct our cylinders which will not absorb and dissipate some of the heat developed; and because, in practice, it would not pay to have an engine so bulky, and with cylinders so large as to allow of our expanding the working agent to such an extent as to allow it to pass from the engine at the temperature of the atmosphere, which is the temperature of exhaust we have in this case assumed.

As compared with this 84½ per cent, which is the ideal theoretical efficiency under the above impossible conditions, we find that the engines tried at the motor trials only had an efficiency of some 26 per cent of this 84½ per cent. The mechanical efficiency, as you know, was stated to be 22 per cent, but this is 22 per cent of the heat put into the engine, and not 22 per cent of the ideal theoretical efficiency under the above conditions.

Let us now examine into the question of the losses which occur in the gas engine; each of the two great heads of loss being represented, practically, by this blue cube which I have here, the total of the two being about 75 per cent of the total heat units put into the engine.

You will see how large this blue cube is (although it only represents a little less than one-half the total loss—that is to say, one of the principal heads of loss), as compared with the red cube we used in our first lecture to represent the mechanical efficiency, or the quantity of heat utilised.

The first head of loss with which we will deal is that due to the heat rejected in the jacket water.

I think if we try and realise what are the practical necessities which compel us (if I may so put it) to bear this loss, we shall be the better able to understand the possibilities there are of eliminating or reducing it in the near future.

I have told you that the temperature of combustion which is attained in the gas engine cylinder may be taken as equal to about 3,500 deg. Fah. absolute, and I have referred you to the experiments of Mr. Clerk, and should also like, upon this point, to again refer you to the records of the motor trials.

Now, the melting point of cast iron may be taken as about 2,500 deg. Fah. absolute. Most of you know that the cylinders of a gas engine are composed of cast iron, and you may ask me why, if these temperatures are correct, the cylinders do not melt. Well, it is because of the jacket, and of the cooling water, which keeps the internal surface of the cylinder sufficiently cool to allow of lubrication.

I should like to relate to you a shop incident, as a practical illustration of a similar cooling effect produced by a liquid, an incident of which I have been told. A manufacturer had to make a pan or vessel in which a certain liquor was to be boiled. It was determined to make this vessel of tin, this metal not being affected by the peculiar liquor to be boiled in it, and wishing to provide a vessel which would last some little time, the manufacturer made it 3in. thick. The vessel was completed, it was filled with the liquor, and the fire put under it; and after a very little time, to the horror of the manufacturer, he found the metal was melting, the molten tin running away through the fire. He got into a great state of excitement, and wanted the fire drawn; whereupon his foreman said to him, "No, sir, leave it alone, and the fire will very soon tell us how thick we ought to have made the pan." And the foreman was right. The fact was that the vessel was too thick to allow of the liquor which it contained absorbing or dispersing in the needed time the heat imparted to the vessel by the fire.

So with the cylinder of the gas engine. It is a necessity, as these are at present constructed, that the metal of the cylinder should be made thin enough to carry off the surplus heat as readily as it is generated by the combustion, and thus to keep the internal surface sufficiently cool to allow of efficient lubrication.

If you remember, I told you that Hugon, in his engine, had suggested the injection of a water spray for the purposes of lubrication, and a spray has also been suggested as a means of keeping down the temperature; but you will, of course, see that if a water spray were to be used in this way it would be a most wasteful means to adopt, because of the large portion of the heat combustion which would be lost, becoming latent in vaporising the water of the spray into steam.

(To be continued.)

THE COMPARATIVE MERITS OF MAIN DRIVING BY SPUR OR BEVIL GEARING, BELTS AND ROPES.

(Continued from page 816.)

The principal objections to belt driving might be classified as follow: (*a*) first cost; (*b*) low co-efficient of turning power; (*c*) excessive space required for large powers and low speed, *versus* ropes; (*d*) stoppage of works by breaking, &c.; (*e*) unsuitability for long spans, &c.

There was no doubt that the first cost of a good double leather belt was much higher per indicated horse power than cotton or hemp ropes would be; some put the difference as 1 is to 3, but 1 to 2 is a much fairer proportion, when the cost of the grooved pulleys is added. However, if the life of the two be compared, the average life of a good rope is, say 5 years, while a good well-kept leather belt would last at least 15 years, and after that could be cut up for narrower widths. The first cost is much more apparent than real.

As regards the co-efficient of plain leather belting on a smooth cast-iron pulley, the turning power varied in proportion to the arc of the driven pulley; embraced in ordinary driving, the arc might be taken as ·4; in such a case, if the belt was in a clammy or moist condition, the co-efficient of turning power might be safely taken as ·5. It was claimed for link belting that for quick speeds the co-efficient was higher than for plain belting, as the air was allowed to escape from between the belt and the pulley. A firm in America claim for a leather-covered pulley as high a co-efficient as ropes in V grooves. A claim is also made by a firm in Lancashire for a perforated pulley in regard to a high co-efficient of turning power.

Engineers differ as to the co-efficient of belts in transmitting power. A safe plan is to make the belt three or four inches wider than is required; if there is no room for this, then put another belt on the top of the present one; this will give cent per cent same as to first belt. He should advise three or four ropes more than were required for the specified load on the engine or machine, so that if one rope broke they were not depending upon a certain number to turn the power.

The best speed for leather belts was about 3,030ft. per minute for double belts, and 4,000ft. for single belts. Professor Rankine was the first to point out the influence of centrifugal tension (see *Millwork*, page 532). With speeds over this there was great loss in turning effect.

Excessive space occupied by belts was now successfully got over by placing one belt on the top of another. Messrs. Tullis, of Glasgow, who were the principal belt makers in the north, specially recommend this plan in their practice. They also make a special belt of double orange tanned leather for long distances; the principal feature of double orange tan being that the belt was only one half the thickness of oak tanned leather, yet 45 per cent stronger, as tested at Lloyd's proving house. The Singer Manufacturing Co., of Glasgow, had between 30 and 40 of these belts over 30in. wide, some of them 150ft. long, running every day at their factory, and giving great satisfaction.

The loss of power absorbed by transmitting motion through a belt varies from 3 per cent to 5 per cent; to keep this as low as possible special attention should be given to the first two main journals on each shaft, driver and driven. They should not only be large enough to resist the load or tensile strain of the belt, but long enough to reduce the friction on the journals. Hot necks consumed a lot of power. There ought also to be continuous lubrication. This also applied to rope gearing. A good proportion for journals was three times the diameter of the shaft. Belts should run flesh side to the pulley, and should be kept moist. A good preparation is to paint the outside of the belt with castor oil occasionally, the inside with curriers' dubbing and boiled linseed oil. If these points were attended to, the adoption of belt driving for direct heavy loads gave an opportunity to the engineer of having noiseless, steady, and almost perfect turning.

In discussing the question of main driving by ropes, which principle was exceedingly popular in the textile manufacturing centres of this country, also in America, India, and other parts of the world, he did not wish to convey to that meeting the idea that he was condemning rope gearing entirely. He had aimed at pointing out the defects, if any, of each principle named as clearly as possible. There was no dispute, however, that for driving a textile factory, where the power was taken direct from the flywheel to the several rooms or flats, rope driving presented great advantages to the engineer other than first cost. Rope gearing, when applied in this form for transmitting power, gave the best results—that was where the load was subdivided into sections, and not all taken to one point. This separation reduces any cross action in the ropes very materially, and so reduces friction in transmission of the power. The principal objections made against this form of communicating power are the following:—

(*a*) Different velocities in the ropes, producing cross action or friction.
(*b*) Difficulty of making ropes all one size, producing the foregoing.
(*c*) Unequal tension in a number of ropes running together.
(*d*) Excessive wear of the ropes by jamming in the V grooves of the pulleys.
(*e*) Failure of the ropes from bending and unbending at high speeds.

There was no doubt that some of these objections were serious where there had been imperfect designing, or the power transmitted had been all taken to one point, such as driving a train of rolls, where the ropes had been made too large in diameter, where the centres of the shafts had not been far enough apart, where the driving drums had been too small in diameter, and where the ropes had been run with too high a tension.

(To be continued.)

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

Sir,—I must apologise for troubling you again on the above subject, for I thought the system of compounding locomotives had been sufficiently argued and explained, in your paper alone, to convince any unbiassed mind informed upon mechanics that compounding, not only stationary and marine engines, but locomotives, was the right thing to do. We find, however, that there are a few like your correspondent, Mr. W. B. Thompson, who are blind, or will not see the benefits derived from compounding, and all they can do is to make foolish comparisons, and try to ridicule the promoters.

I read Mr. W. B. Thompson's letter in your issue of Nov. 8th, but passed it by as not worthy of a reply, but as he has been bold enough to write again in the same style, I feel bound to answer him.

In his first letter, he tells us that because a few locomotive superintendents are not compounding, they are against it, and that those who are compounding never had any reputation for building non-compounds, or simple engines, as he calls them, &c.

Mr. W. B. Thompson must be very ignorant on railway matters, or he would know that locomotive superintendents, as a rule, will not copy each other. All, I believe, are desirous of doing their best for their respective companies, but, at the same time, they have to consider their dignity; a fault, more or less, of all Englishmen, which I consider deplorable. If your Johnsons, Stroudley, Drummond, Stirlings, and others were to give the compound locomotive a trial against their famous non-compounds, and prove them a failure, I could understand these gentlemen setting themselves against compounding. It might be said that the expense was too great. I have stated before the extra expense is a mere trifle, and even after trial, if they were not satisfied, the only loss would be a pair of cylinders—that is, in the Worsdell system. Your correspondent, in the latter part of his letter, ridicules compounding by giving unfair comparisons; he is careful to tell us that Webb's compound averaged 26lb. of coal per mile running the Irish mail, which was neither a heavy nor a fast train, but he forgets to say what kind of trains the Midland new singles took to consume less than 20lb. per mile.

I will now take his second letter, which appeared in your issue of November 22nd, which I consider a most unwarrantable letter to write on this subject. He makes it appear as if Mr. Webb and Mr. Worsdell were losing for their respective companies by building different classes of compound locomotives. Your correspondent knows little about working the traffic on a railway, or he would never have mentioned this. If he would look closely into those companies that do not build compounds, he will find as many, if not more classes, than either Mr. Webb or Mr. Worsdell are building, and I have no doubt it is quite necessary to have different classes of engines to suit the traffic; at any rate, I know that those built by Mr. Worsdell for the North-Eastern Railway are made to suit the traffic, and are giving satisfactory results, which were given by a correspondent in your issue of April 20th, 1888.

To show you, Mr. Editor, how unreliable Mr. Thompson's statements are, I will just point out one remark he makes, which is entirely incorrect. In one part of his letter he states that Mr. Worsdell built for the North-Eastern a six-wheeled engine (1324), about which most unmitigated nonsense was allowed to appear in the daily press, &c. On inquiry I find that he did nothing of the kind. The fact is he did build a compound passenger engine, four-wheel coupled (1324), which was exhibited in the Newcastle Exhibition in 1887, and I am told that neither this engine nor any other engine, either compound or non-compound, ever attempted to pull anything like 64 loaded coal trucks from Darlington to Penrith. As for the locomotive Mr. Worsdell is now building (1517 class) being too heavy for the permanent way, I will leave that to the officials concerned.

In conclusion, Mr. Editor, I would advise Mr. W. B. Thompson to look more thoroughly into this subject before writing you again, and I will refer him to a paper read by Mr. D. L. Barnes, of the *Railroad Gazette*, which appeared in your issue of November 8th, 1889, which I think will convince him—that is, if he is open to conviction—that there is more in compounding locomotives than he was aware of.—Yours, &c.,

LOCO.

QUERIES AND REPLIES.

132. PRESSURE ON JOURNALS.—Will some practical reader show me how to calculate the pressure on the guide bars, crank pin, crank shaft, and other journals of a train of gear wheels: Cylinder 18in. diameter, 42in. stroke, revolutions 40 per minute, connecting rod 8ft. 10in. long, driving pinion on end of crank shaft, radius 9in., the centre of pinion to journal 14in. This gears into a wheel of 30in radius, the centre of wheel to centre of journal 14in. On the same shaft is a pinion of 12in. radius, the centre of pinion to centre of journal 16in. This gears into a wheel of 60in. radius; the centre of wheel to the centre of journals is 16in. and 32in. respectively. The end of this shaft is coupled on to a three-roller sugar-cane mill, by Merrilees, Watson, and Co., Glasgow, with three equal pinions of 15in. radius. Rollers same radius as pinions; the distance between centre of journals supporting rollers is 78in. A graphic or arithmetical solution would greatly oblige?—ENGINEMAN, North Queensland.

Answer.—In the adjoining sketches, fig. 1 represents a diagram (not to scale) of the cylinder, piston, connecting rod, and crank of the engine in question, by means of which the pressure on the guide bars, crank pin, and crank shaft journal can be calculated by graphic construction. Of course the diagram must be plotted out to scale in actually calculating the forces dealt with. When this is done, the triangle formed by the connecting rod BC, the crank AC, and the dotted line AB, will give us all that we require. AB will represent the thrust on the piston, and will be found by multiplying the area of the piston in inches by the steam pressure employed in the cylinder. Having found the value of AB, we then measure BC, when the thrust on the crank pin will be obtained, whilst the length of AC will give us the pressure on the guide bars. "Engineman" does not give the steam pressure employed, but assuming the effective pressure on the piston to be 40lb. per square inch, he will find by setting out the diagram to scale as explained, that whilst BC, the length of the connecting rod, is 8ft. 10in. = 106in., and AC, the throw of the crank, is 21in., the length of AB will = 8ft. 8in. = 104in. This latter value represents the total pressure on the piston = 18 × 3·1416 × 40 = 2262lb.; and from this we obtain the value of AC, or the pressure on the guide bars = 2262 × $\frac{22}{104}$ = 478lb., and also the value of BC, or the thrust on the crank = 2262 × $\frac{106}{104}$ = 2305lb., and this value will also give the pressure on the crank end journal of the crank shaft, viz., 2305lb. There will be a further pressure on the crank shaft journals due to the weight of the flywheel, the pinion, and the crank shaft, &c., and also a further pressure due to the load on the pinion, the method of calculating which might have been more clearly explained if a sketch of the arrangement of the gearing had been given, also giving the lengths between the journals as shown at A, B, and C in the assumed arrangement, fig. 2. To find the pressure on the journals we must first find the pressure or force acting on the teeth of the wheels in pinion *a*. This force $= \frac{\text{total pressure on piston} \times \text{throw of crank}}{\text{radius of pinion pitch circle}}$, and this pressure has to be carried by the journals 1 and 2, the proportion carried by journal 2 being $= \frac{\text{distance from journal 1 to centre of pinion}}{\text{distance between journals}}$. The pressure on teeth of wheel *b* will, of course, be the same as that on teeth of pinion *a*, but the pressure on teeth of pinion *c* will be greater than that on wheel *b* by the same amount that *b* is greater than *c*. The proportion of the total pressure carried by each journal will be calculated in the same way as that adopted for the crank shaft, and also the pressure on the journals carrying the roller pinions will be calculated in the manner shown. The method is to trace through from the engine the force exerted on the teeth of the wheels, and from this to calculate the pressure on each journal; of course, in each case the dead weight of the wheels and shafts should be considered.—HYDRA.

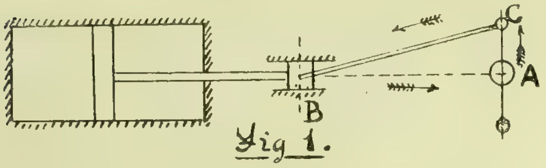


Fig 1.

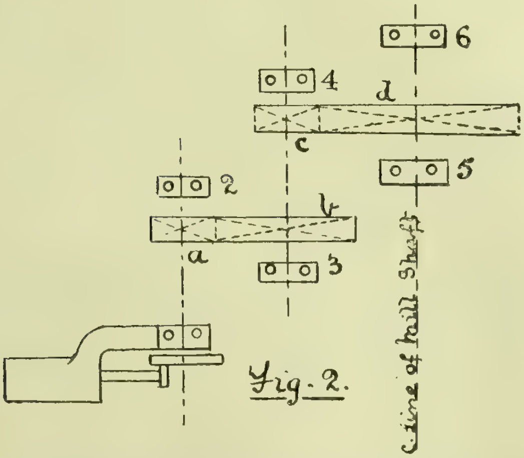
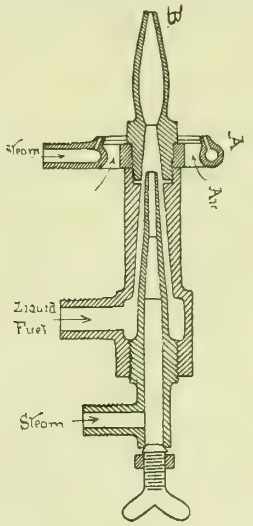


Fig. 2.

134. LIQUID FUEL.—I am told the Great Eastern Railway runs some of their trains with locomotives burning tar and oil, &c., for fuel. Can any of your correspondents give me particulars of the burner or sprayer used, and say if it is applicable to ordinary vertical boilers? How do you start the fire, and what about standing? does the fire go out, as I presume, if the burner keeps at work, too much steam would be made? What do they do about draught? Any particulars would be very acceptable.—W. E. D.

Answer.—The arrangements made by Mr. Holden, of the Great Eastern Railway, for burning liquid fuel on some of their locomotives, in 1888, were somewhat of an experimental character, the liquid fuel being made auxiliary, and not as an entire substitute for coal, the ordinary fire-grate and fire-brick arch being left unaltered, the only alteration in the fire-box being the insertion of a couple of tubes, about 6in. diameter, through the back water space, to the right and left below the fire-door. The liquid fuel injectors, with the ring jet combination for inducing a current of air (see sketch below) are fitted in these tubes. The steam is supplied to the central jet of the injector, in passing through which it meets the annular stream of liquid fuel, this mixture of steam and spray being discharged through several openings in the flattened nozzle B. The necessary draught is obtained by means of the ring jet A, surrounding the front of the injector, a strong induced current of air being formed and directed upon the issuing jet. Mr. Holden works with a thin coal fire on the grate, lumps of chalk being placed on the grate when starting the day's work, which materially assists in keeping the grate properly covered with a very thin fire; the ash-pan dampers being kept almost shut, so that most of the air required to support combustion must enter through the injector tubes. It has been found that the steam can be kept up more easily and steadily than when coal alone is used, and also that steam can be raised more quickly; and the blast may also be more moderate.—SPRAY.



145. THICKNESS OF CAST-IRON PIPE AND PROPORTION OF ENGINE CYLINDERS.—Would any engineer inform me the thickness of cast iron for 8in. diameter steam pipes to be safe from bursting with 80lb. of steam per square inch in the boiler, and what diameter of cylinders would you recommend to work compound side by side? Corliss high-pressure cylinder, short slide valve for low-pressure cylinder, to drive 200 I.H.P., 44 turns per minute, 4ft. 6in. stroke, 80lb. of steam in boiler per square inch. Information will oblige.—J. C.

Answer.—It is unusual for engineers to use material possessing such a low tenacity as cast iron for steam pipes when it can be avoided, and a large margin of safety should be provided. The following formula, derived from ordinary practice, will give the thickness of metal for your pipe:—

$$\tfrac{1}{5} \text{ to } \tfrac{1}{6} \sqrt{\text{diameter of pipe}} = \text{thickness in inches;}$$

the first value being used for cylinders or pipes up to 16in. diameter, and the second for diameters above 16in. Your pipe will therefore be ·56in. thick. With respect to the second part of your query, you do not say what diameter your proposed high-pressure one is. Without this information, it is impossible to advise you.—J. R.

Answer.—A very good rule for the thickness of cast-iron steam pipes is—

$$T = \frac{D \times P}{4000} + \tfrac{1}{2};$$

in which D = diameter of pipe in inches;
P = excess of internal over external pressure in pounds per square inch;
and T = the thickness in inches.

This, in "J. C.'s" case, will be—

$$\text{Thickness} = \frac{8 \times 80}{4000} + \tfrac{1}{2}\text{in.} = \cdot 66, \text{ or } \tfrac{11}{16}\text{in. bare.}$$

Concerning the engine, we have speed of piston = 44 × 2 = 88 strokes per minute × 4·5ft. per stroke = 396ft. per minute. Now, let the ratio of piston areas be 4. Then, that the power 200 I.H.P. may be equally divided between the two cylinders, the mean pressure in the high-pressure cylinder must be to the mean pressure in the low as 4 : 1. Or, writing R for the ratio of cylinders, r the rate of expansion, and P the initial pressure, we have cut-off in high-pressure cylinder $= \frac{R}{r}$.

A very suitable rate of expansion for steam at 95lb. absolute is 10, so that cut off in high-pressure cylinder will be $\frac{4}{10}$ = ·4 of the stroke, which, with steam from boiler at 95lb. absolute pressure, and a back pressure in the low-pressure cylinder of 3lb., will give a theoretical mean pressure, referred to the low-pressure piston, of 25lb. per square inch. Now, taking 90 per cent of this as what we may expect in practice with the class of engine under discussion, and also taking the piston speed at 400, we have—

$$\text{Area of low-pressure piston} = \frac{200 \times 33000}{22 \times 400} = 750 \text{ square inches;}$$

$$\text{And area of high-pressure piston} = \frac{750}{4} = 187;$$

Or, diameters of cylinders 15½ and 31. COMPOUND.

146. RETURNING CONDENSED WATER FROM STEAM JACKET TO BOILER. What is the best means of returning the condensed steam from the steam jacket of a cylinder to the boiler when the level of the engine cylinder is below the water level of boiler?—ECONOMY.

Answer.—Lead the jacket drains into the hot well, and let the feed pump put the condensed water into the boiler.—J.

Answer.—If the engine is condensing, drain to the hotwell; if non-condensing, drain into a tank, fitting a small supplementary pipe from the tank to the feed-pump suction. Thus in either case it will be conveyed to the boiler with the ordinary feed, the temperature of the same being increased by the mixture.—ORION.

147. EXHAUST STEAM INJECTOR.—Will any reader kindly inform me if the above could be applied to a condensing engine, or would it interfere with the vacuum? I believe they require very little steam to work them. A. S.

Answer.—I have never heard of an exhaust injector being fitted between cylinder and condenser, and cannot see how such an arrangement could work. There are many exhaust injectors working with steam taken from connections between high-pressure and low-pressure cylinders, and they work well under conditions in which there is a moderate back pressure in high-pressure cylinder and moderate initial pressure in low-pressure.—CHALKLINE.

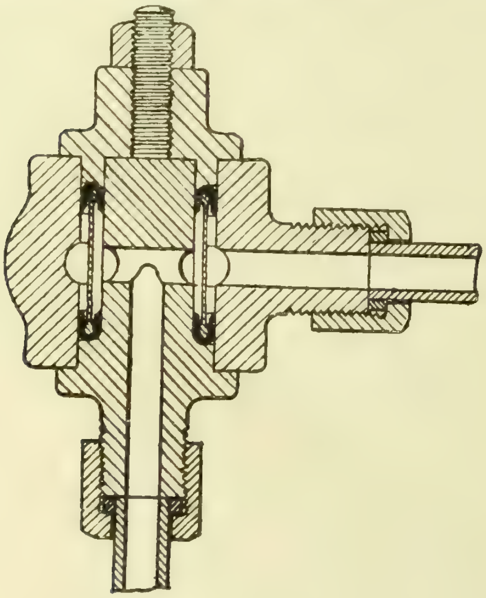
150. LEATHER BELTING.—I wish to know the width of double leather belt to transmit 200 I.H.P. Belt flywheel 14ft. diameter, 72 revolutions per minute; driven pulley 10ft. diameter, 30ft. centre to centre. Please give formula.—ANXIOUS.

Answer.—The following rule may be useful to correspondent signed "Anxious": Multiply 33,000 by the horse power, and divide by seventy times the speed of the belt in feet per minute, which will give the width of single belt in inches. Double belt may be two-thirds width of single belt. This rule will be sufficiently approximate for your size of pulleys and distance to centres.

14ft. diameter = 43ft. 11¾in. = 43·979ft.
43·979 × 72 = 3166, speed in feet per minute.
$\frac{33,000 \times 200}{3166 \times 70}$ = 29·78 in., width of single belt.
29·78 × ⅔ = 19·85in., width of double belt.
Say 20in. wide, which is the answer required. F.

152. HYDRAULIC SWIVELLING JOINT.—Will any of your readers kindly describe by the aid of sketches the construction of a swivelling pipe joint by which water pressure may be transmitted to a crane which revolves or has a limited travel?—HYDRAULIC.

Answer.—Hydraulic joints may be very readily made in cases where the pipes are required to swivel or turn freely by causing a central stem to enter a collar having a crank leading to or from the pressure supply, the stem being channelled or grooved out in its central box, so that water can circulate freely around the moving plug, and thus enter the hole that is drilled through it, leading to the central outlet, or communicating passage. Leathers are necessary at the top and bottom of the plug, and I have found the ordinary Bramah or U leather to answer best on account of the minimum of friction that this form of packing causes. The channel allows the water to enter the hole in any position of the passage in relation to the entrance or exit. The leathers are kept in position by the metal distance piece ring. Of course this swivelling joint must be made out of gun-metal, or at anyrate must have a gun-metal lining, and any form of junction pieces or connections may be employed.—HYDRA.



138. SOLID-DRAWN TUBE.—I wish to make a number of lengths of solid-drawn copper tube ⅜in. internal diameter and $\frac{7}{16}$in. external. I shall feel obliged if anyone will give a description of the necessary tools.—L. M.

141. POWER OF HOISTING BLOCK.—It is found by trial that when P is on the point of lifting W by means of a single fixed pulley, $P = (1 + m) W$, where m is a fraction depending on the friction of the parts of the machine. If three such pulleys are combined into a "block and tackle," find the power requisite to raise a given weight by means of it.—STUDENT.

148. AUTOMATIC VACUUM BRAKE.—Can any reader inform me the reason why, when the brake is applied from the engine, it always takes hold of the last carriage first? It always seems strange to me why it should do, and I shall be extremely obliged for any information on the subject.—W. G.

154. INJURY TO EYES BY ELECTRIC LIGHT AND LUCIGEN LIGHT.—I should be very much obliged if any of your readers could kindly tell me which is the most injurious to the eyes, a strong electric light (without globes) or the Lucigen light?—J. S. S.

155. POWER AND COAL CONSUMPTION OF ENGINE.—Would any reader kindly inform me what I.H.P. engine ought to drive the following dimensions: diameter of cylinder 14in., stroke 24in., revolutions 80 per minute, automatic cut-off valve, boiler pressure 50lb., belt driving from flywheel 6ft. 6in. diameter; also what amount of coal (slack) should be used for the amount required, to work at best advantage?—YOUNG MAN.

157. LOAD ON RAILWAY WHEELS.—A pair of wheels of a railway wagon required to carry 6 tons, the distribution being 4 on one wheel and 2 on the other. The centres of the axles are 6ft. 2½in. apart, and the gauge of the rails = 4ft. 8½in. Allowing a working stress of 5 tons per square inch, what should be diameter of axle, first at wheel seat, second at centre of length?—J.

158. BOILER PLATE GAUGE.—How can I make, or where can I obtain, a simple gauge for taking the thickness of boiler plates (drill test)? Information will oblige.—E. T. M.

159. WHITE COLOUR FOR STEAMBOAT FUNNEL.—Can any reader oblige me with a good recipe for making a white colour for steamboat funnels, one that will not peel off in flakes or turn yellow? I have tried lime with glue in it, but that peels off. I now use zinc white with a little glue and tallow in it; that turns yellow. Any assistance in this respect will be thankfully received.—DACIA.

160. JOY'S VALVE GEAR.—Can any of your numerous readers tell me why Joy's valve gear is not more extensively used in marine engines?—MINERVA.

PATENTS AND INVENTORS' QUERIES.

37. PROVISIONAL PROTECTION.—In a recent answer you state that provisional protection does not prevent the manufacture and sale during the period which it covers by infringers. Wherein, then, consists the protection?—D. A., Manchester.

Answer.—Provisional protection is intended to allow the inventor a period in which to work out his invention, and to give him a date to establish the priority of his invention. During its course the inventor should keep his invention secret, except such necessary disclosure as is required to obtain the co-operation of capital. Whenever the invention is complete and ready for the market, the complete specification should be lodged. When the patent is granted, and not till then, the inventor acquires the right to prosecute for infringement, so that if infringers have been at work he can at once stop them. It would be unreasonable to allow an inventor to prosecute on the provisional merely, as he has not in it completely described his invention, and persons might infringe quite unintentionally. It would be fatal to sell an article before receiving provisional protection.

38. GERMAN PATENTS.—Can a German manufacturer make and sell articles which are patented in England without compensation to the inventor?—D. A., Manchester.

Answer.—Yes. To prevent this a German patent must be applied for.

39. AMERICAN PATENTS.—What is the law regarding American patents of English patentees?—D. A., Manchester.

Answer.—You can apply for an American patent at any time within two years from the date of the English application, and you are practically protected for two years in America by obtaining an English patent.

40. POWER OF ATTORNEY.—Can an inventor arrange that another person shall sign on all patent business, British and foreign?—INJECTOR, Knaresboro'.

Answer.—For foreign patents he can grant a power of attorney. The formalities are different for various countries. If he is in Britain, he must sign himself, but if abroad he can communicate his patent to an agent.

TO CORRESPONDENTS.

FROST, Bradford.—Water in the act of cooling from ordinary temperatures contracts till it arrives at a temperature of 39·1 deg. F., after which further cooling causes it to slowly expand until the moment of freezing, when there is a sudden expansion in the act of passing from the liquid to the solid state at 0 deg. C., or 32 deg. F. Many liquids expand in a similar way just before solidifying, and also molten metals. The cause is supposed to be the polarisation of the molecules, or their rotation just previous to solidification, but it is not clearly understood.

W. A. C., Liverpool.—We shall inquire as to particulars of Allan's quadruple-expansion engines.

T. S., Dursley.—You will find tables of specific gravities or weights of equal volumes of various substances in Molesworth's "Pocket Book," to be had of all booksellers; or in our Pocket Book, to be published in a couple of weeks.

H. B., Wibsey.—We regret that your query is unsuitable for our columns. Send it to *English Mechanic*, where you will find copious information on greenhouses.

DACIA, Galatz, Roumania.—We shall be very pleased to publish for discussion diagrams from the marine engines of the steamer you mention. Please send them on, with all details.

MINERVA, Oporto.—We thank you for your appreciative letter. We take every precaution to give reliable engineering information.

MISCELLANEA.

Phosphor Bronze.—Some enormous castings of phosphor bronze have just been made on the Tyne—the first castings of such magnitude in that metal in the district, if not in England. They were cast by John Abbot and Co. Limited, and are for stem and stern pieces for cruisers under order at Elswick. Weighing several tons each, the value of each casting is defined by thousands of pounds sterling. This is good work for the Tyne.

Another Oil Pipe Line.—There is a proposal amongst Pennsylvania producers of oil to lay a pipe line from the oil regions there to the seaboard, and to build refineries on the Atlantic seaboard. The money—about £2,400,000—is said to be guaranteed by Pittsburg and Pennsylvania men. The great oil monopoly of the United States, the Standard Oil Company, has three such lines; and, if an opposition line be laid, as the *New York Herald* states, American petroleum oil may be cheaper yet.

The authorities responsible for the fitting of the engines and boilers to our ships of war have at last, by the repeated breakdowns, been brought to acknowledge that something is wrong with their arrangements, and are of opinion that their boilers, all of the same pattern, are not suited for the forced draught. Practical engineers who are not in the navy have said this before. Experiments are about to be made with a new boiler in which the water circulates through the tubes surrounding the fire, thus reversing the usual construction, and any other type of boiler which may be submitted will receive full consideration.

Safety Matches.—It is worth while observing that in the ordinary safety match there is no phosphorus whatever. The inflammable mixture into which the match is dipped consists of the chlorate and bichromate of potassium, red lead, and antimony sulphide. It is on the sides of the box where the red phosphorus is, mixed with sulphide of antimony. It is only on a surface strewn with the latter mixture that the former mixture will ignite. "Only" is too much to say; for even a safety match may be made to strike fire by rubbing it quickly over a sheet of writing paper or smooth glass surface. There is a trick in this, and a clumsy hand may try fifty times without striking fire once.

Engineers and Shipbuilders' Institute.—The first general meeting for the season of graduates of the North-East Coast Institution of Engineers and Shipbuilders was held on Nov. 20th, at 4, St. Nicholas's Buildings, Newcastle, under the presidency of Mr. McColl. An introductory address was delivered by Mr. F. T. Marshall, in the course of which it was explained that the object of the graduate section of the institution was to read and discuss papers, and to visit public works. He then referred to the steam engine and the waste of steam, and urged them to study and see whether that difficulty could not be overcome. He also referred to the slope of ships, and its effect on speed.—A discussion then ensued, after which the proceedings terminated.

The highest chimney in the world is now being erected at the Royal Smelting Works, near Freiberg, in Saxony. The horizontal flue from the works to the chimney is (the *Builder* says) 1,093 yards long; it crosses the river Mulde, and then takes an upward course of 197ft. to the top of the hill upon which the chimney is being built. The base of the structure is 39ft. square by 30ft. in height, on which is placed a short octagonal transition, from which the round shaft starts. This is 430ft high, or, together with the base, 460ft. high, with an inside diameter of 23ft. at the bottom, and 16ft. 6in. at the top. It will take a million and a half of bricks, and the cost is £6,000. Mr. H. R. Heinicke, of Chemnitz, in Saxony, is the architect.

Economy in Boiler Firing.—A recently published paper by Mr. W. J. Bird gives an elaborate and careful statement of a long series of experiments in the firing of boilers which have been carried on at the Wingate Grange Colliery, Durham. The object of these trials was to establish the relative value of mechanical stoking and of hand-firing, and one of the results quoted is an annual saving per boiler per annum, where small coal is used, with the mechanical stoker, of £82 14s. 9d. If, however, the hand-firing with small coal is compared with the mechanical firing with "duff" coal, the saving is much greater, amounting to £170 10s. 1d per annum. The increase of duty obtained from a boiler by the use of the mechanical stokers is 33·3 per cent, of which 20 per cent is due to the movable bars.

Petroleum.—Mr. Charles Marvin's latest work is on "Our Unappropriated Petroleum Empire." He points out the prodigious growth of the oil industry in thirty years, and illustrates it thus: Tank steamers are running between Great Britain and the United States conveying 4,000 tons at a time, or over a million gallons of oil. But "it would require a fleet of nearly 2,000 of them to hold all the crude oil that now issues yearly from the petroleum wells of the world." Only two steamers of the 2,000 would be needed, however, to hold all the petroleum the British empire produces. We have splendid oil resources, as Mr. Marvin shows, but we neglect them. Still, he believes we shall awake soon to the value of our petroleum deposits and begin to realise this "unappreciated asset of the empire."

Ten-wheeled Locomotives.—The Baldwin Locomotive Works are to build for the Erie Railway Company three more of the large 10-wheeled passenger locomotives, of the same type as those recently built for that road. These engines represent the heaviest class of passenger motors in the service, and their use increases the belief that the six-wheeled coupled locomotives will be the engine adopted for heavy express service in the near future. These locomotives have 20in. by 24in. cylinders, 68in. drivers, weight 127,000lb. exclusive of tender, and have 97,000lb. available for adhesion. They are adapted for burning anthracite fuel.

According to an American contemporary, "the Pennsylvania Railroad Co. has placed an order for 8,000 journal bearings with the Ashbury car shops, near Birmingham. If this order has gone from America because car brasses can be made in England and brought out at a less cost than they can be produced for in this country, the fact must be discouraging to our journal-bearing manufacturers. That they have all along sold car brasses composed of seven parts of virgin copper and one part of pure and unblemished tin for several cents per pound less than the raw material could be bought for in the market is stated by themselves to be a fact. That is, each one of them states that all the others do it. After thus paying immense sums out of their own pockets for the privilege of supplying the railroads with journal bearings, it will be a sore trial to find out that brass founders in England have discovered a way to produce even more wonderful results from 'seven of copper and one of tin.'"

Discovery of Lignite in Germany.—Borings of lignite have lately been repeatedly undertaken in the Herzogenrath neighbourhood, and thick beds of that mineral have been discovered. Previously the presence of lignite in thick seams had only been established in the Maria Theresa Mine, where the work was taking place on a large scale. Recently, however, the mining experiments undertaken by the "Gewerkschaft Koppenberg," on the table land between Herzogenrath and Alsdorf, have resulted in the discovery of extensive beds of lignite, the thickness of which will only appear when they are opened out and worked. While borings had demonstrated the existence of lignite at different points of the great coalfields, the Gewerkschaft Koppenberg undertook a closer examination by the aid of shafts. The result was extremely satisfactory; in the shafts on the heights above the village of Koppenberg, at a depth of about 11 metres, a bed composing about eight feet of pure lignite was reached. The second shaft sunk in the vicinity of Bierstrass encountered the same bed of coal 10 metres below the surface, and at the same time large masses of the much sought for sulphur coal. In both shafts the beds were free of water, which will likely facilitate the latter working. The borings are being diligently continued by the company in question.

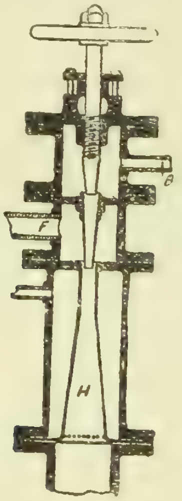
Extralite: Experiments with the New Explosive.—In the Croton aqueduct excavations in the Central Park, New York, some experiments were recently performed with extralite. Rudolf Ericsson, the holder of the patent, conducted the operations, which were designed to show the safety of the composition and its effectiveness as a blasting agent. Extralite is a yellowish powder, a mechanical mixture of several constituents, including nitrate of ammonia and naphthalene. The powder used in the experiments was made by the inventor in his own house, without any special appliances. A fire was lighted, and a quantity of the powder was burned in it; some was poured upon a hot plate of iron and quietly burned. It was hammered between stones, and a pistol ball was fired through a can filled with it, without effect in either case. A detonating cap was exploded when embedded in a cartridge of extralite, also without effect. Finally, three holes in the rock were charged, tamped, and fired by detonators. Owing to the confinement in the bore holes the extralite detonated with immense power, throwing pieces of the rock to a great distance, and upheaving a large mass of material. The explosive, in general terms, was shown to be one that can only explode when confined, and it then possesses immense power. Its adaptation for blasting and for charging percussion shells was apparently very well illustrated.

A Great Bridge.—New York seems to be in earnest about making the World's Fair of 1892 something worthy of American fame. The idea of erecting a tower to eclipse that of M. Eiffel does not appear to find very great favour. In its place a far more practical scheme is advocated by the American press. A Philadelphia contemporary advises the New Yorkers to put a cantilever bridge across the Hudson, from the Heights to Morningside Park. Any engineer can set a truss up on end, as M. Eiffel has done. It takes a genius to put that truss sticking out sideways over space. The Eiffel Tower would not make a railing to the Forth Bridge, which is equal to six Eiffel Towers strung out sidewise, and while the Eiffel Tower only bears its own weight, the Forth Bridge would carry a pile of 300 locomotives. If New York really wants to add to the wonders of the world, she should match the Forth Bridge with a mightier marvel. The Eiffel Tower is mere gingerbread and spun glass by the side of such a bridge as would span the space from the exhibition site to the New Jersey Heights. The two 700ft. cantilevers and the 350ft. of the central span in the Forth Bridge would have to be beaten, even with a central pier; but once done, all New York valuations would feel the impulse for a century of a bridge that blotted out the Hudson for railways and left it untouched for steamships. Our contemporary is giving good advice.—*Iron.*

ILLUSTRATED PATENTS.

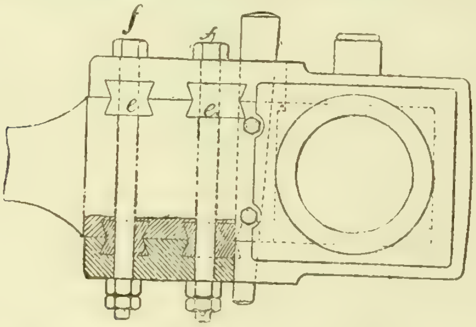
6640. Injectors. F. and A. Craven, Waterloo Mills, and W. Pinder and P. H. Stansfield, both in Bradford, Yorkshire.

Water in the form of spray or air and water mixed, are blown into pipes used to heat buildings, vats, &c. by injectors. A section of an injector for this purpose is shown, in which B is the steam supply pipe and F the air supply pipe. The water is drawn in through small holes in the end of the cone H, and is thus finely divided. The water may be supplied by a perforated pipe in the delivery pipe in place of through the perforations in the cone, as shown in the figure.—May 4, 1888. [8½d.]



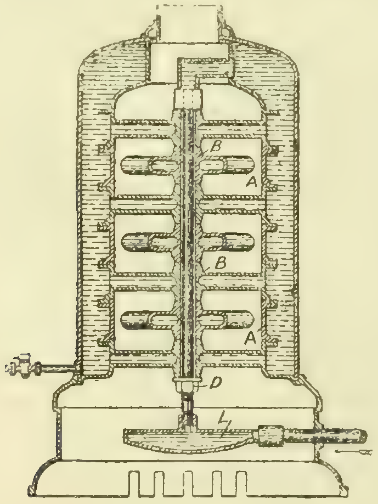
6897. Steam Engines. G. Hutchinson, Newcastle-on-Tyne, and S. S. Younghusband, Darlington.

Connecting Rods.—For securing the strap, keys, *e*, *e* are inserted in the connecting rod end and strap, passing transversely partly through each. The portions of these fitting the strap and connecting rod end are of dovetail form. Through each also passes one of the strap bolts *f*. Otherwise the connecting rod is of ordinary construction.—May 9th, 1888. [6½d.]



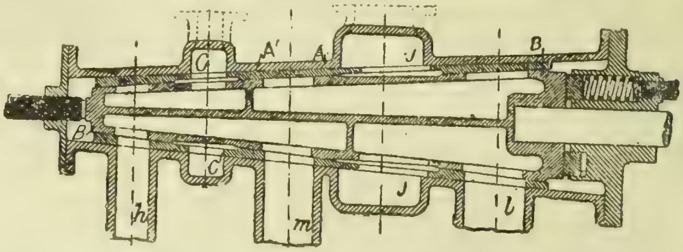
7287. Boiler. H. J. Davis and H. C. Turner, Camberwell, Surrey.

Relates to a simple construction of gas-heated boiler for generating steam or heating water. To give extended heating surface and facility for cleansing, the firebox is formed of a series of superposed wheel-shaped segments A, the central bosses B forming, when placed together, a central vertical water passage. The segments are held together by a tubular stay secured by the nut D. Immediately above the burners G is located the water chamber L, communicating with the central stay. As shown, the boiler is filled with water for heating purposes, but when used for steam generation the upper portion is occupied by the steam space.—May 16th, 1888. [8½d.]



7443. Steam Engines, &c. R. T. Terrero, Middlesex.

Consists in a form of rotary valve for compound engines. The drawing illustrates the application to a triple-expansion engine. The rotary portion of the valve B is in the form of a peripherally-ported conical shell divided into four compartments, and works in a casing A, preferably with a lining A¹. The steam inlet and exhaust branches respectively open into the annular spaces C J of the casing. The casing communicates with the first, second, and third stage cylinders by the branches *h*, *m*, and *l*. The arrangement of the ports and compartments in the valve is such as to make the various connections between the cylinders, and the steam and exhaust, required to effect the proper distribution of the motive fluid.—May 19th, 1888. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq. *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

November 11th.

17920 Tubular Boilers, L. White, jun., and W. Y. Baker, London.*
17931 Stoppers, J. Hay, Glasgow.
17940 Mechanical Stokers, A. Slater, Gloucester.
17958 Water Tube Boilers, A. F. Yarrow, London.
17978 Rotary Motor, E. T. Cleathero, Kent.

November 12th.

17981 Calipers, H. Brown, Newcastle-on-Tyne.*
17986 Propellers, A. Gibb, Greenwich.
17987 Worm Gearing, A. Gibb, Greenwich.
17989 Vertical Boiler, T. J. Sullivan, Wallsend-on-Tyne.
17996 Drills, J. W. Newall, London.
18015 Bolts and Nuts, J. Bühr, London.*
18019 Nut Locks, M. Albers, Liverpool.
18023 Locomotive Steam Carriages, W. P. Thompson, Liverpool. (J. B. Vidal, France.)
18038 Propeller Shafts, J. F. Hall and J. Verity, London.
18076 White Lead, H. H. Lake, London. (J. B. Tibbits, United States).
18078 Rotary Engines, J. N. Miller, Midlothian.

November 13th.

18083 Waste Heat, W. Burns, London.
18089 Furnaces, C. T. Phillips and R. Archer, Leeds.
18092 Governors, S. Carnaby, Liverpool.
18105 Tube-sawing Machine, J. Hill and I. Hill, Derby.
18106 Slotting Metals, F. Evans, Seaforth, Lancashire.
18108 Retorts, J Roscoe, Hyde.
18110 Dynamos, J. Farquharson, Acton.
18112 Electrical Cables, H. Edmunds, London.
18116 Rope-driving Gear, R. Hornsteiner, London.*
18124 Propellers, G. J. Stevents, London.
18130 Valves, J. Andrews, London.
18140 Grinding Steel, G. F. Simonds, London. (J. J. Grant, United States.)
18143 Screws, H. Nettlefold and J. Sheldon, London.
18146 Electric Meters, J. J. Tylor, London.
18156 Rotary Engines, J. P. H. Gastrell, London.

November 14th.

18160 Steam Boilers, W. H. Wood, Birmingham.*
18161 Sprinklers, J. Marshall, Manchester.*
18162 Sawing Metals, C. Carter, Manchester.*
18169 Vaporising Water, R. Fradera, Glasgow.
18196 Flue Cleaners, J. Ehrlich, London.*
18208 Steam Engines, C. Wells, London.
18213 Couplings, A. R. Bastick and J. Rhodes, London.
18220 Signalling Apparatus, H. Kirchmann, London.

November 15th.

18227 Gas Engines. J. Mohs, Philadelphia, United States.
18240 Carding Engines, R. Lord and G. Fletcher, London.
18252 Valve Gear, C. F. Dixon and W. N. Dack, Manchester.
18256 Driving Gear, T. H. McMurray, Belfast.
18258 Gas Engines, J. C. R. Okes, London.
18260 Gas Motors, A. G. Melhuish, London.
18261 Joints for Wires, R. J. H. Rastrick, London.
18264 Shaping Bolts, P. Koch, London.*
18269 Electric Motors, W. P. Thompson, Liverpool. (L. Gutmann, United States.)
18272 Fluid-pressure Generators, R. D. Bowman, London.
18278 Governors, F. H. Anderson and F. W. Crossley, London.
18287 Cranks, A. Leckie, London.
18301 Lathes, J. W. Curtis, London.
18303 Axle Boxes, The Patent Stamped Steel Railway Axle Box Co. Limited and J. Donnelly, London.

The Practical Engineer,

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

DECEMBER 13TH, 1889.

THEORETIC ENGINEERING.

WE are pleased to notice how gradually the idea of practical knowledge and practical training is becoming to be a condition for which the politician as well as the educationalist endeavours to provide. The movement, now rapidly assuming definite form in our large manufacturing centres, towards obtaining the grant to be provided for technical educational purposes, cannot be too highly commended, but we must utter a note of warning to our friends who appear to think that they can produce skilled mechanics and superior handicraftsmen direct from the desk or classroom of the ordinary school. It cannot be too generally understood that there is a concensus of opinion tending to show that the technical training given in any school is but of the most elementary and simple character, and therefore cannot possibly in any degree take the place of actual practical experience to be obtained in our workshops and factories alone.

We very much question whether some of the teachers who are laden with certificates from the Science and Art Department, and who in consequence pose as experts in applied mechanics, steam, machine, and building construction, are capable of passing an opinion as to the merits or demerits of any piece of practical work that may be placed before them. We know that many teachers lecturing weekly on those technical subjects have never been engaged upon the design or construction of a practical piece of work in their lives; and yet they, forsooth, are to be the instructors in our new technical schools. Such theoretical training can have but one end, and that most serious and disappointing for all concerned. Those of us who have had experience in directing the designs suggested in our drawing offices by young college-trained theorists, or the young foreigners who seek to acquire from us that which the technical school or polytechnic has failed to teach, know most assuredly what blunders have come to be repeated by the managers and teachers of the new movement. No man can impart to others, by the most elaborate lecture or the most skilfully-worded description, that which he himself learned by practical manual working. As well may we expect that the novice should be able to skate after attending a course of lectures upon the art of skating, as that the youth shall become an engineer by simply attending a technical school. Yet we find it set forth most seriously by those whose position enables them to guide and direct the opinions of others, that the new mechanic—the new workman—is to be produced by technical education alone.

We have plenty of good men, with experience, who can ably direct the studies of those under their care in matters pertaining to engineering, but who would shrink from the suggestion that their training was sufficient, seeing that they know that such knowledge which they can impart will be simply the introduction to the practical experience which must be personally acquired. No one will suggest that we are advocating the uselessness of technical teaching, for we hold it to be essential to the commercial prosperity of our time. We desire to advocate that the extent of the benefit shall not be overrated, that the larger and equally important after practical training shall not be lost sight of, and that the teachers themselves shall be men who have not a theoretical knowledge only, but a practical knowledge of the subjects they essay to teach.

We should not expect an architect, with great and varied experience in buildings, to be equally competent to design a bridge or a gasometer, whichever might be asked of him. Neither should we be surprised if a design for an engine-house, prepared by the engineer who designed the engine, looked somewhat heavy and unattractive in elevation. But we do not allow our knowledge to be equally our guide in matters not quite so definite in form, preferring the easier course of following the lead of some popular idea or some popular theory.

The many difficulties that every pattern maker and moulder continually has to meet in arranging his cores and patterns on account of faulty design on the part of the draughtsman will be in no measure lessened by technical teaching. Nothing but actual practical experience will enable a draughtsman to design machines that will turn out well in all parts of the work during their construction; and all the certificates that can be obtained will stand in no avail when new practical problems have to be faced, and entirely new difficulties overcome. The text-book young man is a nuisance to every head draughtsman, and it is little wonder that our drawing offices are so crowded out with indifferent draughtsmen, while first-class men can only with extreme difficulty be obtained. There are scores of young men who can most mathematically determine the strain upon the three legs of their office stool, who cannot, while sitting upon that stool, produce anything unless they have every detail carefully checked and every practical point determined for them by others. Some young men seem desirous of doing their work in a way which looks well on a picture; utterly regardless of the cost of the patterns, the cost of planing and fitting generally, and the general commercial side of the business. Yet this tendency is not sought, but is rather a part of their training in some school where mechanical drawing has been a great item in the accomplishments, and where a pretty picture is oftener produced than a mechanically-commendable engine or machine.

This tendency to follow in the lead of their teachers and instructors is apparent even in the published specifications and conditions of testing issued by some engineers, for work to be done for the departments or bodies whom they represent. There are but few specifications that cannot be ridden through roughshod by the experienced practical man, and yet, at the same time, some conditions are imposed truly impossible. We have recently seen specifications published wherein it is set forth that the wrought iron is to have a tenacity of 27 tons per square inch, and is to be of *best* quality. Now, every person accustomed to deal practically with iron is perfectly well aware that the brands or trade designations run for quality as follow: best, best best, and best best best—that is, B, BB, and BBB. Thus iron stipulated to be of the best quality is only really inferior iron, and is thus perfectly understood by all interested in the manufacture and daily use of such material. Therefore indiscriminate copying and repetition of expressions and conditions used by those having only a theoretical knowledge of the materials, may often lead to serious errors and misunderstandings between all concerned, in following such directions. We should like to see the technical subjects of the Science and Art Department taken over by technical men, on lines similar to those established and in successful operation in connection with the City and Guilds of London Technological Institute. Technical schools should be arranged according to local requirements, and should seek to assist, not to supersede, such training that the locality affords. As a matter of fact, we would provide that each locality should become a nursery for its trades and manufactures, so that every facility and inducement would be offered to the students for pursuing their studies. We do not believe in any central system controlling all technical teaching; and providing only that engineers with practical experience are selected to teach engineering subjects, we think a great future is before this country by the local authorities taking this matter in hand at once. Where local schools are already established, the authorities should combine with them, not attempt to enter as rivals. They should seek to strengthen and improve existing institutions, so that, with the powerful aid of their support, financially and socially, the young men of our towns can be trained and educated in those principles which will make them more valuable in every trade and calling in which they may be engaged.

COMMISSIONS OR BRIBES.

Some little commotion has been caused in some of the larger Government Manufacturing Departments at Woolwich Arsenal, by the sudden dismissal of two prominent officials from the position which they had occupied for many years with a certain amount of ability and apparent success. The charges alleged against these officials are somewhat vaguely defined in the columns of our daily contemporaries as "Malpractices, and receiving royalties" or commissions, from the contractors who were supplying machinery and stores to the Government. Now, we are not concerned so much in the matter of investigating that which is a scandal in one establishment, seeing that the course would be of little benefit to our readers; but we are greatly concerned as to the whole question which is thereby opened, and to the base system which is now slightly exposed. We do not imagine many of our leading firms are aware of the general character of corruption which is alleged against our European Government officials, or they would not take such pains as is only too commonly done to secure Government orders.

The question of bribery, whether by means of a gift in the veiled form of a present, or the openly paid cash or cheque, as a consideration, handed to the person who secures the order, is one which affects all trade honesty, and which lies at the roots of commercial enterprise. That any servant should sell his principal in order to obtain a gratuity from another person supposed to be giving value for the money to be paid him, is, we contend, as base a crime as to forge a signature to a cheque, or to openly appropriate the funds of that principal. Probably, however, from the long familiarity which has accustomed us to the little tricks of the trade, by which term all kinds of questionable conduct is covered, we are not quite so logical in our conclusions respecting actual dishonest dealing as we otherwise should be. We know it to be an understood thing with some firms that no gratuity of any kind, or commission upon orders placed, shall be paid to any person placing or influencing such orders; and yet we know also that the same firms have officials who, whilst recognising the stand made by their principals, themselves actually wink and connive at practices which they say they are bound to keep up or lose large orders.

The whole existing commission system is getting, indeed, lamentable, when we find firms of established reputation sending boldly to other firms and asking for a commission upon an order which their friends have placed, owing, they say, to their having recommended the machinery in question. At the same time, too, such applicants are usually careful to request that the matter be kept quite private, and must not be mentioned to the actual purchasers. In plain words, they profess to act as disinterested friends, and then after that seek to get an allowance from the pockets either of those selling or from those buying, the only condition being that the transaction must be paid for by the person selling the article without the knowledge or consent of those buying it.

We have of our own knowledge no doubt at all that many of the firms thus endeavouring to levy an unwarrantable toll upon honest industry are themselves being made victims of similar dishonesty upon the part of their own officials and subordinates.

Commercial dishonesty is, perhaps, not quite the expression which such firms would care to have applied in describing those practices, yet we fear in the eyes of the law such must be the verdict as to their conduct and as to their actions. We were informed only recently, by one of the largest firms in the country, that they had received no less than four separate applications from manufacturers asking for commissions upon a sale that the firm had made to a certain establishment, which each of the applicants had also been supplying articles to. They one and all claimed to have recommended the articles in question, and wanted a percentage, if such favours were to be expected in the future. We are pleased to say that the answer was a refusal in definite terms, which indicated that such a practice was not to be recognised either upon that or upon any future transaction. In another case, we remember reading a letter from an official asking for a commission upon an order just placed with a firm for some machinery which this official would have to take charge of; and it was even suggested that future orders might result if this person was pleased with the machinery when it arrived. No commission was paid, and the machinery was reported shortly after to be failing in its duty. A letter was sent to that official, intimating that unless all went well and was reported working satisfactorily, a certain letter would be put forward as an explanation of the alleged failure. From that time no further complaint of any kind was received, but a report was forwarded that all had been adjusted. There is no reason why one or one hundred firms should be subjected to this invidious task of offending the applicant for commissions; it should be an understood principle in all trades that commission means bribery, and bribery is pure theft.

RULES AND TABLES.

Of the many aids which the practical engineer must have at his command, none are so much in demand as the collection of notebooks containing his rules and tables, which may be considered to put in brief form his actual experience and his long-tried methods of procedure. We imagine that few engineers would care to be cumbered with a collection of detailed statements and proofs establishing the true results of those formulæ which he has been long accustomed to work with, and we fear that in the hurry and rush of practical operations we care little about demonstrating the actual methods or systems which we adopt in order to determine the points necessary for immediate decision. We are satisfied if we can rely upon the rules and tables we have used, and if we have once noted the actual connections of the rules, or the methods set out in simple form, we are content to go on, caring little for the mathematical proofs or the philosophical reasoning which underlies every investigation we make.

But there is nothing more misleading than a tabulated statement or result which has been carelessly prepared, or which expresses probably only half the truth which should be told. We have known grave errors committed by draughtsmen and others from placing too great confidence in such compilations, and even those who purchase such tables think that anyone is competent to prepare a table or set down a simple rule. We know of pocket-books professing to give information to engineers and others which would be simply amusing were they not dangerous in the false confidence which they will induce.

Having practical experience of the dangers of cheap compilations, and, at the same time, a dread of the unwieldy treatise, we have arranged with experienced engineers of unquestioned ability in their particular branches of the profession, who have prepared and compiled a series of rules and tables which, in diary form, will be a most valuable companion to every practical engineer and student.

We have no desire to suggest that a book of rules and tables is to take the place of original study and personal investigation, but what we know is, that questions have to be settled every day, and in every workshop, which cannot wait for a long, elaborate calculation, but must be done at once, rightly or wrongly.

A pulley has to be removed from a shaft by an engineer during the meal hour, and another one placed there to give higher speed, and the notice given of such alteration is but a few minutes. It is a question of selecting at once the proper size that will give the speed, and no time is to be lost in trying all kinds of methods to check the size determined upon.

A load is to be raised, and chains or ropes are to be immediately fetched for the purpose. Working out the strength of such would take valuable time. A reliable table must be at hand to help in the selection of the chain or rope for the load to be carried.

There are rules utterly worthless, and there are tables which are worse than useless, for they are positively dangerous. It has been the aim of the compilers of "The Practical Engineer Pocket Book and Diary" to avoid these.

The new 7ft. driver express compound passenger locomotives recently turned out at Crewe are doing excellent service, and have been running an average of 300 miles per day with two sets of enginemen.

STEAM ON COMMON ROADS.—III.

(Continued from page 644.)

Church.—Dr. Church, of Birmingham, introduced a number of novelties pertaining to steam locomotion on common roads in 1832 and 1835. His patent specifications are very extensive and elaborate. His carriages were fitted with wheels having spring spokes, and the tires were also elastic, presenting a flattened surface in contact with the road. The London and Birmingham Steam Carriage Company was formed in Birmingham with a large capital for the purpose of introducing Church's steam carriage. Large sums of money were advanced by the company to Church, in the confident conviction that he would bring out a practical steam carriage. After various attempts, Dr. Church at length brought out the steam coach shown by the illustration, fig. 4, on page 842, the multitudinous combinations and the workmanship of which, says a competitor, were very scientific and beautiful. In 1835, this engine was brought out for public trial, and started from the factory with forty passengers, and proceeded at a rapid rate for a considerable distance, but in turning round the hind part struck the footpath and damaged some detail connected with the boiler; it was deemed unsafe to work it further, so the engine was hauled back to the works.

A few days afterwards the *Birmingham Gazette* said: "The attention of many persons was attracted to Church's beautiful engine running on the Coventry Road, six miles out and six miles home, over heavy roads;" three miles were run on the level road at the rate of 15 miles an hour. Dr. Church, like most of his contemporaries, was not satisfied with a moderate speed, and consequently his carriage failed because it was impossible that such a complicated machine as he built would run at the rate of 15 to 20 miles an hour on any common road without constantly breaking down.

A few months after the trip recorded above, the London and Birmingham Steam Carriage Company were advertising that all the difficulties of running steam carriages upon gravel roads were now overcome, and would be done to great profit to those engaged in it. It was wisely suggested that, instead of puffing and advertising, the company should put a carriage on the road at once for constant passenger traffic between Birmingham and London; but this scheme was never practically accomplished; the carriages were constantly brought out, and as constantly failed. Previous to the opening of the London and Birmingham Railway, Dr. Church built the "Eclipse," the first four-wheel tank railway engine ever made. It was used as a ballasting engine on the above railway during its construction in 1838. He does not appear to return to the subject of steam on common roads. The only record we can find concerning Church after this date is that he sailed for America in 1861.

Yates and Smith.—On the first of July, 1834, a steam carriage on a new principle, invented and made by Messrs. Yates and Smith, started from their factory, Colchester Street, Whitechapel, London, on its first trial. It ran up Whitechapel Lane, along High Street, and returned down Red Lion Street and Leman Street to the factory, at the rate of 10 or 12 miles an hour. The exhaust pipe joint broke when running over the rough paving. When repaired the makers took the carriage for a trip on the Brighton Road. The engines were of the vibrating type, working in horizontal framing. The coach was similar to an ordinary stage coach.

Field.—After Sir Charles Dance had removed his steam coaches from the Gloucester and Cheltenham Road, he took one of them to Lambeth to be repaired by Messrs. Maudsley, Sons, and Field, the well-known marine engineers. The result was a patent, taken out in the joint names of Sir Charles Dance and Mr. Joshua Field, for an improved boiler. Many journeys were made with this improved carriage, Mr. Field often accompanying Sir Charles Dance to Marlborough, Brighton, and other places. Mr. Field constructed a steam carriage which made an excursion in July, 1835, the passengers consisting of baronets and a select party. In the course of its journey, it went up Denmark Hill, and did the distance, nine miles, in forty-four minutes. It also ran several times to Reading and back, at the rate of 12 miles an hour. Mr. Cubitt, C.E., was one of the party who subscribed towards the building of Mr. Field's steam carriage, and he says that it was a success mechanically, but was far from being economical.

Mr. Field was one of the six gentlemen who founded the Institution of Civil Engineers. He died at the age of 77 years, in August, 1863.

Millichap.—In reply to a correspondent's letter to one of the engineering papers in 1837, G. Millichap, of Birmingham, says: "If your correspondent will take the trouble to call at my house

I shall be happy to show him a locomotive carriage in a state of great forwardness, intended decidedly for common roads."

This engine was on an entirely new principle, but we have no record of a public trial, so we are led to infer that the carriage was not a practical success.

A correspondent residing at Luton in 1840 said: "There has been so little written respecting steam road locomotion that I feared the matter was likely to fall through altogether. But I came across a gentleman whom I knew to have made experiments with a small steam carriage, who showed me two handsome and powerful carriages in his factory. One was complete, and had been out several times; the other was very nearly finished. The large one, with two cylinders, each 8in. in diameter and 18in. stroke, was intended to carry twenty passengers. The smaller one was built for conveying fifteen passengers. No expense had been spared to render them in every way a success." In addition to these engines, a large omnibus ready to attach to either of them had been constructed. We are unable to give the name of the maker of these carriages.

Colonel Maceroni about this time refers to some newly-designed road locomotives as follows: "There are three or four productions now being tried upon the Vauxhall Bridge and Finchley roads, but in mercy to the inventors I will not mention names, having seen their performances, which, like so many others, bring common road steam carriages into utter contempt."

Deitz.—Mr. Deitz had run an engine about the streets of Paris previous to Maceroni's having been taken there, and in 1840 the engine was described in the Reports of the Academy of Sciences and Academy of Industry in Paris, from which we quote a few particulars. The carriage had eight wheels, two of which were larger than the other six, and gave the impulsion. The six smaller wheels rose and fell according to the irregularity of the road, and at the same time assisted in bearing the weight of the carriages. The wheels were bound with wood tires, having cork underneath. Deitz's locomotive was merely a drag; the passengers were drawn in a separate carriage. The engine was of 30 horse power, and travelled at a speed of ten miles an hour.

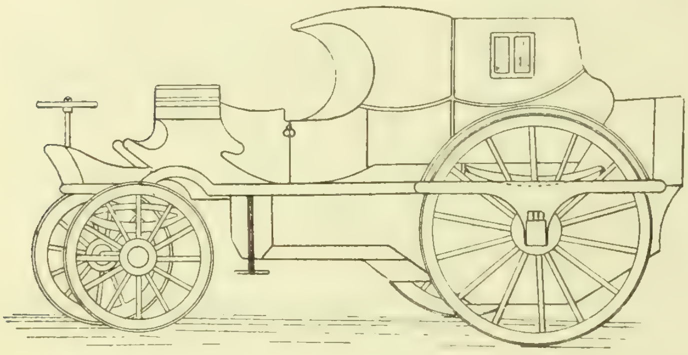


FIG. 4.

Hill.—Mr. F. Hill, of the Deptford Chemical Works, must be classed among the successful steam road locomotionists. We meet with him first in 1839 among the distinguished passengers who accompanied Mr. Hancock in one of his latest trips with the Automaton from London to Cambridge and back.

Mr. Hill was doubtless taking a lesson in steam-carriage construction during the journey. In after years he devoted much time and attention to the subject, and was very successful in his carriage experiments. In 1840, Mr. Hill made repeated trips to Sevenoaks, Tunbridge Wells, &c., with satisfactory results. He also ran on the Brighton Road, up steep hills, with the carriage fully loaded, at twelve miles an hour, and on the level at sixteen miles an hour. We find that Mr. Hill used the compensating gear among his steam-carriage improvements, a device invented by Mr. Richard Roberts, of Manchester.

LARGE CASTING OF SWEDISH STEEL.—The Bofors Engineering Company, Sweden, has just despatched an unusually large steel casting to the Elsinore Shipbuilding Company, Denmark. It forms part of the keel and the stern-post of a new ice-breaking steamer, and measures 35ft. in length and 14ft. in breadth. It is cast in one piece, and is of very heavy dimensions, but the quality of the casting is pronounced exceedingly good. The State Railways were not able to convey it, so it had to be brought to Otterbucken, and from there by water to Gothenburg. From this town it goes by rail to Helsingborg, as none of the steamers from Gothenburg could receive it on deck.

IRON TOWERS.

By FRANCIS CAMPIN, C.E.

WE have undoubtedly reached an era of great things in iron and steel. The Forth Bridge and Eiffel Tower stand forth as the most stupendous examples in metal of this or any other age of which we have any record, and amongst the traces of the "lost civilisations of the remote past" we find nothing indicative of the use of metal—in a structural sense—in the gigantic works of prehistoric peoples.

The successful completion of undertakings of such magnitude encourages others to essay works still greater, and thus issue the proposals for a Channel Bridge to connect England to the Continent, and a lofty tower to adorn the east end of London. The bridging of the channel is no new idea; at different times during the past thirty years schemes to that end have appeared, only, however, to die of inanition. The successful completion of the North British bridge has undoubtedly revivified the larger project, and the promoters obviously look to the experience of the engineers of that structure for guidance in the execution of their own designs. In like manner, the construction of the Eiffel Tower, in Paris, has created an emulative desire to erect one of yet larger size on English soil. The French work is nearly one thousand feet in height; the English one is not to be less than twelve hundred.

As to the difficulty of carrying out such enterprises, it is one of degree; but there is a marked difference between the two classes of structure, inasmuch as the extension of the bridge spans will not involve any great altitude, at all events to the extent of reaching heights at which the power of the wind currents is untested. In either case special machinery must be designed to execute the work, but the same principle which rules the smaller design will also control the larger. One very saddening reflection is that the shadow of death overhangs the execution of these great works; their cost is not in material alone, but in human life, and in the course of years the record of fatalities attains a grevious height, but this does not appear in the estimates. We cannot, however, in all cases blame the supervisors for the accidents that occur, for many, if not most, are due to reckless and uncalled-for daring and carelessness of danger, bred by familiarity on the part of the workmen themselves; and we must believe that in the generality of cases the contractors make every possible provision for the safety of those they employ, though there have been isolated cases where they have shown more anxiety about their horses than their men.

The great public charge against iron structures is that they are ugly—not only not ornamental, but absolutely and hideously ugly; and they quote the Eiffel Tower as an instance. There is an idea in some quarters, that were the work placed in the hands of architects different results would accrue. Now, without advancing any definite opinion on this point, we may call attention to the fact that the nature of wrought iron and steel, and the character of the works for which they are generally used, are not particularly favourable to the evolution of artistic detail, and in works of moderate dimensions all ornament must be adventitious; but in structures of magnitude we look not for prettiness of detail, but for bold, artistic outline. That the Eiffel Tower is beautiful few will contend—the straddling legs upon which it stands are sufficient to settle that point; so, in the first place, it is interesting to inquire whether that form of design is essential to the safety of such structures.

The essential disadvantage at which iron stands in point of stability, or resistance to overturning, as compared with masonry, lies in its less weight, which calls for a greater width of base than is sufficient when the latter material is used. But, on the other hand, we have in the metal structure tenacity, which does not exist in any reliable degree in works of bricks and stone—at all events, not until a long time after completion, and then it is inappreciable when compared with that of iron and steel.

The conclusion to which this points is, that to avoid the distorted base we must avail ourselves of the tenacity of the material, have the necessary stability in the underground foundations, and secure the safety of the superstructure by anchoring it down. The amount of sectional area necessary to resist the tension would not probably be very much more than that which, in any case, must be put in to support the work, so that there would really be no extra cost entailed by the anchorage upon the superstructure, and of course the weight of the work would be taken into consideration as aiding in resisting the wind pressure.

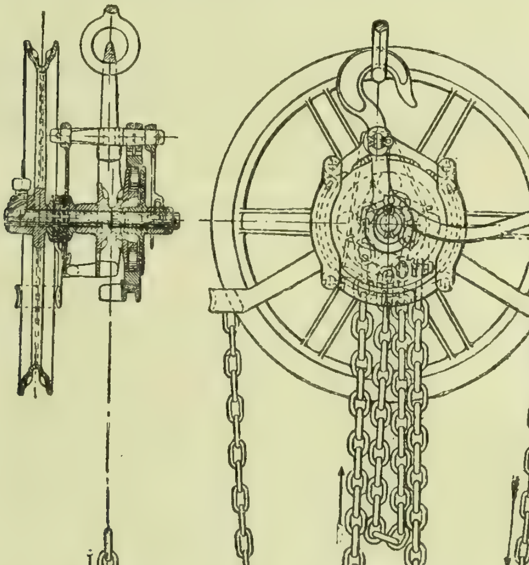
To give an approximate idea of how the figures stand, we may assume a tower twelve hundred feet high and forty feet square to weigh 9,000 tons empty, which is the weight which must be taken in calculating stability. The wind pressure will probably increase with the height; so we will assume the average pressure as 50lb. per square foot, and the centre of pressure at two-thirds of the height. Then, taking the whole surface of one side of the tower as offering resistance, the overturning moment will be 857,000 foot tons. The moment of stability of the tower itself amounts to 180,000 foot tons, leaving 677,000 foot tons to be provided for by anchorage. This would put a direct pull on one side of the tower of about 17,000 tons, requiring an area at the base of some 2,500 square inches of steel, this area of course diminishing as we proceed upwards. In calculating the weight to be carried by the supporting columns, there will be, in addition to the assumed 9,000 tons of structure, the maximum temporary load; so that the sectional area required for this purpose will probably not run very far short of that thus arrived at. This, however, will, of course, depend upon the purposes to which the tower is intended to be put after it is erected. Below the ground the foundation can, of course, be spread as much as is desired or may be convenient.

The construction of the foundations will naturally be regulated by the kind of subsoil upon which they will rest, but there is no reason to anticipate any special difficulty in that direction, though this is a matter that cannot be dealt with on general principles.

Taking the figures here put forward as substantially accurate, there would seem to be no absolute restriction as to form imposed upon the designers by the requirements of strength and stability; and under such circumstances it may be expected that the competitors sending in plans for the proposed East London Tower, whether engineers or architects, will send something that will not discredit the Metropolis, even if the example be taken from China.

PORTABLE HOIST.

THE annexed engraving is a sectional view and elevation of a portable hoist, invented, patented, and constructed by J. G. Speidel, of Reading, Pa. It is one of those hoisting devices found to be so exceedingly useful and labour-saving in all machine works, manufactories, and engine and boiler rooms. Reference being made to the engraving, it will be seen that the machine is suspended by a hook, and is provided with an endless hand chain laid over the large chain wheel, which is secured by means of a set screw to the shaft. To this shaft is also attached a small chain wheel for the lifting chain.



A novel feature of the upper mechanism is the automatic brake, which holds the load at any point from running down when the operator lets go the hand chain; the brake wheel, which is loose on the shaft, serves as a bearing for the shaft during the hoisting of the load, as indicated by arrow. Surrounding the brake wheel is a toggle frame, serving as a brake band, hinged to the cross bar. The lifting chain wheel is coupled to the brake wheel by means of rollers and cams in such a manner that it may rotate freely in the direction for hoisting, but is immediately checked from reversing its motion as the hand chain is released.

The lowering of the load is perfectly under the control of the operator, who needs only pull on the hand rope attached to a lever, having its fulcrum on the side frame. This action raises the shaft slightly, thus relieving the grip of the toggle frame on the brake wheel; relieving or breaking of the hand rope will apply the brake and hold the load instantly.

The usual method of lowering by pulling backward hand chain may also be adopted.

The novel feature of the lower block is the simple and ingenious method of securing two speeds, which is an important feature where variable loads are to be lifted.

This device is self-disengaging when a load is to be lowered below the point from which it was lifted, which is of great importance and gives the block a wide range of adaptability, so that it can be used to advantage on cranes and other hoisting machines.—*American Engineer.*

A NEW TELEPHONE.

PRACTICAL test was made on Wednesday of last week of a new system of telephone communication entirely independent of electricity. Though novel in this country, the Pulsion telephone has been for twelve months in successful operation in America, and has already, it is stated, commended itself experimentally to the notice of railway companies, the post office, police, and other organisations in Great Britain. Wednesday's trials were made on the Midland Railway through wires laid from Finchley to Hendon, a distance of about three miles, and on shorter lengths fixed in the grounds and sunk in the lake of the Welsh Harp. The apparatus is contained in a circular sounding-box about five inches in diameter and three deep, and consists of a metallic disc fixed with spiral wires, which not only transmits but attunes vocal or instrumental sounds imparted to it. The conveying medium is an ordinary wire. Tested first over a taut line between two stations, verbal messages, whistling, singing, and the playing of a musical-box were perfectly audible, not merely at the ear-tube but to a dozen or more persons in the small telegraphic huts of the railway service. Equally good results were obtained through a slack line, through a wire coiled around branches of two intervening trees, and through a quarter of a mile of wire in 16ft. of water across the bottom of the lake. Still more remarkable were the amateur tappings of the line by the mere placing of a hat or stick on the wire, the result being that through the hat on the wire by the railway a shout from the transmitter a mile away could be distinctly heard by the whole party of some thirty gentlemen scattered along the embankment and by a railway porter on the opposite side of the line. Sir Edward Reed, M.P., is chairman of the proposed British Pulsion Telephone Company Limited, intended to be launched in January to work the patent. There were also present at the experiments Mr. Johns, Mr. W. Leatham Bright, M.P. (who is one of the directors), and several other gentlemen interested in the success of the scheme. It is claimed that the Pulsion telephone can be fixed from 30s. to 40s. per mile, and by means of small switches can be readily adapted to communicate with all parts of large establishments.

THE FOULING OF STEEL SHIPS.--The construction of a steel navy introduces a problem which confronted the designers of iron men-of-war many years ago, and forced the use of composition sheathing or composite construction. It is found that the bottoms of the new steel cruisers of the United States, which lie in harbours for weeks and months, become heavily coated with barnacles, and, moreover, that a destructive action occurs which pits and deteriorates the plates. The barnacles decrease the speed of a vessel to a very material extent, and it is now proposed to attach composition sheathing, preference being given to a bronze invented by Past Assistant Engineer, John A. Tobin, U. S. A. The sheathing will increase the displacement, but it is calculated that the advantage of a clean hull will greatly overbalance this objection. At present it is necessary to dock the cruisers frequently and clean their bottoms. This operation is quite expensive, and might be impossible in case of hostilities.

THE MANUFACTURE OF WROUGHT-IRON AND STEEL TUBES.*

By J. E. Blandy, A.M.I.C.E.

As pipes or tubes are used in such a great variety for the conveyance of water, steam, gas, air, and other fluids, as well as for structural purposes, the writer feels sure that some attempt to describe the processes by which they are made must necessarily be interesting to all engineers.

The material—iron or soft steel—from which the pipes are to be made is delivered at the works of the manufacturers in flat strips, cut or sheared to size required, and known or described commercially as either gas strip, sheared strip, sheets, or plates, according to the thickness of the metal. These strips, which are cut to various widths corresponding to the diameters of the pipes to be made, have then to be worked up into tubes.

It is evident that they must be got into cylindrical shape, and either jointed by welding, or, in the case of large tubes, riveting. Before it will be possible to describe the processes of manufacture in detail, it is necessary that two main distinctions are well defined, viz., the terms "butt welding" and "lap welding." No doubt these terms are familiar to all, the former being applied to tubes made by welding together the natural edges of the iron strip, which, bent into an approximately cylindrical form, closely abut on each other, and which, when closed properly, form a complete cylinder; the latter referring to tubes made by overlapping the edges of the strip, and so giving a larger surface of metal to be joined by welding; the "lap" being the superfluous width of metal over that necessary to form a butt-welded tube of the same diameter.

It may here be mentioned that, so far as the writer knows, *steel strip* has not as yet been welded by the "butt" welding process. To manipulate the strip it must be *heated*, and it would, no doubt, be interesting here to trace the history of the variety of furnaces which have been used for heating the metal from the earliest days of tube making to the present time; and much useful information on this subject may be gained by a perusal of Mr. F. W. Huckwood's "Wednesbury Workshops," quite recently published.

As time would hardly permit this being done with any degree of justice to the subject, the writer must content himself with dealing more practically with those in use now, merely noting that, up till the year 1825, tubes were not welded in lengths much beyond 6ft., while now manufacturers can make tubes as long as are suitable for the carrying appliances in use to convey them to their destination.

In 1825 Mr. Cornelius Whitehouse patented his invention for making tubes by an improved process and in greater lengths than they had hitherto been made. It was then that Messrs. Jas. Russell and Sons purchased the invention, and the smith's hearth gave place to the hollow fire. From this gradual improvements have taken place, but undoubtedly the late Dr. C. W. Siemens' regenerative gas furnace, so usefully adapted to metallurgical operations, was destined and proves to be an inestimable boon to this special manufacture. Messrs. Russell, with others, were among our first manufacturers to adopt this class of furnace. This furnace has not, however, entirely superseded others, for many air furnaces are in use at the present day, being chiefly used for large pipes.

It is now customary to weld tubes up to 2in. diameter, whether they are to be used as gas tubes or for steam, by the "butt welding" process. As gas tubes of small diameter have not to sustain so great an internal pressure as steam of like diameter, the thickness of the iron strip from which they are made is somewhat less than that used for steam. The strip, being deposited in some convenient place in the works, is then placed into and heated in a furnace, from which it is abstracted while hot, and bent into an approximately cylindrical form called a *skelp*.

The furnace for heating strips to be made into skelps has doors front and back, and the strip is put into the furnace at the back and abstracted in front. For these small-sized tubes the operation of skelping is usually performed by drawing the strip while hot through steel *dies*. The machinery for this consists of an endless chain, which is so arranged as to run in the same longitudinal direction as the furnace, and as nearly as possible horizontally, about the height of the bed of the furnace.

On either side of this endless chain benches are built up, which really are the metal tracks on which this "carriage" runs, and which holds up the grips and attachment tool, which, placed in the chain in motion, pulls the strip its whole length through the dies; the whole apparatus, chain, tracks, carriage and all, being called a "draw-bench."

It would be well, perhaps, to mention here that the strip is cut in lengths to suit the furnace, and that the horizontal part of the endless chain is somewhat in excess of the length of the bed of the furnace. The skelps thus produced are slid down from the draw-bench to a receiving pit on one side—usually the right hand of those working in front of the furnace—ready for the next operation.

These skelps, which in section assume somewhat of a "pippin" shape, are, when cool, now passed on to a second furnace, when, after being gradually heated, they are submitted to a similar process of being pulled on a draw-bench, *not* now through *dies*, as was the strip, but through three sets of graduated tongs, which produce the butt weld.

As these furnaces are worked from the front, and have *no back door*, about half the skelp is welded at one time, the remainder being done after the straightening process; the object being to allow sufficient cool part of the skelp to be handled and passed on from one part of the furnace to another, until they come to a welding heat just opposite to the run of the chain, when the carriage is run up close to the heated part of the skelp, the grips are attached to the cool part, the tongs are placed over the skelp, the attachment part is placed in the chain, and immediately the drawing through commences. When the part of the skelp to be welded has been pulled through the tongs, the attachment to the draw-chain is immediately set free, the skelp is again thrust into the fire, and the process repeated twice or thrice, after which the welded skelp is shot along a trough to boys stationed at the end of a "draw-bench," who handle it and straighten it while hot, under the straightening tables. When cool, the partly formed tube is reversed, placed in the furnace, and submitted to similar treatment, by which the remaining part of the skelp is welded, and the tube is now produced in its crude form. In some works a double bench is used, and after being welded the pipe is passed on to the second bench, which is parallel to the first, through a set of tongs, to bring it to the required size. The tubes are then straightened, cut to required length, screwed at each end, if for gas work, and a socket or coupling attached to one end.

To make pipes of very small diameters, it is usual to weld the pipe at an ordinary diameter, and then to pass it through a series of tongs, which reduce the original to the required size. This process is called "drawing down pipes," or, more briefly, "drawing pipes."

(To be continued.)

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* Paper read before the Birmingham Students Section of the Inst. Civil Engineers.

ELECTRIC-CABLE SUBWAYS.

For the last three months (says the London correspondent of the *Scotsman*) the foot pavements at the West End have been in the most disagreeable condition. In August the whole of one side of Piccadilly was torn up. Since then the workmen have gradually cut their way down St. James's Street, and now what may be termed the club land side of Pall Mall is a great open ditch, across which members of the Reform and the Carlton have to clamber on single planks to reach their clubs. All this excavation is due to the construction of subways for the electric-lighting companies. The work, notwithstanding its present discomfort, is, it is said, being overtaken as rapidly as possible. It strikes one that the staff of workmen might be larger; but, at all events, it may be hoped that the subways are being prepared with a little more care than Mr. Edison seems to think has been employed in New York. The way in which the pipes have been laid in that city Mr. Edison describes as "decidedly criminal." Hydrogen, he says, forms in carelessly-laid subways, and, as it is more explosive than gas, it might be lighted by a microscopic spark from the wheel of a vehicle passing over one of the junction boxes. Where hydrogen was thus located a spark would send the pavement into the air, and it is believed it is to this cause that several of the street explosions in New York have been due. Mr. Edison, who has very decided opinions about the use of powerful alternating currents, thinks we are "sailing too close to the chasm" to be perfectly safe, especially with the sort of insulation which is employed in some wires. But Londoners need hardly be alarmed. A repetition of the lamentable electric accidents which have occurred in America lately is not likely to be witnessed in this country. The proper insulation of wires is much better looked after here than on the other side. We have been slow to adopt the electric light as compared with the Americans; but our lethargy has had some advantages. It has enabled us to profit by the experience of others, and to introduce many improvements which might have been overlooked if the electric light had been as eagerly seized upon here as in the States. Mica, by the way, is being pressed into the service of the insulator; and it is believed it will form an excellent non-conductor. Mica is coming to the front; for, in addition to its use as an insulator, it is said to form an excellent lubricant for machinery, and to have had some very successful trials for railway purposes.

BRITISH COLONIES AS FIELDS FOR THE EMPLOYMENT OF THE CIVIL ENGINEER.

(Concluded from page 828.)

The President then entered into the statistics of the chief engineering works which had been, or were being, carried out in British Colonies, and the scope which existed in those colonies for the future employment of civil engineers, giving their position, general configuration, and physical features, area and population, climate, industrial products, and mineral wealth; and public works, whether executed, in progress, or contemplated in the immediate future. Canada, the largest of the colonial dependencies of Great Britain, had an area of 3,610,000 square miles, of which 140,000 square miles were covered with water, and the system of inland navigation was the largest in the world. The St. Lawrence alone in conjunction with the great lakes afforded unbroken water communication to Port Arthur and Duluth from Liverpool. The total length of railways in the Dominion was about 14,000 miles, and the area of territory in the Dominion per lineal mile of railway was in the proportion of 258 to 1. Although completed thirty years ago, the Victoria Bridge across the river St. Lawrence still remained one of the finest engineering works of the last half-century; and the Ship Canal in the St. Lawrence, 27½ft. deep, completed twelve months ago, had a very important bearing upon the commercial prosperity of the Dominion, enabling merchant steamships of the largest class to reach Montreal. Two large graving docks had been constructed, one at Esquimalt, in British Columbia, and the other at Halifax, in Nova Scotia, while a ship railway, 17 miles long, was being laid for the transport of vessels across the isthmus which connected Nova Scotia with New Brunswick. In the West Indies, the harbour of Castries, in St. Lucia, had been selected as the chief coaling station for the British fleet. When finished, the depth of water at low-tide alongside the quay would be 27ft.; the harbour would become of very great importance in the event of the completion of the Panama or the Nicaragua Canal. In Europe, Heligoland was the smallest of the British possessions, its area being about one quarter square mile, and Gibraltar, Malta, and Cyprus, within the Mediterranean Sea, were held for strategic purposes only. In Southern Africa there was at the present time only two British Colonies, the "Cape Colony" and "Natal." The Imperial Government has just granted a charter to the British South African Company, to develop the resources of a tract of country four times larger than Great Britain, northward of the Cape Colony, to be called "British Zambesia." The public works of Cape Colony comprised 1,700 miles of railway, being 1 lineal mile to 126 square miles of territory; harbours, a breakwater and a graving dock at Table Bay; two iron jetties, together about 1,700ft. long, at Port Elizabeth, in connection with the general railway system of the Colony; and a breakwater and training banks at East London. Of the Colony of Natal, more than four-fifths of the population were Zulu Kaffirs. The railway mileage was 220 open, epuivalent to 1 mile to every 86 square miles of territory. In Ceylon, the most noticeable feature was the growth of the tea industry, which had increased from the insignificant production and export of only 15lb. sixteen years ago to 32,500,000lb. in 1888. Of railways, which were all owned and worked by the Government, there were 180 miles, or 1 lineal mile of railway for each 137 square miles of country, upon which the net profit had risen to nearly 11 per cent on the outstanding capital. The Harbour of Colombo, 500 acres in extent, sheltered by a breakwater 4,200ft. long, was being deepened to 28ft. and upwards. At Singapore, the capital of the Straits Settlements, a sea wall 3,000ft. long was in course of execution, and at Hong Kong, which, like Singapore, was the emporium of a large trade, a sea wall rather more than 1⅔ mile in length, and founded in about 30ft. of water, was about to be constructed parallel to and 250ft. seaward of the existing wall. An area of about 60 acres would be reclaimed between these walls, whereon high-class buildings would be erected. In New Zealand, 1,750 miles of railway had been completed up to the end of March, 1888, giving 1 lineal mile of railway to 59 square miles of territory. Breakwaters and training banks were being constructed for the improvement of the entrance of the river Buller, at Westport, and similar works were in progress at Greymouth. A new graving dock had lately been completed at Auckland, 500ft. long and 80ft. wide, with a depth of 33ft. of water over the sill at spring tides. Otago Harbour entrance had been improved, and a harbour created at Lyttleton, near Christchurch, enclosing an area of about 112 acres, with jetties and wharves having a length of berthage of 11,000ft., with lines of railways in connection with the general system of the island. The depth of water within the harbour varied from 19ft. to 25ft. at low water. In Tasmania, 440 miles of railway had been opened at the end of 1887, being 1 lineal mile of railway to 55 square miles of country. Sir John Coode then referred to Australia, treating it first as a whole, and afterwards dealing separately with the five colonies into which it is divided. It was about six-sevenths of the size of Canada, and only about one-fifth smaller than the continent of Europe. An index of its magnitude was to be found in the size of the catchment basin of the river Murray and its tributaries, the area of which was 510,000 square miles, or nearly six times greater than Great Britain. In Western Australia, with a population of only 1 inhabitant to 25 square miles, there were 450 miles of railway, or 1 lineal mile for each 2,375 square miles of territory. In South Australia, at the end of 1888, there had been constructed 1,820 miles of railway, or 1 mile to 496 square miles of land. At Port Adelaide there was a total wharf frontage of about 13,000ft. and the channel leading up to the port from the sea had been deepened from 9½ft. to 22ft. at low water. The works for the water supply of Adelaide were of a very extensive character, and when completed would include a storage reservoir of 2,760,000,000 gallons capacity. Victoria, the smallest colony in Australia, had 2,200 miles of railway in operation at the end of 1888, being 1 lineal mile to 40 square miles of area. As an instance of the wonderful growth of the City of Melbourne, the capital of the colony, the President stated that little more than 50 years ago a corner plot of land, near the centre of the city, was sold from a tree stump as a rostrum for £45, and that the same plot, with the buildings upon it, had just been valued at £493,500. Until recently, the navigation from the bend of the bay, by the river Yarra-Yarra to the city, a distance of 6⅔ miles, was through a narrow, tortuous channel. This had been greatly improved by training-works and the cutting of a canal, and the navigation was now through a channel 5½ miles in length, and when completed would have a depth of 20ft. and bottom width of 150ft. The storage capacity of the Yan Yean reservoir, for the water supply of Melbourne, was 6,400,000 gals. the expenditure on the system had exceeded £2,500,000, and further works were in progress. Irrigation on a large scale had been fostered by the Government of Victoria, the area intended to be irrigated amounting to nearly 1,250,000 acres. In New South Wales, at the end of 1888, 2,160 miles of railway were open, being 1 lineal mile to 144 square miles of country. The length of the great bridge over the Hawkesbury River, which formed the last link in the continuous railway system between the principal cities of the four colonies of South Australia, Victoria, New South Wales, and Queensland, was 2,900ft. between the abutments, and the foundations of the several piers, six in number, were carried to depths varying from 101ft. to 162ft. below high-water level. The President then referred to the recently constructed graving dock on Cockatoo Island, in the harbour of Sydney, 600ft. long, and 84ft. wide; to the Macquarie lighthouse, at the entrance to Port Jackson; to the water supply of Sydney; and to the works at Newcastle, at the mouth of the Hunter River, the great coal-shipping port of the colony. In Queensland, the returns up to the end of 1887 showed that 1,770 miles of railway were open, or 1 lineal mile to 378 miles of area. River improvements had been effected in the channel leading up to Brisbane, at the Fitzroy River, from the sea up to the town of Rockhampton, at the entrance of the Pioneer River, and also at the entrance to Norman River, in the Gulf of Carpentaria. As an instance of the mineral wealth of this colony, the Mount Morgan Mine, near Rockhampton, was now turning out gold to the value of £128,000 per month, of which £28,000 went in working expenses, and the balance in dividends to the shareholders. The President then observed that the questions naturally arose: Whether the colonies had been justified in constructing public works? and whether they were capable of bearing the financial obligations they had thereby imposed upon themselves? To these questions, he said, circumstances warranted a reply in the affirmative; taken as a whole, the market value of the public works already executed by the colonies would be fully equal to their cost. The earlier settlers had in many cases been brought face to face with large and pressing demands, for the execution of such public works as had been absolutely essential for securing ready intercommunication between district and district, more especially between the seaboard and the interior, involving roads, railways, &c., within their own borders, and between themselves and the outer world. Further, in not a few instances our colonies had found it absolutely necessary to incur a considerable annual expenditure on subsidies to ocean-going steamships, to insure frequent, regular, and rapid communication with the rest of the world.

The question whether our colonies were capable of bearing their financial burdens could only be answered in general terms; but perhaps the most conclusive reply in the affirmative was to be found in the readiness with which invitations by British colonies for large loans were met in the money market of the city of London. It was doubtless not overlooked that in the larger colonies vast areas of land were yet unappropriated, and formed so much capital in reserve. Moreover, in the case of some of the Government lands occupied by squatters, the rentals were subject to a percentage of increase periodically. Further, the financial position, and consequently the spending power, of the colonies was favourably affected by the present low rate of interest obtainable for capital in this country. Many were now able to raise loans at 3½ per cent, which not so very long ago found it necessary to offer 6 per cent. While our own country had for the last 300 years been steadily building up a great empire by the acquisition of colonial possessions, it was only within the last decade that any other European State had taken action of importance in the matter of colonisation. It is also worthy of remark that, within those portions of the world possessing such a climate as to admit of the

NEW DOVETAILING MACHINE.

CONSTRUCTED BY THE BRITANNIA CO., ENGINEERS, COLCHESTER.

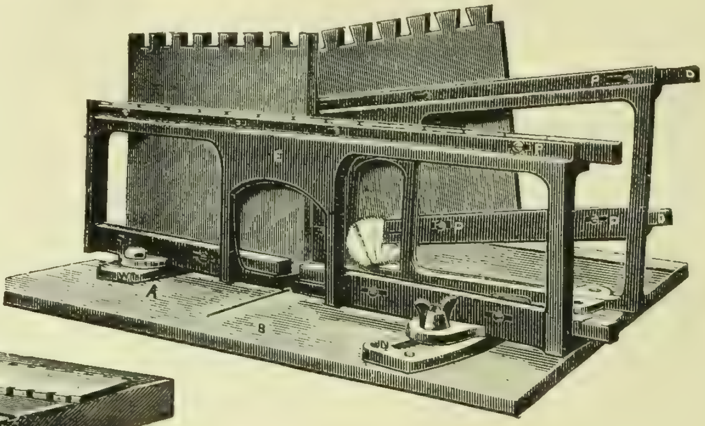


FIG. 2.

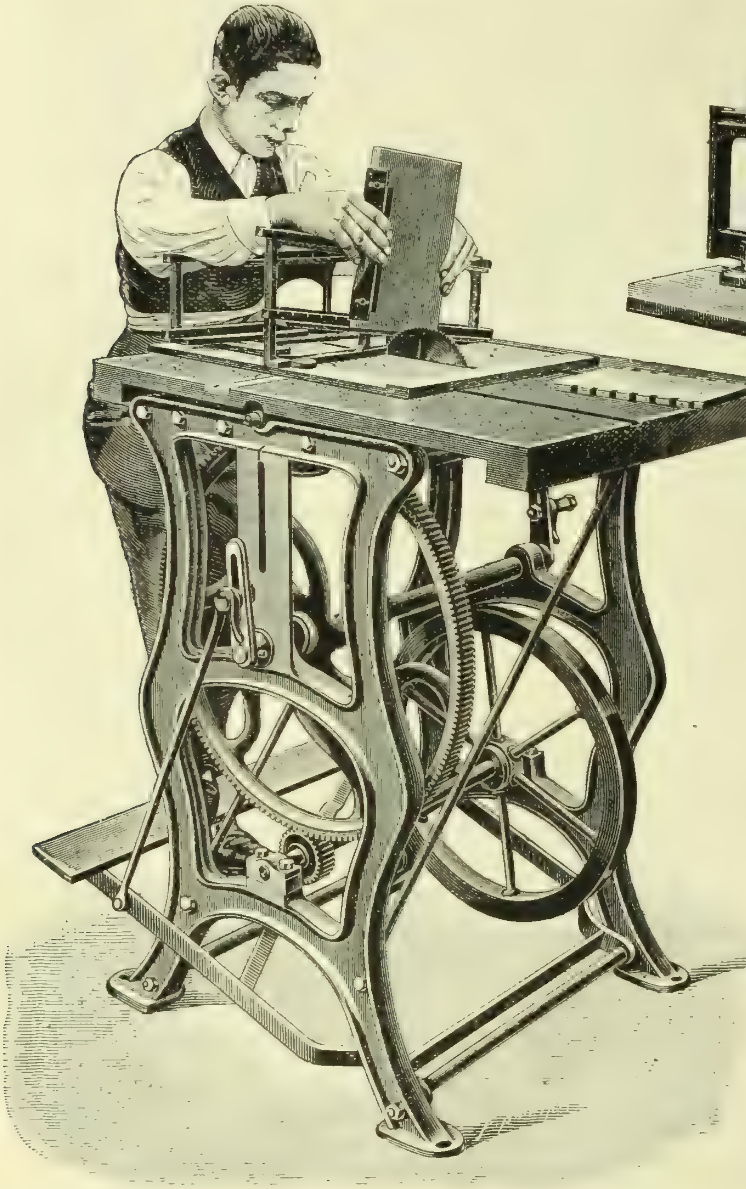


FIG. 1.

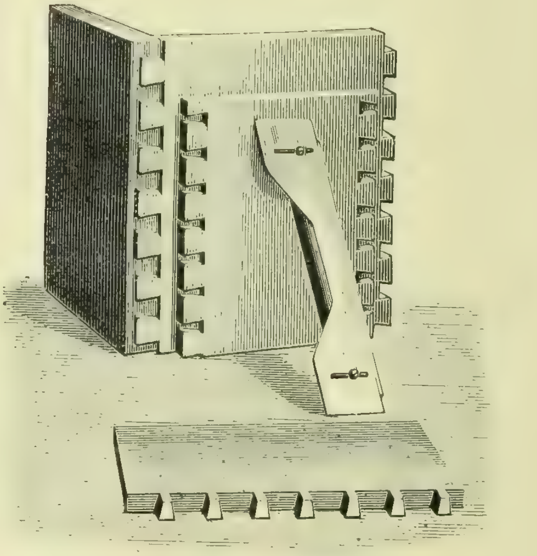


FIG. 3.

employment of white labour upon out-door operations, there was not now a single region of any magnitude available for colonisation, and that no inconsiderable part of the area of the globe was under the imperial ægis of Britain. In concluding, Sir John Coode spoke of the capabilities and possibilities yet to be developed by the civil engineer, whether in the colonies or in the mother country. The field was indeed a vast one; great advances had recently been made, and were still being made, in every branch of engineering. Notwithstanding, he would be rash who would venture to prescribe a limit to engineering achievements. He was convinced that as long as the present dispensation might last, so long would there be a continuous progress in the science and practice of every branch of labour in the field appertaining to the civil engineer. Neither to the engineer, nor indeed to any other disciple of natural science, would it seem to have been announced, "Thus far shalt thou go, but no farther."

NEW DOVETAILING APPLIANCE.

THE Britannia Company, of Colchester, have patented and introduced a very simple and ingenious appliance for cutting dovetails and tenons, which is cheap and efficient, and should prove extremely useful in economising time where even but a small amount of dovetailing or tenoning requires to be done. Fig. 1 shows it in use as an attachment to an ordinary fast-driven saw table; fig. 2 shows its two parts side by side; and fig. 3 shows a side view.

The mortices are not cut completely out, but gates are cut by the saw, and the remainder is cut out with a chisel. To apply the machine a board is fitted to the saw table, with a slot allowing the same to pass through, and it is constrained to slide parallel to the plane of the saw by a projecting spline fitting the saw table groove, as seen in our illustration, fig. 1. The machine consists of two frames, carrying incline planes and gauges, which are adjusted to the correct angles and spaces required for the successive cuts. To cut the mortices, the wood is placed upon the inclined plane, after adjusting the saw table to cut the required depth. The front edge of the wood is then brought up to the end of the gauge, and the marker is held in the left hand, so that it falls into the various slots in the gauge pieces as the wood passes up the incline. One row of cuts is thus made, and then the wood is turned round, and the marker held in the right hand, and cuts made following each other up the incline. In this way the cuts are completed; and after that the end cuts are made by chisel or morticing machine. The tenons are cut by a similar process on the other frame, and the appliance effects, as can be readily seen, a very great saving of time with a little practice in its use. The accuracy of the dovetails is also much improved.

HOT-AIR ENGINE.

CONSTRUCTED BY THE PULSOMETER ENGINEERING CO., LONDON.

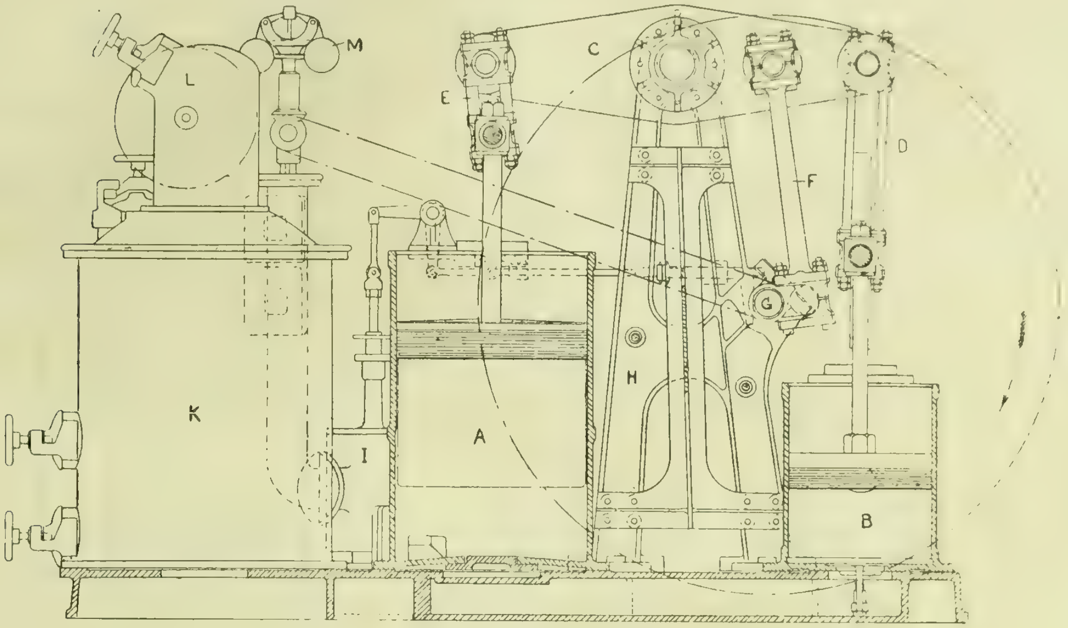


Fig. 1.

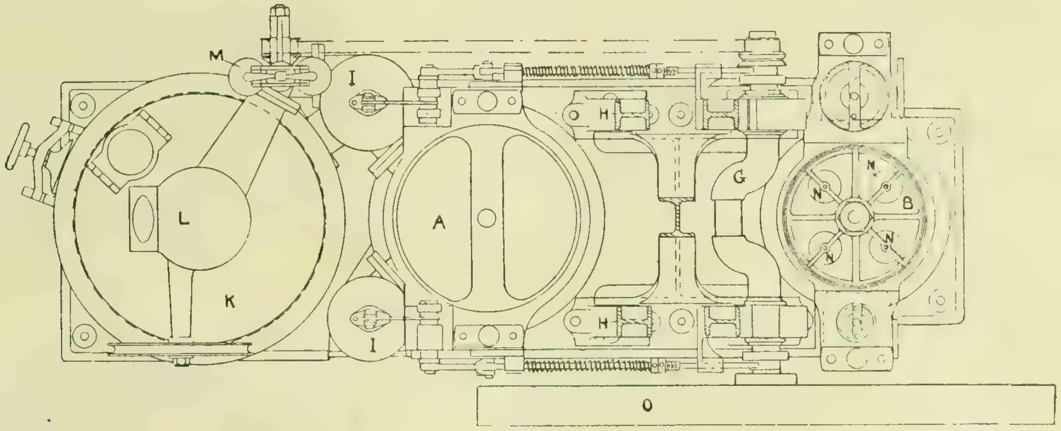


Fig. 2.

Among the numerous specialties contributed by the Pulsometer Engineering Co. Limited, Nine Elms Ironworks, London, not the least interesting is an internal combustion hot-air engine, to which they have devoted much attention and careful arrangement. It belongs to that type of compression hot-air engine in which the fuel is burned under pressure in the interior of a closed furnace, and the products of combustion are utilised to furnish motive power in the engine cylinder. Many previous attempts have been made upon this plan, and in the engine we now propose to describe the difficulties have been very fully overcome, and a practically useful engine produced, with less complexity, and more substantial and less delicate detail, than with any other hot-air engine with which we are acquainted. The very small hot-air engines, in which the heat is conducted to the air through metal plates, are, of course, more simple in constructive detail, but they are quite unsuitable for anything but extremely small power, on account of their very low working pressure and the difficulty caused by the burning out of the cylinder bottoms in engines of any size. The engine we illustrate at figs. 1 and 2 is suitable for comparatively large powers, and is easily applied on those of from 10 horse upwards. Fig. 1 is a longitudinal section part in elevation, and fig. 2 is a plan showing the essential parts. In figs. 1 and 2, A is the working or motor cylinder, B the air supply and compressing pump, and K the closed furnace. The power is transmitted from the motor piston working in A by the piston rod and connecting linkage E to the beam C, and thence by the connecting rod F to the crank shaft G. The connecting rod D actuates the air-pump piston in the cylinder B, and the beam C is carried by substantial framing H.

The action is as follows: The cylinder B is of smaller capacity than A, and it first draws in a charge of air from the atmosphere, and then compresses it into the furnace K by passages in the bed of the engine and outlet valve, shown at the bottom of the cylinder B, in fig. 1.

The inlet air valves are shown at N, N, N, N, in the plan fig. 2. On entering K the air passes through the furnace and burns, causing a high temperature, so that a larger volume leaves the furnace K than enters it. The hot gases pass to the working cylinder by the piston valve I, fig. 1, and although the burned air is at or near the same pressure as in B, yet its volume is much greater, and so a balance of power remains, which drives the piston. On the termination of the up stroke, the exhaust valve I, shown in the front of the plan (this is also a piston valve), opens, and the contents are discharged into the outer atmosphere by the exhaust pipe. Suitable linkage and cams drive the valves I, I, as shown in figs. 1 and 2.

The engine is single acting, and while the hot gases are impelling the piston and thrusting up one end of the beam, the other end of the beam is compressing the charge of air, and resisting to a certain extent. The flywheel O is large enough and heavy enough to carry the engine through half a revolution without appreciable variation, as is common in the case of gas engines. The governor M is driven from the crank shaft G, and controls the course of the air through the furnace in such a manner that, when full power is required, all, or nearly all, the air coming from the pumps passes through the burning fuel in the furnace, and so gives the highest temperature and the maximum power; while if less power is required, part of the air is taken into the cylinder A without passing through the fuel, and so the temperature is lower and the power developed is less. The furnace K is supplied with suitably fastened doors to allow of clearing out ashes, &c., while fuel can be supplied while the engine is at work by the valve hopper arrangement, shown at L.

The whole of the details of the engine are most carefully arranged and well made, so that the engine is capable of giving the maximum power possible from a hot-air engine for its bulk and weight. The engine, in fact, seems considerably smaller to us than those we saw at Paris, and is suitable for many purposes, notably lighthouse work.

HEAT ENGINES OTHER THAN STEAM.—III.

(Continued from page 834.)

You will remember I said that air was an extremely bad conductor of heat; one result of this is that in the gas engine cylinder only the film of air which is in contact with the side of the cylinder and with the piston communicates its heat to the cylinder, or is cooled, and the cooling effects do not extend appreciably away from these surfaces. This want of conductive power of air, which we found was a disadvantage in those hot-air engines where the heat is communicated by contact with hot metal or other surface, is therefore, in practice, of advantage in the gas engine.

Lubrication, at the temperatures of which I have told you, would be impossible, if it were not for the water jacket, and for this quality of air. If any of you have examined the cylinder of a gas engine, you will find it is frequently as clean, and sometimes as bright, as that of a steam engine, proving, therefore, that the lubrication of these machines, is, as a rule, sufficient.

The water of the jacket, however, is not, as a fact, the only means by which cooling is done. The "cycle" of operations in a gas engine is such that an appreciable interval is allowed between the time of explosion and the time when the fresh charge of mixture is drawn in, and invariably during this time the piston has passed over the internal surface of the cylinder, thus helping to cool it, and the incoming cool charge of gaseous mixture has itself assisted in this, even in those engines where there is not a "scavenger" charge.

If it were not for these methods of cooling, it would, for a further reason than any which I have at present stated, be impossible to satisfactorily work a gas engine. Pre-ignitions of the explosive mixture would take place before compression could be effected, due to the heat of the cylinder walls, as well as to the heat generated by the compression itself, and these pre-ignitions would be irregular in their action, might occur even before the mixture had been compressed, or would almost certainly occur as compression was taking place—that is to say, as the piston was coming back, or in opposition to its motion.

Many suggestions have been made that the cylinder should be composed of, or should be lined with, some substance which was non-absorbent, or opaque to heat, but as it is impossible to find any substance absolutely opaque, and as any substance which to any extent absorbs the heat would—unless its internal surface were cooled in some way or another—allow of, or even induce pre-ignitions, it does not seem to me that great improvement in this direction is likely to be attained, unless the internal surface of the cylinder is cooled by some means, say by a charge of cool air passing as a "film" over this surface.

The second great head of loss, which is practically equal to that of the loss by the jacket water, is due to the heat passing away in the exhaust.

You will remember I have just told you that in the ideal (Carnot) gas engine the greatest efficiency would be attained if we rejected the working agent from the cylinder at a temperature approaching that of the atmosphere, say some 70 deg., or some 530 deg. absolute. As a fact, in the gas engine the temperature of the exhaust is about 1,300 deg. or 1,400 deg. absolute. Now, the lower we can reduce this 1,300 deg. or 1,400 deg. the more we shall utilise, and the greater power we shall obtain by a given consumption of gas in our engine. The efficiency of 22 per cent, of which I have told you, would be largely increased, and some of the 40 per cent of this head of loss would be put upon the right side of our balance-sheet, and would be utilised.

Messrs. Crossley Brothers are making efforts in this direction, which is probably the most hopeful in which to look for improvement.

I will ask you to look at the three views shown on fig. 21; these are from a tracing supplied to me by Messrs. Crossley. You will see that we here have two double-acting cylinders, each with its piston, piston rod, and connecting rod, these rods being attached to cranks on a crank shaft, the cranks being placed at the same angle, so that the pistons move in and out together.

Roughly described, the action of the engine is as follows. One of the cylinders draws in a charge of explosive mixture behind its piston as the pistons go out; the pistons return, the charge is compressed, then ignited, and the pistons go out again—being driven out by the force of the explosion behind this one of them; and then the gases, instead of being allowed to exhaust directly into the atmosphere, are, by means of the valves which are shown, allowed to pass to the other side—the forward side—of both pistons, and act there on both, to drive them back again, and to drive out the products of combustion from behind that piston of the cylinder in which combustion has taken place. Whilst this has been going on, the other cylinder has had its charge drawn in by the forward movement of its piston, has had it compressed by the return stroke, and the charge is, at this moment, ready for ignition. When this ignition takes place, the two pistons are driven forward together, expelling into the atmosphere the expanded products of combustion from the front ends of both cylinders.

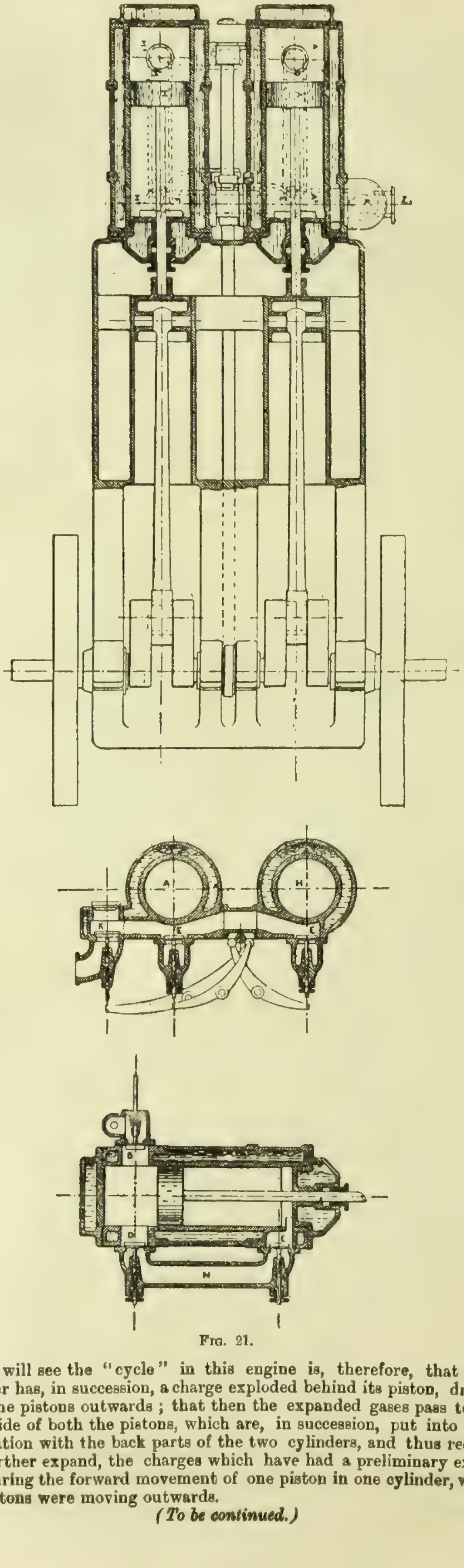


Fig. 21.

You will see the "cycle" in this engine is, therefore, that each cylinder has, in succession, a charge exploded behind its piston, driving both the pistons outwards; that then the expanded gases pass to the front side of both the pistons, which are, in succession, put into communication with the back parts of the two cylinders, and thus receive, and further expand, the charges which have had a preliminary expansion during the forward movement of one piston in one cylinder, whilst the pistons were moving outwards.

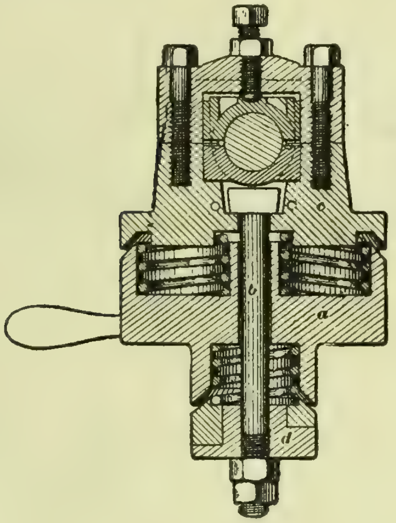
(To be continued.)

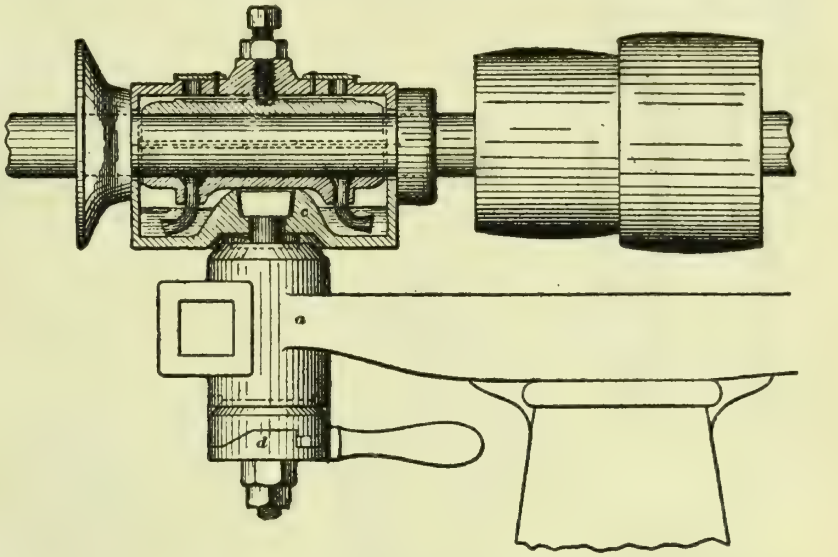
YIELDING JOURNAL BEARING FOR GRINDING MACHINERY.

On this page we present engravings of a yielding journal bearing, intended primarily for use on grinding and polishing machines, devised by Mr. Thomas McGrath, of Albany, N.Y. The perspective view shows a grinder provided with these journals, the construction of which is made plain by the sectional view.

The object of the improvement is to provide a bearing which, instead of being rigid, is so arranged as to yield and admit of a wheel placed upon the arbor running true, whether mounted exactly true upon the arbor or not, and thus avoid all jar or vibration in the machine or floor, and also prevent heavy pieces of work to be ground being struck a succession of rapid blows, as is the case where the wheel is out of true, but mounted upon a rigidly held shaft; these blows sometimes, in the case of thin plates of large dimensions, resulting in fractures of the castings.

As will be seen by the sectional views, the casting *c* which holds the parts of the box, and to which the cap is attached, rests upon spiral springs, and is held in place by the bolt *b*. Two nuts are on the lower end of this bolt, which are locked together, and above them is a cam *d*, which, when turned to the right, draws the bolt down, and seats the casting firmly on the bevelled surface, the similar surfaces at the bottom being, of course, drawn together at the same time. It is thus seen that, by the simple movement of a handle one way or the other, either a yielding or a rigid bearing is secured.





It has been proved by trial that the amount of trueing up by diamonds or burr pickers is very much reduced by the use of this bearing, and in many cases entirely done away with, at a considerable saving of time and wear of wheels. The machines are made either for the bench or with a column, as shown, by the Cohoes Iron Foundry and Machine Co., Cohoes, N.Y. The improvement seems an important one, and will, we think, be well received by users of emery wheels.—*The American Machinist.*

SOLID PRESSED STEEL WAGON FRAMES.

At a meeting of the Society of Engineers, held at the Town Hall, Westminster, London, on Monday, December 2nd, Mr. Jonathan B. Baillie, president, in the chair, a paper was read by Mr. Perry F. Nursey (past president) on "Fox's system of solid pressed steel wagon frames." The author first pointed out that the invention grew out of Mr. Sampson Fox's corrugated boiler flues, which have so largely added to the efficiency and endurance of marine boilers. It was in connection with the flanging of these flues that Mr. Fox gave his attention to hydraulic pressing, and this in time led him to the production of locomotive side frames, and the under frames of rolling stock generally. This is effected by powerful hydraulic presses of large size, which produce and reproduce with perfect accuracy all kinds and shapes of frames from Siemens steel produced at the works. The plate to be flanged is operated upon simultaneously over the whole of its surface, and the flanges are formed either inwards or outwards, as may be required. The author then briefly described so much of the Leeds Forge Works as relates to the manufacture of pressed plates. He noticed the steel works where the steel is made by means of three 15-ton Siemens-Martin furnaces, and the plate mill where the ingots are heated, hammered into slabs, and then rolled into plates. The plates are then taken to the pressing department, which is a large building having an area of 124,800 square feet, where they are heated to redness, placed between dies, and subjected to a steady hydraulic pressure of 850lb. per square inch. The materials used are chemically tested as they enter the works, and the products, both chemically and mechanically, at every stage of manufacture. In the steel, so far as the chemist is concerned, the object is to get ·10 of carbon. Mechanically, it must stand a tensile strain of from 24 to 26 tons per square inch, with an elongation of from 25 to 30 per cent in 10 inches. In the bending test the steel has to stand the temper test prescribed by the Admiralty, the Board of Trade, and Lloyd's. The author then described the different kinds of carriage and wagon underframes produced at the Leeds Forge Works on Fox's system, which were illustrated by diagrams and models. They included frames for the following railways: The Great Northern, the Great Western, the London and South-Western, the Lancashire and Yorkshire, the North-Eastern, besides Belgian, Spanish, Indian, Japanese, and American lines. Summing up the practical advantages of the system, the author observed that while the ordinary wood and iron frame weighed 4 tons 14 cwt., Fox's present frame only weighed 3 tons 14 cwt. Hence a saving of 1 ton, or 20 per cent per wagon of dead weight hauled, the lighter wagon being well able to carry all that the heavier one did. Another advantage was that whereas wood frames were valueless at the end of the wagon's life, the value of the steel frames as scrap was always that of pig iron. Other advantages were interchangeability, duplication of parts, and longer life in rolling stock on account of the elasticity of the frames. Fewness of parts was also an important feature, there being only about fourteen parts in one of Fox's frames as against 47 in frames as ordinarily constructed.

The Standard Metre.—The International Committee of Weights and Measures, recently in session at Paris, has ordered the construction of standard metre measures of platinum, for distribution to the different governments which have authorised the use of the metric system. These standards are to be carefully tested by the International Committee before issue.

The Grand Narrows Bridge.—The Dominion Bridge Co., which is building the long railroad bridge at The Narrows, Cape Breton, has just launched a second scow to be used in floating the spans to position. These scows are each 91ft. long, 20ft. wide, and 6ft. 7in. deep, and are estimated to float 300 tons with a good freeboard and are the largest ever built in the Lower Provinces. Something like 100,000ft. of timber is used up in their construction. After a span is erected on two temporary wharves, the scows are filled with water, placed under the ends, then pumped out, lifting the span clear of the wharves. The scows are then towed out between two piers, and allowed to fill. As they sink the span rests on its place on the piers.

WIRE-ROPE FASTENERS.

A CORRESPONDENT sends us the following account of a novel and ingenious form of wire-rope fasteners :—

Your readers may be interested to know something of a new system of wire-rope connection now coming into use instead of the old system of splicing or shoeing, which is very laborious, and takes up much time. A perfect fastener ("Keller's") is now made by a firm in Cardiff—H. Hamecher and Co.

These fasteners can be fixed with any kind of wire rope. The method of fixing is easy, as will be seen by the illustrations (figs. 1 to 8). The shell of the fastener is slipped over the rope end, and the wires are laid out in the shape of a paint brush, as shown at fig. 2, and also at fig. 6. The core wires are then brought together to the centre, and taken through the hollow slot cone, and then the rope is pulled down and the cone driven home, during which process the cone closes upon the centre wires, and, gripping these firmly, is kept in position, thus securing the outside wires between itself and the shell. Each individual wire is therefore bound to take its proper share of strain, and thus enables the rope to retain the highest possible percentage of its ultimate strength. This will be seen to be of great advantage in colliery and shipping work. Lloyd's use these fasteners for testing wire ropes up to breaking strain, which is in itself a good guarantee of their success. Since writing I find this firm has received a first bronze medal from the Polytechnic Exhibition, at Falmouth.

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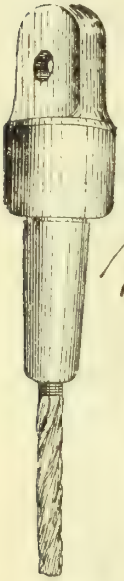

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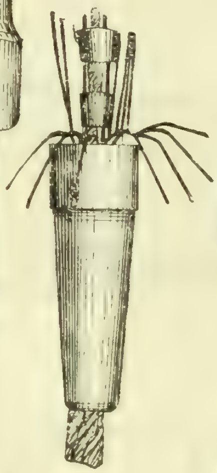

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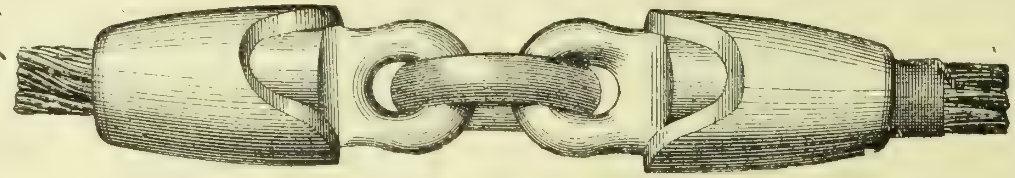

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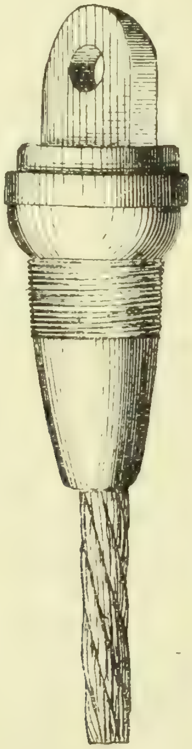

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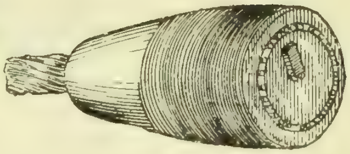

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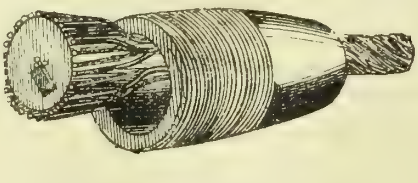

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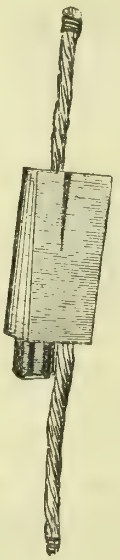

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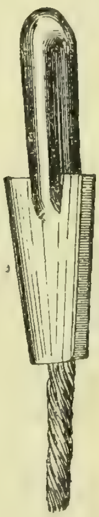


TRIAL OF A NEW ELECTRIC RAILWAY BRAKE.

A SERIES of experiments to test a newly-invented electric brake applicable to railway carriages were made on December 8th on the London and North-Western Railway. The brake has been brought out by Professor Forbes and Mr. J. A. Timmis, of London, who claim many advantages for it. That the brake has been successfully tried previously goes without saying, seeing that an entire train of carriages fitted with it are being constructed at the present time by Messrs. Brown, Marshall, and Co., of Adderley Park, for use on a line in Russia. The experiments were made, however, to further test the capabilities of the invention. It is totally different in working to ordinary brakes in use on the railways of the United Kingdom, inasmuch as they act upon the periphery of the wheel, while the one in question works upon the inside face of the wheel, or rather upon an iron disc fitted to it. This disc is a large plate of iron, of considerable thickness and several inches in depth, and is bolted to the inner side of the wheel in such a way that it may be said to form part of the wheel itself. Opposite this disc is another, which so encircles the axle that the latter can run loosely as though a bearing. This second disc, however, is fixed by stays in such a manner that it cannot revolve with the wheel, but can be moved laterally so as to come into contact with or recede from the circular plate attached to the wheel. In shape it may be compared to the half of an ordinary life-belt used on board ship, split so as to have one side flat and the other rounded. It contains a powerful magnetic coil, and constitutes, in short, a large electro magnet. When the electric current is supplied to it it is powerfully attracted to the plate on the wheel, with the effect of arresting its revolution, and so acting as a brake.

The apparatus experimented with was but temporary and incomplete. An old coach which has, judging from its dirty appearance, earned a well-deserved rest from service on some Northern line was fitted up with the new brake during the week by two of the representatives of Messrs. Timmis and Forbes. It was a small coach running upon four wheels only, each of which was fitted with the appliance above described. In one of the compartments was a battery consisting of 17 secondary cells of the electric power storage type, and wires from the battery ran down and were connected with the four magnetic discs forming the brake. On the partition of the carriage were three electrical instruments, two for measuring the current, and the third for applying the brake. The latter was merely a small handle which switched the current on or off as required. It was but a primitive instrument, inasmuch as it was impossible to regulate the strength of the current by it; consequently the whole electric force developed in the battery had to be applied to the wheels all at once. The carriages which are to be sent to Russia will, however, be provided with a regulating instrument, so that the amount of force to be applied to the brake will be left entirely to the discretion of the brakesman in charge. The importance of this contrivance is manifest, for whereas the whole force of the battery may be such as to instantaneously arrest the revolutions of the wheels, a regulated current would only diminish the speed of the rotations. A more effectual "braking" is thus given, inasmuch as when all rotation of wheels is suddenly prevented they slide on the smooth surface of the rails—a thing to be guarded against, especially in frosty or wet weather. The brake can be used either as a separate or continuous one. In the latter case the wires will simply have to be connected with all the magnetic coils. It is estimated that a train of average length will feel the brake-power throughout its length in a second and a half, as against three or four seconds required by the vacuum brake. There is thus a distinct gain in time.

The carriages which are being constructed for Russia will be illuminated with the electric light, the power for which will be supplied by the same battery from which the brake power will be draw. Sixteen secondary cells will be required for this double purpose, and will be stored in a brake van, which will also be fitted with a dynamo for recharging the secondary cells that form the battery. The dynamo will be driven either by a small engine contained in the van, or by steam from the locomotive. This is, of course, a very necessary arrangement, as otherwise the cells would at certain periods have to be taken from the van and charged. The brake is a perfectly new idea, but the system of electric lighting is in use at the present on railways in the Argentine Republic and in France.

The line chosen was in every way suited for such a trial, there being a straight run for nearly a mile and a half, over an almost level line. On this portion of the track, a distance of a quarter of a mile was marked off by fog signals, on account of the mist, and a sufficient space being allowed for the driver to get up speed, the signal "right ahead" was given. At the end of the distance the coaches were slipped, and although running, as was afterwards ascertained, at the speed of thirty miles an hour, were brought to a standstill in about two hundred yards. This was considered to be a very good trial, inasmuch as the rear van was running free, and would necessarily impel the first coach over the lines, coated as they were with a film of ice. Two or three other trials were made with almost precisely similar results. As it had been demonstrated that the electric brake was effective, Inspector Carr permitted the guard's van to be detached, and trials were made with the single coach. The results arrived at were, of course, of a more satisfactory character. A half-mile run was tried, and the coach slipped whilst travelling at the rate of forty-two miles an hour. The brake being instantly applied brought the coach to a standstill in 150 yards. No doubt that distance would have been considerably diminished but for the fact that the wheels, being instantly locked, glided along the glazed surface. It might naturally be expected that the sudden application of the brake would have manifested itself in an unpleasant manner to the occupants of the coach; but the application was only slightly appreciable by nine occupants. This is one of the great advantages claimed for the new brake, and is attributable probably to the fact that the brake is in no way connected with the body of the carriage, the magnetic discs being kept in position by stays running from one to the other. The trial lasted for about three hours, the best result obtained being the stopping of the car in 60yds, when travelling at 30 miles an hour. The experiments were considered by the company's officials to be highly satisfactory. A significant fact in connection with the trial was the distance the engine ran before brought to a standstill by an ordinary hand-brake, at least 500 or 600 yards being required. With a steam brake a much less distance would have been required, but it is very doubtful whether the locomotive would have been brought to a standstill nearly as quickly as was the coach.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

FIRE BRIDGES.

To the Editor of "The Practical Engineer."

Sir,—In his letter on the above, "Chalkline" asserts that no useful purpose is served by the fire bridge beyond keeping the fire on the grate, and instances the good results obtained by Salmon's bridge. He states, also, that his advice invariably is to keep the bridge low, but make it as wide as you like.

Now, I never knew how economy could result by having a long sloping bridge like Salmon's extending some feet in the flue tube, and I should like to have "Chalkline's" explanation of how saving in fuel can be effected by using such a bridge. If there had been a chamber in the bridge, through which air could be admitted, and thus cause more effective combustion, I could have understood it; but how economy could result from a long level or sloping bridge, along which it is recommended that all the clinkers, ashes, &c., should be pushed away from the fire grate, in order that they might be "slowly and entirely consumed," has always been one of those things I, for one, could never understand.

"Chalkline," having had large experience with these bridges, can doubtless throw some light on the matter. Such excessively wide bridges must necessarily cover one or more seams of rivets in the flue tubes, and they must consequently be a great nuisance and expense to remove for thorough inspection.—Yours, &c., ENGINEER.

BOILER INSPECTORS AND THEIR WORK.

To the Editor of "The Practical Engineer."

SIR,—As one whose livelihood is so very much intermixed with boilers, their construction, examination, and repair, I was much pleased when I first glimpsed at the heading (as above), and, before I had time to read a line, anticipated something interesting and instructing, but the second sentence so winded me that I had a rest, and more than once looked to see if I had got my right paper. "We have boiler-makers who inspect and report on boilers, generally to their own advantage." Is that all? If so, the information, however gratuitously offered, is neither flattering nor charitable, and as one whose duty it has been to do this class of inspecting in years gone by, I do not feel any "taller" for your kind explanation. I have before now pointed out in your valuable columns that there are "inspectors" *and* "inspectors," but have never before found out that the line of demarcation was in the fact of his being a "boiler-maker's" or "insurance company's" inspector, and that the "typical inspector" is exclusively of the latter class; but having been on both sides of the line, I will "bide a wee" before comparing notes as regards men I have met during my twenty years' experience.—Yours, &c., CHALKLINE.

QUERIES AND REPLIES.

141. POWER OF HOISTING BLOCK.—It is found by trial that when P is on the point of lifting W by means of a single fixed pulley, $P = (1 + m) W$, where m is a fraction depending on the friction of the parts of the machine. If three such pulleys are combined into a "block and tackle," find the power requisite to raise a given weight by means of it.—STUDENT.

Answer.—Let W = weight raised. For first pulley $P_1 = (1 + m) W$. Combining first and second, we get $P_2 = 1 + m) W (1 + m) = W (1 = m)^2$, and combining first, second, and third, $P_3 = W (1 + m)^2 (1 + m) = W (1 + m)^3 \therefore P = W (1 + 3m + 3m^2 + m^3)$.—H. G. C.

143. CONSUMPTION OF FUEL.—Will any reader kindly supply me with the following information, taken from the most modern practice of our principal engine builders? 1. What is the consumption of coal per I.H.P. for (*a*) ordinary high-pressure steam engines working expansively; (*b*) ditto condensing; (*c*) ditto compound non-condensing; (*d*) ditto compound condensing; (*e*) ditto triple-expansion non-condensing; (*f*) ditto triple-expansion condensing. 2. What difference does steam jacketing make in coal consumption? 3. Is there any material difference in the consumption of coal per I.H.P. shown by engine, in multitubular, Lancashire, and Cornish boilers? Any information relative to the above, also *re* consumption of coal per I.H.P. for direct-acting steam pumps, such as Worthington type, will be esteemed by—F. J.

Answer.—(1) It is impossible to give a precise answer to the questions under the various headings. For any one of the engines named 2lb. of coal per indicated H.P. per hour would be a good result. The coal consumption on trial trips, if scanned too minutely, is misleading. A great deal depends on the stokers employed on such trips; and also if there are certain tabulated differences in coal consumption between various types of engines when the engines are new, the proportional differences will certainly vary from this when the engines have been at work for a short time; also in deciding upon any type of engine, coal consumption is rarely regarded as the principal factor. (2) There has been, and still is, much difference of opinion concerning the saving effected by steam jacketing. The view, however, seems to be gaining ground rapidly that steam jacketing saves little or no coal, while some authorities regard it as causing a waste of fuel. (3) A new multitubular boiler gives better results than either of the other boilers named. After a short time, however, it loses this advantage, and the three types show little difference in fuel consumption. Here, also, fuel consumption is a secondary matter. For rapid steam-raising multitubular boilers are preferred. For ordinary work, where large power is required, Lancashire boilers are used, as giving less trouble. For small powers Cornish boilers are used. To get the fuel required for a pump, ascertain the weight of water to be raised per hour, and to what height, allow for friction of pump, and calculate at about 3lb. of coal per horse power per hour.—C.

144. CURVATURE OF RIM OF PULLEY.—How do you find the proper curvature to give to the rim of pulley? Does it simply depend on the width of the belt, or does it also depend on the thickness of belt, speed of belt, and diameter of pulley? A leather belt, about ¼in. thick, is to travel at about 3,000ft. per minute over a 27in. pulley of 8in. face. What should be the difference between the diameter of pulley at the centre of the rim and at the edge?—RAW HIDE.

Answer.—The usual practice is to allow about half an inch rise per foot of the breadth of the pulley, so that $\cdot 5 \times \frac{8}{12} \times 2 = \cdot 66$, say $\frac{11}{16}$in. larger in diameter at the centre than at the edge. Another rule being to strike the curvature of the rim with a radius equal to three or four times the width.—ORION.

145. THICKNESS OF CAST-IRON PIPE AND PROPORTION OF ENGINE CYLINDERS.—Would any engineer inform me the thickness of cast iron for 8in. diameter steam pipes to be safe from bursting with 80lb. of steam per square inch in the boiler, and what diameter of cylinders would you recommend to work compound side by side? Corliss high-pressure cylinder, short slide valve for low-pressure cylinder, to drive 200 I.H.P., 44 turns per minute, 4ft. 6in. stroke, 80lb. of steam in boiler per square inch. Information will oblige.— J. C.

Answer.—A good thickness for cast-iron steam pipes is, for 8in. diameter, ⅝ths of an inch, with flanges $1\frac{5}{16}$in. thick. I extract from some old notes of mine a table headed "Cast-iron pipes for high pressure," which I append. In the table, A is the internal diameter or bore, and B the external diameter of the pipe; C is the diameter of the circle through the bolt holes in flange, D diameter of flange, E thickness of flange, F diameter of bolt holes, and G distance of edge of holes to edge of flanges.

A	B	C	D	E	F	G
In.	In.	In.	In.	In.	In.	In.
2	2¼	4⅜	6	¾	¾	⅞
2½	3⅜	5¼	7½	$\frac{13}{16}$	¾	1
3	4	5¾	7½	⅞	¾	1
4	5	6¾	8½	1	⅞	1⅛
5	6⅛	8¼	10	$1\frac{1}{16}$	⅞	1⅛
6	7¼	9⅝	12	$1\frac{3}{16}$	⅞	1⅛
7	8¾	11¼	14	1¼	1	1¼
8	9½	12¼	15	$1\frac{5}{16}$	1	1¼
9	10½					
10	11½					

Of course the thickness in the smaller sizes is excessive, as always the case in cast-iron pipes, especially when not designed to be cast vertically, in order to allow for shifting of the core. To proportion engine cylinders for 80 gauge pressure, assume a final pressure of about 8, which will demand say 11 expansions. Then, to get 200ft. × 33000 foot-pounds of work from a piston moving 9ft. × 44ft. per minute, requires a mean piston load of $\frac{6600000}{396}$ or nearly 16500lb. Now, 95lb., the absolute pressure, expanded 11 times, gives an average of $95 \frac{1 \times H}{R}$, where R is the expansion rate = 11, and H is the hyp. log. of 11 = 2·39. Working out gives 29lb., and deducting three for back pressure, we get 26lb. as the mean forward pressure on large cylinder of equivalent simple engine. Then $\frac{16500}{26} = 635$in., which is the area of a 29in. cylinder—allowing for a stout piston rod. The high-pressure cylinder may be about 16in. diameter. The relation of cylinders is not a matter of such terrible importance as some would have us believe. It is essential, however, to economy, that the high-pressure cylinder should be of a size sufficient to allow of considerable expansion of the steam before passing to the second cylinder, and it is of more importance to jacket the small than the large cylinder. The admission to the large cylinder should also be cut off at a sufficiently early point to prevent a heavy fall of pressure between the two cylinders, or loss may ensue. Of course, a very large first cylinder is to be avoided, as it affords too large a radiating surface, one of the advantages of compounding being that steam of high temperature is contained in vessels of small radiating area.—W. H. B.

146. RETURNING CONDENSED WATER FROM STEAM JACKET TO BOILER. What is the best means of returning the condensed steam from the steam jacket of a cylinder to the boiler when the level of the engine cylinder is below the water level of boiler?—ECONOMY.

Answer.—The best and usual means to adopt is to drain the jacket water through a steam trap into a feed tank, from whence it may be returned to the boiler by the ordinary feed pump.—J. R.

Answer.—There are several steam traps now in the market which will deliver the condensed steam a few feet above their own level. Have one of these traps attached to the steam-jacket drain pipe, keeping the cock on this pipe (if there is one) always full open. Fix a small tank on a level with the mean water line of the boiler for this trap to empty its hot water into, and use an injector for forcing this hot water into the boiler. The injector must not be placed above the hot-water tank, or it may give trouble. McDougall's steam trap lifts water considerably, and would answer your purpose. See our advertising columns.—W. F.

147. EXHAUST STEAM INJECTOR.—Will any reader kindly inform me if the above could be applied to a condensing engine, or would it interfere with the vacuum? I believe they require very little steam to work them. A. S.

Answer.—There appears to be no reason why an exhaust injector should not be applied to a condensing engine exhaust pipe, except the fact that instead of having its working fluid at the atmospheric pressure, it would only be at perhaps 3lb., or even 2lb. absolute, and could not have the energy to drive into a boiler at 70lb., which is, I believe, about the limit of the injector when working with atmospheric steam. The injector would improve the vacuum by withdrawing some of the heat, but the vacuum would certainly interfere with the injector. You might utilise it in such a case to elevated water to a cistern placed not too high above it.—W. H. B.

149. GRINDING STEEL KNIVES.—In our establishment we use steel knives, bolted on to a metal pulley, for chopping rope, &c. They have to go through the process of grinding twice a week, which takes two men, one at the end of the lever, and one to stand by the knife; in some mills similar it is done by one. I send sketch of our present system, fig. 1, and also an idea of the principle of the one-man system, fig. 2, one hand on knife and one on lever, which might be greatly improved. Would any of your readers suggest an idea applicable with little expense? The one-man system is very simple, but, in my opinion, dangerous.—PRIMROSE.

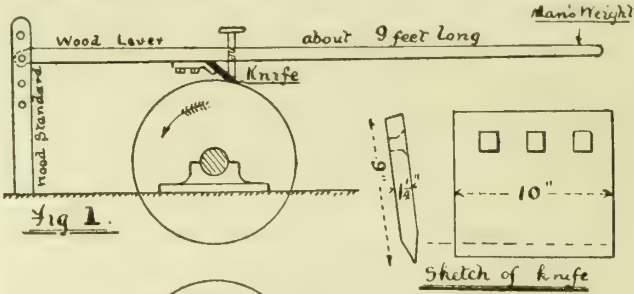


Fig 1.

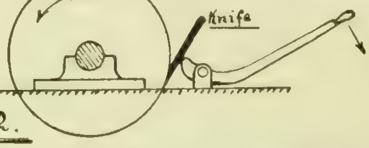
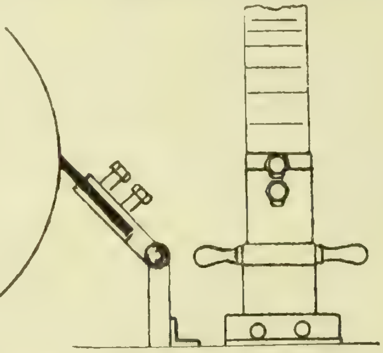
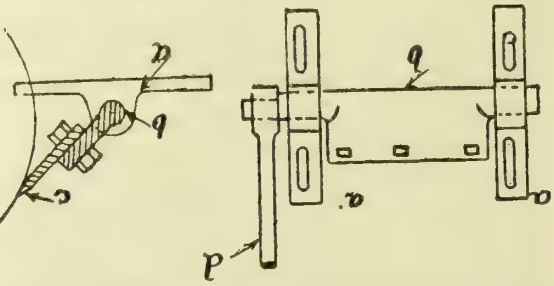


Fig 2.

Answer.—I give sketch of my idea. Fix an iron upright in front of grindstone—another piece is hinged to this at the top, and has a slot to receive the knives, which are secured by screws. Two handles are fixed on for the man to apply pressure. The knives could be done in a planing machine with emery wheel.—HEAVY TURNER.



Answer.—Such an arrangement as sketched below, consisting of two small brackets *a* *a*¹ bolted to the grindstone trough, forming supports for the ends of the crossbar *b*, which has a lip for fixing the knife *c* to, as shown in section, and a lever *d* fitting a squared end of *b* for the purpose of holding the knife to the grindstone, would obviate all risk of danger due to the knife slipping, and could be attended to by one man. When not in use, *b* could be turned back free of the stone. The slotholes in the brackets would allow of adjustment to take up wear, also to suit the angle of the cutting edge of the knife.—ORION.



150. LEATHER BELTING.—I wish to know the width of double leather belt to transmit 200 I.H.P. Belt flywheel 14ft. diameter, 72 revolutions per minute; driven pulley 10ft. diameter, 30ft. centre to centre. Please give formula.—ANXIOUS.

Answer.—The first step is to ascertain the power given off the driving pulley, and this will be obtained as follows;—

$$\frac{200 \times 33{,}000}{14 \times 3{\cdot}1416 \times 72} = \frac{6{,}600{,}000}{3{,}168} = 2{,}083\text{lb.}$$

The tension of the tight side of the belt, working under the conditions named, will be about 4,000lb., and the safe working tension of double leather belting of good quality may be taken at 200lb. per inch of width ∴ required width of belt $= \frac{4{,}000}{200} = 20$in. It will be seen that no deduction has been made in the calculation for the friction of the engine itself. The correct basis to work upon is the actual or brake-horse power, and not the indicated. It would probably be found more satisfactory in every way to employ rope driving instead of one large belt.—Hydra.

148. Automatic Vacuum Brake.—Can any reader inform me the reason why, when the brake is applied from the engine, it always takes hold of the last carriage first? It always seems strange to me why it should do, and I shall be extremely obliged for any information on the subject.—W. G.

151. Marine Governors.—Could any reader tell me whether there are any marine governors that work independently of the engine—that is, do not derive their motion from the engine. If there are any, I should be very much obliged for a short description of each.—Marine Engineer.

153. Saturated Steam.—Why does its pressure rise in a ratio which slowly increases, referred to the temperature? And why does the amount of total heat slowly increase with the increase of temperature?—S. B.

154. Injury to Eyes by Electric Light and Lucigen Light.—I should be very much obliged if any of your readers could kindly tell me which is the most injurious to the eyes, a strong electric light (without globes) or the Lucigen light?—J. S. S.

155. Power and Coal Consumption of Engine.—Would any reader kindly inform me what I.H.P. engine ought to drive the following dimensions: diameter of cylinder 14in., stroke 24in., revolutions 80 per minute, automatic cut-off valve, boiler pressure 50lb., belt driving from flywheel 6ft. 6in. diameter; also what amount of coal (slack) should be used for the amount required, to work at best advantage?—Young Man.

156. Triple Expansion.—Can you or any of your readers advise me as to the best proportions of cylinders for 150lb. boiler pressure? We have a pair of horizontal condensing engines, with cranks at right angles, now working with 60lb. boiler pressure, and we propose putting in new boilers for 150lb. pressure, and converting the engines into a triple expansion by substituting for one of the cylinders two smaller ones, placed tandem fashion. Present cylinders 40in. diameter, 6ft. stroke, to run when altered at 35 revolutions, horse power about 600. As the first cylinder will be of very small diameter for the stroke, should any difference be made in the ratios? What is best point of cut-off? How about jacketing?—J. R.

157. Load on Railway Wheels.—A pair of wheels of a railway wagon required to carry 6 tons, the distribution being 4 on one wheel and 2 on the other. The centres of the axles are 6ft. 2½in. apart, and the gauge of the rails = 4ft. 8½in. Allowing a working stress of 5 tons per square inch, what should be diameter of axle, first at wheel seat, second at centre of length?—J.

158. Boiler Plate Gauge.—How can I make, or where can I obtain a simple gauge for taking the thickness of boiler plates (drill test)? Information will oblige.—E. T. M.

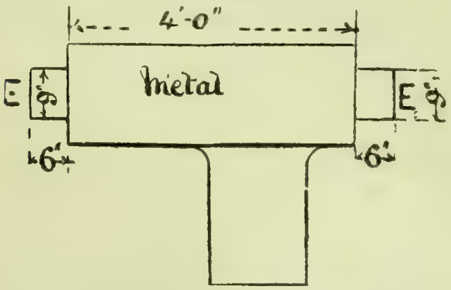
159. White Colour for Steamboat Funnel.—Can any reader oblige me with a good recipe for making a white colour for steamboat funnels, one that will not peel off in flakes or turn yellow? I have tried lime with glue in it, but that peels off. I now use zinc white with a little glue and tallow in it; that turns yellow. Any assistance in this respect will be thankfully received.—Dacia.

160. Joy's Valve Gear.—Can any of your numerous readers tell me why Joy's valve gear is not more extensively used in marine engines?—Minerva.

161. Engine Connections.—Will any reader kindly furnish me with a formulæ, or explain how to determine the following, viz., distance between centre of connecting rod, length of piston rod, depth of piston, and distance between centre and face of crosshead under various conditions of pressure?—Anxious.

162. Method of Boring out a Rod.—Could any of my fellow-readers inform me on the following: I have a rod of bell metal, 6ft. long, and 2¾in. diameter, through which I want to bore a hole 1½in. diameter. I wish to know the best way to hold it in the lathe, and also the best method of boring it. There is a cut to come off the outside; should I take this off first or last, and what tool will best do for the job?—Heavy.

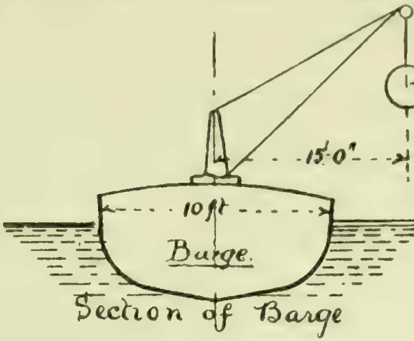
164. Facing Forging.—Could you, through your paper, inform me how to do this job, of which I give sketch? The ends E have to be made true, and as I have no lathe large enough, I wish to know of another method. I have a boring machine. Could it be done on that? If so, a sketch of the tool required would greatly oblige.—Truth.



165. Cast-iron Piston Rings.—Will you kindly inform me the correct width and thickness of piston rings, cast-iron split, for a cylinder 10in. diameter, 16in. stroke?—Fitter.

166. Calculating Coal Consumption of Engine.—Will any of your readers kindly inform me how to ascertain, approximately, coal consumption from indicator diagrams, diameter of cylinder stroke, revolutions, temperature of injection and discharge, and hours worked per week, being given? I should also be glad to know which is the best book on the indicator, suitable to a practical engineer whose theoretical training s somewhat backward—in fact, had but little?—E. D.

167. Barge Crane.—If a crane is fixed on the centre of a barge, and works a 2-ton load on jib at a radius of 15ft. overhanging the side of barge and at right angles to the same, and the beam or width of barge is 10ft., what will be the strain or dead weight on edge of barge, tending to compress it down into the water? Kindly show how obtained. I append rough sketch.—Vulcanite.



169. Worm Gearing.—I have a worm wheel, making 17 revolutions per minute, with 39 teeth. The worm makes 663 revolutions per minute, and is constantly wearing out. How can this be remedied, or should other form of gearing be employed?—Worm Gear.

170. Brake Power of Gas Engine.—I have a small gas engine, about 5 H.P., and wish to know the brake H.P. of it. I have an indicator, and should be glad of sketch of brake, and other particulars that would assist me in the trial.—Novice.

171. Travel of Valve.—Would some of your readers oblige me with a formula for finding the difference of travel in a valve when linked up, and various amounts?—Novus Manus.

172. Hopkinson Safety Valve.—I have to erect a Hopkinson safety valve, and want information on the following points:—(1) How shall I weight it to blow off at a certain pressure? (2) What height should the float be placed above the furnace tubes? (3) How much lift shall I allow? The lever is so near the boiler that it only allows a lift of 2½in. Is this sufficient? (4) How am I to determine the counterbalance for the float, in order that the lever will act on the low water valve? (5) Does this valve act the same under all pressure; for instance, would the low-water valve blow off at a pressure of 5lb.? also at a pressure of 200lb. in case of low water?—In Doubt.

PATENTS AND INVENTORS' QUERIES.

41. Gunpowder Engine.—Can you give a few numbers and dates of gunpowder engine patents, or patents mentioning similar explosives as applied to motive power?—T. B., Leeds.

Answer.—The following list only gives a few of those patents; there are many others. Explosion of gunpowder used in various ways to produce motive power: J. Allen, No. 513 of 1729; R. B. Boyman, No. 1155 of 1860; J. E. Holmes, No. 1288 of 1864; W. E. Newton, No. 3690 of 1867; M. P. W. Boulton, No. 392 of 1868; Boulton and Imray, No. 1005 of 1868; Hammond, No. 171 of 1869; C. H. Wood, No. 3395 of 1873; J. D. Ridley, No. 777 of 1874. The use of gun cotton is mentioned in Holmes' and Boulton's and Imray's specifications, as well as in Luke's and Plessner's. Luke, No. 387 of 1872; and Plessner, No. 2525 of 1872. Nitroglycerine is also proposed by some inventors. There are many other attempts, some quite recent, but space forbids a complete list. Our Patents Department can supply such a list if required.

42.—New T Square.—Kindly give an opinion of my invention, of which I enclose sketch. Is it worth patenting?—Lelgub, Bury.

Answer.—The arrangement is ingenious, and would be useful in many cases, and is worth patenting if you have means of pushing it personally. You should get provisional protection, and see what can be done with it before going to the expense of filing a final specification.

TO CORRESPONDENTS.

E. D., London.—You should send your full name and address, as it is against our rule to attend to communications without it; we have, however, inserted your query.

J. S. M., Whitehaven.—You can purchase bismuth in the metallic form from any chemical apparatus firm in large towns; or write to Messrs. Burgoyne, Burbridges, Cyriax, and Farrier, 16, Coleman Street, London, E.C. It is not very expensive.

P. M., Belfast.—The small size of your safe will render it a difficult matter for you to put those bolts in. We fear it will be quite impossible to obtain such from any makers' stock, and it will be costly to purchase so small a quantity. A small local firm will probably make them for you, but a large firm would scarcely be able to give the time to it. We know of no practical work on safe construction.

Tom.—Write to Messrs. Smith and Coventry, Salford, or the Britannia Company, Colchester.

Paper Bag.—The account of paper-bag machinery was by Mr. Job Duerden, Burnley, who, we believe, is the patentee and maker of the machine described. You will no doubt get all the information by writing to him.

T. S., Dursley.—We do not know of any tables giving the weights of a series of articles tabulated in the manner you require. We fear the demand would be too limited for such information to pay for the publication.

J. C., Batley.—There were two answers to your query, No. 145, *re* compound engines, in our last week's issue, in which, we think, all the information you require is contained.

MISCELLANEA.

Proposed New Derbyshire Railway.—The London and North-Western Railway Company have given notice of their intention to apply to Parliament for powers to construct a line of railway for passengers and goods between Buxton and Ashbourne, a distance of some 22 miles.

The number of visitors on the closing day of the Paris Exhibition was 370,000, the number of tickets presented—five for every admission after five o'clock—being 511,000. The total number of paying visitors to the Exhibition was 25,000,000, as compared with 12,000,000 in 1878, and 8,000,000 in 1867. Of the 30,000,000 tickets issued, 28,000,000 have been utilised.

The Price of Steel.—Steel is now from 30 to 40 per cent dearer than it was in 1887. This will sensibly affect the naval defence scheme, and will cause the cost of the building of ironclads to be £30,000 per ship more than is calculated. There is also a proportionate increase in work, so that much delay will be incurred in obtaining the delivery of plates and single bars. This will likewise add from three to four months in the construction of a cruiser.

The Manhattan Elevated Railroads.—It is stated that the directors of the Manhattan Elevated Railroads, New York, intend spending $20,000,000 for the enlargement of stations, termini, and the entire equipment on the Third, Sixth, and Ninth Avenue routes. The city authorities of New York are expected to make large concessions of space for these improved facilities. Seven cars will constitute a train, and locomotives already ordered will have a correspondingly increased power. The fixed charges will amount to over $800,000, which the increased earning capacity of the road, it is assumed, will fully warrant.

German Electric Light Installations in Madrid.—The new Compania Madilena de Electricidad has just been constituted at Madrid. Among the directors are the Spanish ex-Minister Moret, chairman, the manager of the Banco Hispana-Aleman, Mr. Lobo; and the following Germans: Messrs. Rathenau, Siemens, and Grimner, all of Berlin. The plans of the new company, as also the new buildings, machines, and lighting installations, have been ordered of the Allgemeine Electricitats-Gesellschaft, Berlin. The enterprise is favourably commented upon by the Spanish newspapers, which refer to the commendations bestowed by Edison on the electric light of Berlin.

Electric Lighting in England and Wales.—The time for gazetting notices of all provisional orders for which application will be made to the Board of Trade or the Local Government Board has now expired. So far as England and Wales alone are concerned upwards of 208 applications will be made to the Board of Trade for provisional orders, of which 160 relate to the electric light. Of these 160 electric-lighting orders twenty-three relate solely to the metropolis, the orders covering practically all parts of London two or three times over, while in several instances the orders include areas for the electric lighting of which powers were granted last session.

The Oldest Observatory in the World.—The observatory at Pekin is the oldest in the world, having been founded in 1272 by Kubla Khan, the first Emperor of the Mogul dynasty. There are still in it three of the first instruments of observation. These were used for the observation of Halley's comet in 1738, and may also be used when, 22 years hence, this comet again appears. The oldest observatory in Europe is that founded by King Frederick III., of Denmark, on the island of Hveen, in the Sound, and where the famous Tycho Brahe carried out his celebrated observations, among others that of the "bright star" in Cassiopeia. The Paris Observatory was established in 1671, and that of Greenwich three years later

Two stations have been established from which to operate the Brennan torpedo, one at Sheerness to cover the approaches to the Medway and Thames, and the other on the Isle of Wight to cover Portsmouth. A factory, too, has been established at Chatham, at a cost exceeding £100,000, for the manufacture of the weapon, and a still larger sum has been paid to the inventor. Yet the authorities most concerned are of opinion that up to the present this particular weapon has scarcely justified its existence, and that before it can be of really practical use, many modifications must be introduced. At present, torpedo experts are decidedly of opinion that it is of far less value for the defences of estuaries and ports than the Whitehead torpedo when discharged from properly equipped boats.

Manchester District Institution of Gas Engineers.—The quarterly meeting of the Manchester District Institution of Gas Engineers was held in the Memorial Hall, Albert Square, on Saturday, November 30. Mr. T. Banbury Ball (Rochdale) presided, and there was a large attendance. On the motion of Mr. Braddock (Rochdale), seconded by Mr. Mackenzie (Wilmslow), Mr. W. W. Hutchinson, of Barnsley, was elected president for the year 1890-91. Mr. Isaac Carr read a paper on the "Dinsmore Process," in the course of which he stated that the process had for its object the conversion of tar formed in the distillation of coal into permanent illuminating gas. This gas being generated in conjunction with the ordinary coal gas, increased the quantity and quality of the production over that of the ordinary method of carbonising. Mr. Carr then described the plant in operation at the Widnes Gasworks, and his experience in bringing the process to its present stage during the two years he had had the work in hand. That this gas was equal to the ordinary gas, in what might be termed both its storing and its travelling properties, he was satisfied, as he had had the quality checked at a distance of a mile from the works without any diminution being apparent. The cost of labour per 1,000 cubic feet on the Dismore beds was actually less than in the other case on account of the extra quantity of gas made per ton, the weight of coal in each case being about the same. The value of this system to them, situated as they were so favourably for the manufacture and disposal of their residual products, was to be found in its light-producing power, as it admitted of the use of coals of a lower quality than it had ever previously been deemed expedient to use.—Professor Foster, F.C.S., had examined the system and tested the gas produced, and in his report he stated he was much impressed with the simplicity of Mr. Carr's method of working the process, and he had no doubt that the merits of the system were such as to warrant gas companies in giving it a trial.—Mr. Thomas Newbigging, C.E., submitted a paper on "The utility of water in gas manufacture." He drew attention to the usefulness of water in the work which it did in the ashpans under the retort furnaces, and in the slaking and quenching of hot coke. He pointed out that in hot climates the crude gas could best be reduced to the temperature necessary to admit of its satisfactory purification by causing water to trickle down the exposed surface of the condenser. In the slaking of the oxide of iron and the lime with which the purifying vessels were charged water again was indispensable. He also pointed to the value of the water-seal for the lids of the purifying vessels, in the hydraulic valve, in the station governor, in the gasholder tank, in the cups of telescopic holders, in the wet gas meter, and in the water-slide pendant. Water or water vapour was one of the products of the combustion of coal gas. This product was brought about by the combination, at the point of consumption, of the oxygen in the air and the hydrogen in the gas. The presence of water, whilst objectionable under certain conditions, yet played an important, and indeed an indispensable part in the economy of a gas undertaking.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

November 16th.

18308 Steam Traps, J. Keighley, Bradford.
18327 Carding Engines, T. Rothwell and J. W. Rothwell, London.
18328 Furnaces, J. Mellar, Sheffield.
18338 Tires, J. Harrington and J. Hopper, London.
18348 Bearings, M. Lacombe, London.
18350 Dynamo-electric Machines, J. H. Davies, Essex.
18353 Tires, J. H. Ball, Kent.
18359 Valves, I. B. Harris, London.
18360 Dynamos, W. R. Renshaw, London.
18361 Electric Meters, S. Z. de Ferranti, London.
18364 Indicators, H. S. Barron, Kent.

November 18th.

18378 Slide Valves, H. B. Daglish, R. S. Daglish, and T. Windus, London.
18379 Self-oiling Wheels, J. Trippett, Sheffield.
18402 Rotary Engines, J. Morgan, London.
18409 Purifying Water in Steam Boilers, A. Grant, A. McDonald, and J. McDonald, London.
18414 Electrical Railways, J. Hopkinson, London.
18424 Furnaces, H. H. Lake, London. (J. R. Paddle and C. V. de Velde, Belgium.)

November 19th.

18431 Propellers, C. Inwood, Gravesend.*
18441 Water Heaters, W. J. Righton, Paddington.
18465 Stuffing Boxes, H. H. Lake, London. (T. Tripp, United States.)*
18471 Metal Cylinders, W. Crawford, Glasgow.
18488 Spray Lamps, A. Shedlock, London.*
18494 Carding Engines, L. A. Peckham, London.*
18496 Pulverising Machines, H. H. Lake, London. (E. Wiman, United States.)*
18502 Furnaces, E. Fales, London.*
18504 Bearings, J. F. Morell, London.*
18506 Locomotive Engines, F. C. Winby, London.
18510 Pumps, W. Stainton and A. J. Fairfax, London.
18511 Hot-air Engines, W. Stainton and A. J. Fairfax, London.

November 20th.

18542 Furnaces, F. H. Shuttleworth and J. Clegg, Manchester.
18546 Steam Traps, J. S. Stubbs and S. H. Stubbs, Manchester.
18550 Electric Heaters, E. Simpkin, Manchester. (W. L. Burton, United States.)
18567 Retaining Rings, W. McLaren, London.
18568 Axle Boxes, G. Wilkinson, London.
18576 Carding Engines, G. Paley, London.
18602 Brake Mechanism, A. J. Boult, London.*

November 21st.

18611 Spanners, J. Mackenzie and G. Sonnenthal, Durham.
18613 Rotary Engines, F. Lister, Keighley.
18627 Economising Fuel, C. G. S. Hills and G. Paine, Kent.
18632 Revolving Clutches, A. M. Vereker and S. M. Yeates, Dublin.
18656 Brakes, H. J. Haddan, London. (C. Conneau, Belgium.)

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Vol. I. (bound), price 6s. 6d., and Vol. II., price 7s. 6d., can be obtained through any Newsagent, or will be forwarded, carriage paid, from our Manchester Office on receipt of postal order or stamps for the amount.

All communications should be addressed to 6, Victoria Station Approach, Manchester; those intended for insertion in the current week's issue not later than by first post on Tuesday.

Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE
PRACTICAL ENGINEER,

DECEMBER 20TH, 1889.

APPLIED MECHANICS.

THE Science and Art Department have established a certain standard or definition for the practical or applied subject of mechanics, which we contend is much too narrow, and more fitting as a standard for theoretical mechanism than for actual constructive or applied mechanics.

We have always claimed for the Science and Art Department that it has done an immense amount of good to the large official staff of examiners and inspectors, and a limited amount of actual solid work in the shape of payment to the teachers and encouragement to the students. The large sums of money voted annually to the department do not, to anything like the extent we should desire, encourage the pursuit of knowledge for its own sake.

We have expressed our views boldly and fearlessly respecting technical education, and we have tried to uphold the supreme importance of practical as against theoretic knowledge. We desire to urge upon all young engineers the desirability of studying the subjects closely which are allied to their daily duties, and to become familiar with all the branches of the great subjects involved in any one direction of practical engineering. We think, however, that our young men and our engineering students are somewhat fettered by the provisions of the Science and Art Department.

With the system as a whole we are in complete accord, for nothing can be fairer than the means and methods adopted for testing the candidates' knowledge; indeed they are above suspicion even, in the admirable arrangements by which the papers are simultaneously delivered and collected at the same minute throughout the United Kingdom. Similarly, too, the system which requires that a candidate shall not twice obtain a prize is an incentive to higher study and a progressive reading of any subject. There are some twenty-five separate subjects, and each of these is divided into three grades, viz., elementary, advanced, and honours, with the single exception of mathematics, which has further class sub-division. Having, then, this very wide field and extensive range, it would appear that every student would in any subject find his level most correctly gauged, and his knowledge determined by means of the questions to be set at the particular examination that he entered. But we regret that in the subject of applied mechanics, which is really a most important and fundamental one for all engineers, the questions are certainly not those likely to be in any measure a proper test of knowledge. We understand applied mechanics to comprehend all those practical points which actually arise in constructing machinery of every description; that is to say, we do not expect to work out a calculation as to the effect of a man's labour upon a rope which forms the free end of some tackle, and pulleys by means of which a certain load is to be lifted, without determining the actual useful effect of such labour after deducting frictional resistance. We expect that the centre of a wheel shall be treated as a surface absorbing a certain amount of energy, and that it shall not be considered as a purely mathematical and impossible point. We expect to be able to determine a true relation between that which is given to the machine and appliance, and that which is produced by the machine.

We come to the examination, having studied the strength of materials,—the frictional resistance caused by certain loads upon certain materials—the power to be transmitted by a belt or by a system of gearing—the strength and proportions of teeth suitable for such gearing—the construction and principles of hydraulic machinery, and similar every-day problems which have to be faced in all workshops the world over by anyone professing to be a practical engineer, or one acquainted with applied engineering.

The questions given to such a candidate we will now examine upon the basis of those given at the examination of the Science and Art Department for 1888. There are questions printed here in this paper quite outside the province of any person engaged in a practical mechanical workshop, and we certainly contend that they can be no test for practical men who enter the lists prepared to get a kind of gauge given them by which they can adjudge themselves, or which may be useful in enabling other people to estimate their knowledge, when any question of competency is to be determined.

The candidate finds himself asked questions upon clocks, condensing syringes, scale pans, epicyclic trains of wheels, unusual forms of peculiar teeth for wheels, chronometer escapements, geometrical motions, a bad form of dynamometer, and peculiar cams. Now, we cannot approve of this standard or test for the knowledge of any mechanic;

we rather think the whole of the questions savour too strongly of theory and lecture-room knowledge to be very valuable as gauges for our practical men. The questions relate to mechanics, we grant, but they relate more to the amateur's conception of mechanics than the engineer's. Life is too short, and time too valuable, for any one man engaged in practical work to attempt the whole range of odd motions that can be devised by peculiar and curious wheels or cams.

We cannot study clock-making and mechanical movements generally, together with the important every-day problems of practical life which we have to meet in our workshops and offices. Therefore we maintain that no examination paper should be so broad, and so full of all kinds of varying types of mechanical questions, as to prevent a good mechanic doing justice to his own training and experience. The applied mechanics examination should be what it proposes to be—not an examination as to ideal mechanism rather than actual machinery. The City Guilds have distinguished between the wide realm of subjects covered by the term mechanical engineering by dividing the allied industries and trades into entirely separate subjects, so that tool making and iron manufacture are each distinct from the comprehensive subject of engineering, which may be said to embrace them both. Similarly, too, questions are set which enable any tradesman to answer, and which give him an opportunity of showing his knowledge in his own trade.

We know that a subject which has to be taught in so many schools throughout the kingdom must, in a measure, be made wide and general, yet at the same time we should like to see practical wants provided for by a division of the questions being made under the heads of *Mechanism* and *Practical Mechanics.* Students would then be able to obtain their award under one heading, while the well-informed practical man would have his knowledge provided for by the other division of the subject.

ENGINEERING CRITICS.

We are constantly reminded that other engineers are better than we are, the term "other" usually meaning European and American. It seems fashionable to deplore the lack of English skill and ingenuity; not, however, because we have not the talent or the ability, we are told, but because we are not taught more, and because we have so few opportunities of acquiring knowledge, when compared with other continental engineers. We are loaded with heavy burdens. We have no exact science—simply a blind adherence to precedent. We are neither accurate in thought nor perfect in workmanship. Our designs are guessed and arrived at in unscientific ways, and when we do produce a sound piece of workmanship, it is so ugly as to be perfectly hideous as an erection that forces itself upon public view.

In Germany and in France they do things far more scientifically, we are told, because their engineers are trained under the direct supervision of professors, who reduce everything to a formula or a mathematical expression, and who understand the principles of every scientific action.

We always need to know something of the individual when we listen to his criticisms, for nothing is easier than to knock down and to assail with random statements which do not admit of being momentarily disproved. We do not care always to inquire as to the reasons leading some persons to continually bewail the shortcomings of their fellow-countrymen, and to assert the superiority of the foreigner. We may dismiss their statements by putting one simple question as to how they have learnt of these superior works, and how they have come into contact with the superior foreigner. Only too commonly the critics know nothing at all of the questions they glibly sit in judgment upon, and not unfrequently they simply repeat the utterances of some would-be authority, who is, perhaps, more recognised for eccentric speech than for correct judgment. We are amused at the public utterances of certain men who know nothing as to the strength of materials and the stability of structures, yet who venture to condemn the Forth Bridge, in its simple correctness of design and its undoubted superiority of constructive principle, because it is not their ideal of a pretty or a beautiful structure. It is the old cry of despoiling the scenery that was urged against the early engineers, but which now has been so completely reversed.

EXHIBITION AWARDS.

The value of medals and exhibition awards is becoming a question of degree, depending entirely upon the conditions governing the exhibition. We are not surprised that some firms discount these public awards as being in a measure dearly obtained advertisements, which, perhaps, do not produce any return. With local exhibitions only too often is the system of awards made purely a question of patronage given to the exhibition committee; and we are surprised that any great desire exists for the continuance of the baneful system. Speaking at a meeting held at the Society of Arts, Mr. Lee Bapty, who has an extensive knowledge and experience of such work, declared his opinion that it was almost an impossibility to obtain a jury which should be both competent and impartial. He stated that he had found whenever a man possessed any knowledge of the subject he was to adjudicate upon, he would have practically made up his mind before he entered the room for judging.

Notwithstanding this statement, the Council of the Edinburgh Exhibition have been obliged to consent to give awards in all sections in order to comply with the wishes of foreign commissioners. At the same meeting it was generally agreed upon by all the speakers that the Paris Exhibition awards had been most remarkably fair and just, so that holders of the awards from Paris have the satisfaction of knowing that the opinion respecting their worth is quite favourable, and that they are not measured by the standards set up at some of the local exhibitions, which have been more places of entertainment and promenade than serious exhibitions of industrial and manufacturing products.

INSPECTING ENGINEERS.

Manufacturers are sometimes harassed by contracts hastily and eagerly sought after, when they subsequently find that the work is to be subject to inspection before leaving their works. If they have never had an experience of such an inspection, they probably do their best to make a good show for the engineer, to show what can be done by them when he happens to call. They paint most carefully every article, and with scrupulous regard to the number of coats to be given to it. But when the engineer arrives, if he is worthy of his name, he is likely to give them considerably more trouble in removing the paint than they had to put it on. We have seen and know inspecting engineers who would detect a bad weld in a forging, a flaw in a casting, a fault in a machine, or a bad joint in a girder, without requiring many minutes for examination; and we have known others to pass without observation work which those concerned in its construction and manufacture had expected to have had called into severe question, even if not condemned, and which has even been replaced after the "inspection" was passed, in order that better work should be sent out.

The only guarantee for excellent results from the "inspection at works" trial is that the engineers shall be men of repute, conversant with the trade generally, and possessing a keen insight into the possibilities of trade practices and customs likely to be resorted to in any emergency. With large orders and heavy contracts a resident inspector is a necessity, so that he may watch all that goes on during the many stages of construction—this, too, not so much to check the principals of the works, as to aid them; for carelessness is only too common a fault in all works, and when mistakes are made a great temptation exists to patch up the fault, and thus to send out a defective article.

There are points which arise in the construction of large machines, and which come up for consideration and adjustment with long and large contracts, so that if the inspector be but a superficially educated or an inexperienced engineer, he may cause not only great loss to those whom he represents, but immense trouble to the manufacturers themselves. There are always questions of expediency to be determined, which should be judged and decided by the inspector. There is frequently great trouble in fitting up and erecting a large engine or machine, and a manifestly better method is seen by those erecting, which, while costing actually less to produce, will save its cost many times over by the facility with which it can be erected and re-erected. Yet there are some men who will take nothing in the shape of a departure, however desirable, from the actual lines laid down in a drawing office, only too often hundreds of miles away from the scene of manufacture, and where consequently practical difficulties of erection were never considered or provided for. Fortunately most large and recognised buyers of engines and machinery have inspecting engineers, who can be relied upon to appreciate a difficulty, and thus to assist rather than to hamper the contractor.

HYDRAULIC MACHINERY EMPLOYED IN THE CONCENTRATION AND TRANSMISSION OF POWER.—XI.

Hydraulic Accumulators.

Hydraulic power is generally employed in an intermittent manner, and when the pressure is produced by mechanical means the demand upon the pumping machinery is frequently very great, while at other times it may not be required at all for some period. It is thus evident that if the water were to be used direct from the pumps, they would have to be of sufficient capacity to meet the utmost demand, and to be capable of giving the maximum quantity required at all times and periods ; so that, in fact, an immense waste of energy would result, owing to the diminished conditions requiring a diminished supply from the pumps. Thus, supposing for example that a lift and a press are to be supplied with hydraulic pressure by means of a pumping engine, and that the lift requires 100 gallons and the press 60 gallons per minute, a pump must be employed capable of meeting this double demand, and must supply 160 gallons of water per minute. But the lift will not require the water more than once in every five minutes, while the press will require to be supplied once only in every ten minutes, when working at its greatest possible speed. This united demand, then, requires in one minute out of every ten that 160 gallons of water at full pressure shall be supplied with promptitude and certainty; but for nine minutes out of every ten this amount would be considerably in excess of the actual needs, seeing that during every five minutes an absolute cessation of delivery to the lift and the press is thus secured for a period of four minutes. The average amount of water that could be supplied, provided means were at hand for storing up the quantity ready for the full demand, we can determine very easily. During every ten minutes the lift will have made two strokes, and in so doing will have consumed each time 100 gallons of water. In the same time the press will have required 60 gallons of water. Thus 260 gallons of water will be required in that time, so that, if the pumps can be allowed to run constantly, they can be set to work with a delivery of 26 gallons per minute theoretically. But to provide for leaks or waste we require, say 25 per cent above this amount, and thus supply 32½ gallons per minute for the duty named.

The simplest way of storing up this water is to erect a tank at a height sufficient to give the required pressure by the weight or head of the water column alone. This arrangement is frequently and generally adopted for hydraulic lifts in warehouses, hotels, and lofty buildings. The water used upon such premises for this purpose is usually pumped up over and over again, so that a large amount of water is not required, as the water escaping from the lifts discharges into one common tank, from which the pump draws it again. As soon as the water rises to its determined height within the tank, a ball or other valve closes the delivery pipe, and the pumps stop; and when the water level falls, they again start automatically. With this kind of demand it is absolutely essential that the pumps should start off without any dead centre to be overcome or met, and it is found that no pump will maintain this supply, stopping and starting even after standing for a length of time, so well and so effectually as the Worthington. The advantage of employing a tank for such work as that of supplying a lift is obvious from the fact that water may be pumped up in the daytime, ready for any demand which may be made during the night, while the pumps are themselves not at work.

When pressures such, for instance, as 700lb. to the inch are employed, it becomes quite impracticable to adopt a tank or a water tower, seeing that a column to give that pressure would need to be 1,610ft. high, and pressures as great as three tons to the inch of course could not be provided for at all in this direction. In such cases accumulators are employed, and assume generally the form of a vertical cylinder, fixed at one end, as illustrated in fig. 49, and free at the other, having a ram or plunger working through a stuffing box and gland, or through a gland and leather cup packing, as indicated in fig. 50. The hempen packing is the best, owing to its being more easily renewed, but great friction is often induced by such glands being too tightly screwed down. The ram or plunger carries a load, which, in the example illustrated, is made up of cast-iron weights of circular form, which are suspended from the head of the ram cap by means of long bolts passing through them. Instead of cast-iron weights, where space is not so valuable, a tank or vessel is carried by the bolts passing down from the ram cap, either in a truly vertical form, or inclined so as to obtain a more central or distributed support for the load. Within the tank all kinds of material in loose form, such as slag, stones, bricks, &c., are thrown to make up the amount necessary to give the required pressure upon the ram, in order that it may store up the work that the pumps are doing.

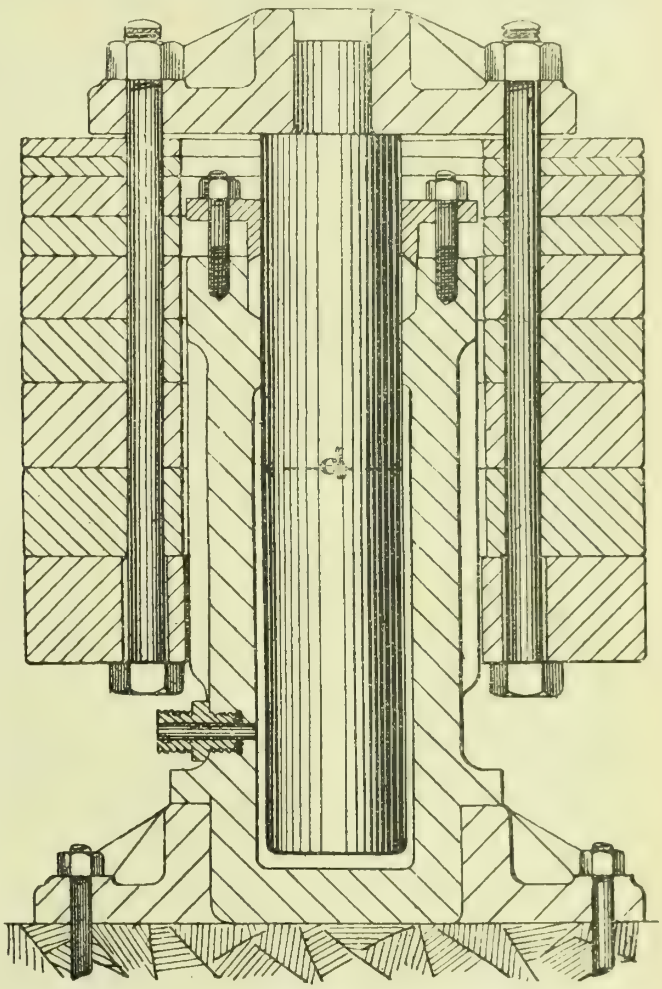


Fig. 49.

The accumulator should be placed as near to the pumps as possible; and if the system of pipes supplied is very extensive, it is often desirable to place another accumulator in some position where it may be of most service in taking up quickly any sudden demand that may be made upon the pipes. The load of the accumulator is made to strike against a stop when quite up, so that as soon as it is lifted to the full height the water cannot escape from the pumps, and they are compelled to stop until the reduction of the pressure by the draught of water permits them to start again. The weights are sometimes arranged to act upon a rod which has a collar attached at any desired point, so that when the weights or the tappet oar strikes the collar the valve is closed, the steam supply shut off from the pump, or the belt driving the pumps is thrown on to the loose pulley. When the weights fall away from the collar by reason of the draught of water from the accumulator, the rod controlling the valve or the belt also falls by its own weight, or under the influence of an added weight. Thus so long as the accumulator ram is not up at its full stroke the pump will continue to supply water, and will stop when the full stroke is reached.

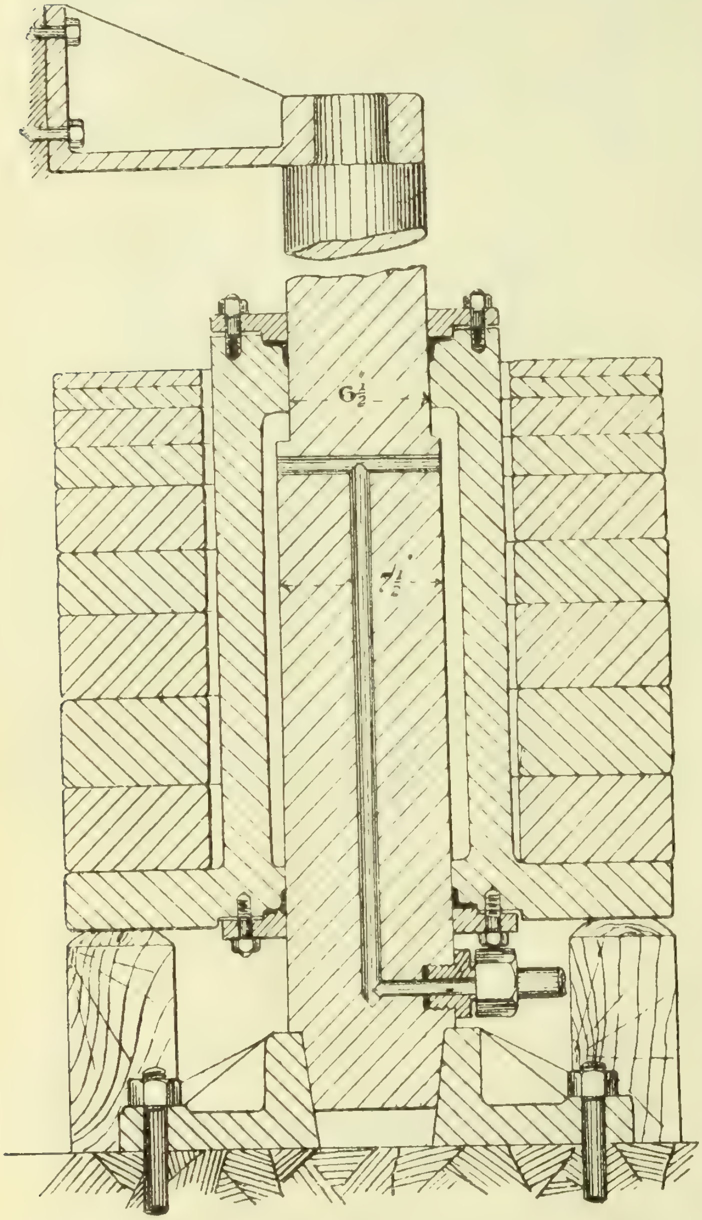


Fig. 50.

When the pressure is very slight, and only a small quantity of water is required, a plain ram, as shown in fig. 49, would not be suitable, on account of the small diameter that would be required. Again, when only a small quantity of water under high pressure is required, a small ram, heavily loaded, might not be possible. In these cases a differential accumulator, as shown at fig. 50, is employed. These accumulators are used with great success by Mr. Tweddell in connection with his hydraulic riveting machines. The ram in the ordinary accumulator (fig. 49) is free to rise in the cylinder, and carries with it the weight. The cylinder rests in the bottom or base plate, which is securely bolted to the foundations. There is only one gland, and that at the top end of the cylinder. Assuming the ram to be 6½in. diameter, the area of which is 38·18in., and the pressure upon the water to be 700lb. per square inch, then the load, together with the weight of the ram, must exceed 33·18 × 700 = 23,226lb; whereas, with the differential accumulator, as illustrated in fig. 50, the same load of 10 tons 7½cwt. is acting upon an annular area obtained from the difference of the two diameters, viz., 7½in. and 6½in.

Thus— 7½in. dia. = 44·17in. area, and
6½in. dia. = 33·18in. „

Net area, say = 11·0in.

$$\text{Pressure per square inch} = \frac{23226}{11} = 2111\text{lb.}$$

Similarly, if only a light pressure of 700lb. per square inch is required from the differential accumulator, then the load must include the weight of the moving cylinder, which has two stuffing glands, one over each part of the ram, as indicated. The weight then upon the column or ring of water within the cylinder will be 700 × 11 = 7,700lb., as against 23,26lb. in the simple accumulator.

The cylinder of the differential accumulator is in reality the load plate in addition to the water cylinder. Chocks of timber are provided for the weight to rest upon when right down and not in use.

Spring-loaded accumulators have been adopted in some cases, but their range is too narrow to require our giving any attention to their construction.

A NEW FORGE AT WEST HARTLEPOOL.

A NEW forge has just been completed at the Central Marine Engineworks of Messrs. W. Gray and Co. Limited, and is now in full work. Some particulars of this latest addition to the industrial establishments at the Hartlepools will interest many of our readers.

The main building of the new forge is 500ft. in length by 85ft. clear span, with side buildings for boiler-house, stores, bar-iron store, stern frame and rudder templet store, &c. The roof of the main building is entirely of wrought iron, the beautiful design being made by the John Cockerill Company for the main transept of the Antwerp Exhibition. It is covered at the lower part of the roof by corrugated iron sheeting, the upper part being entirely of glass from end to end, for a width of 50ft.—25ft down each slope from the ridge. The span of the shop is wide enough to take the large steam hammers in the centre, with furnaces and cranes on both sides of the shop, and beyond these a coal gantry on each side, at a height of 8ft. from the ground, forms a coal depot from behind the furnaces as far as these extend. The coal trucks are lifted up to these gantries by hydraulic lifts, and taken along to the back of the furnaces, where they are dropped as required, so as to avoid coal wheeling.

At the entrance to the shop a huge steam hammer on the Morrison principle is placed. The cranes at this hammer are worked in all motions on the hydraulic system, with a pressure of 1,250lb. per square inch. A "Glen and Ross" hammer is next, with two steam cranes; other hammers by Davis and Primrose, Glen and Ross, the boilers driving which bear a very heavy pressure.

A large and complete plant for the making of stern frames and rudders consists of a steam hammer standing on the middle of a wrought-iron girder, about 36ft. long, which girder is supported by large cast-iron columns at the ends. On one side of this hammer there are two enormous jib cranes to be worked by steam power; and on the other side two light cranes for the lighter class of work. Although the whole of this forge department has been erected during the present year, no less than ten large stern frames have already been turned out, the ships containing some of them being already in the water. Beyond the centre of the length of the shop, it is divided into halves by a row of columns down the middle, one half being covered by overhead travelling cranes, which serve a number of heavy machines adapted for dealing with the forgings composing stern frames and rudders, keel bars and engine shafting. Some of these tools are novel in character, and designed specially for this shop and the work they have to do, and deserve mention at greater length than space allows. The other side of the shop is devoted entirely to the lighter class of smithwork, being, indeed, a complete smiths' shop in itself, containing about twenty smiths' fires, with three light steam hammers, a stamping plant, rivet-making apparatus, &c. Altogether this forge contains, under one roof, a most complete and unique set of plant for dealing with heavy forgings.

MODERN METHODS OF TESTING ENGINES.

By William Lee Church.

If the duty guarantees as usually made are run down to their source, it will generally be found that the performance undertaken is based on a theoretical computation from the data of steam pressure, degree of expansion, clearance, &c. In other words, the duty is one which the builder hopes to get. Possibly he has gone further, and made an accurate test of one or more of his engines in actual service. On the results thus obtained he predicates his guarantee for all other engines, without regard to size, conditions, or individual deficiencies. In other words, it is a duty which he has once had. He may even go further, and, at a considerable expense, erect and test an engine in his own shop, and assume that all other engines of the same size would give the same performance. In other words, it is a duty which he thinks he has got.

Contrast the above, of which the first is by far the most common case, with the way duty is actually determined. At the works of the Westinghouse Machine Co. is a test room containing foundations on which ten engines can be tested at once. These foundations are provided with planed-bed tops, so that any size of engine can be readily bolted to them. Three large boilers, fired with natural gas, furnish steam at any pressure, and superheating devices are added for experiments in that direction. The full load is given to the engine by a Prony friction brake, lubricated with suet, and cooled by the circulation of water in the hollow rim of the wheel. This company has from the first tested all their engines individually under a full load, simply for power and running qualities, from the 5 horse power junior engine to the 250 horse power standard engine. On the completion of the single-acting compound engine came the conviction that it must go before the public on an unimpeachable record for economy. To this end the manufacturers must know the duty of each engine individually, and it was determined that each engine should be tested for its actual consumption of steam, and brought down to a standard performance before shipment. A large surface condenser and air pump was therefore provided, of sufficient capacity to maintain vacuum for 500 horse power. Below the condenser are two galvanised iron tanks, standing on iron scales in such a position as to receive the discharge from the condenser in either tank at will. It is evident that with this arrangement all the steam which enters the engine will be accounted for in the condenser in the form of water, except such as may pass from the overflow in the crank case, which is separately measured. The accuracy of the test is therefore beyond question, while at the same time it is practical in its nature, and presents no refinements beyond what may be reproduced in ordinary commercial usage.

Each engine, when completed, is bolted to a foundation and connected with the boilers and the condenser. A force of three skilled men are constantly employed in the tests. No. 1 manipulates the brake, maintaining a full and steady load and noting the brake readings which give the net horse power. No. 2 takes frequent indicator diagrams, showing the gross or indicated horse power. No. 3 fills, weighs, and empties the tank, keeping the log of the run.

The difference between the indicated and brake horse powers is that lost in friction of the engine. In new engines, which are stiff and close in their fits, the friction would range from 6 to 8 per cent of the full load. After a few days' run the friction falls to 3½ or 5 per cent, doubtless a lower percentage of loss than can be realised in any other engine not similarly lubricated. It having been demonstrated that the water rate is independent of the length of the run, the tests are for convenience usually of ten minutes' duration, and are repeated several times on each engine. The weight of water collected in the condenser, divided by the horse power, and corrected for the duration of the test, is, therefore, the duty of the engine, in pounds, of water per horse power per hour. The first tests are always made with the condenser open to the atmosphere, no vacuum being maintained, and the condenser serving only to collect the steam exhausted. If a vacuum test is desired, the condenser is closed and the air pump started. Every engine turned out is obliged to show a water rate, non-condensing, as low as 24lb. per horse power before it is passed. Experience has shown that its duty is improved at least 1lb. after the packing rings, &c., have worn tight by two or three months of use.

The log and results of the test are entered in a record book, an abridged facsimile of one page of which is here shown :—

Test No. 90. Date—April, 1889.

OFFICE RECORD.

No. of engine........................ 52	Tested for........................
Class of engine ....Compound	Address........................
Size of engine......... 12 and 20 by 12	Jacketing .... None
Maker's name..Westinghouse Machine Co.	Steam lap .... 1¼in.
Tested at.................Pittsburgh	Exhaust lap .... 0in.

TESTER'S RECORD.

	No. 1.	No. 2.
Number of engines	52	52
Boiler pressure ....lb.	100	100
Speed ....rev.	300	303
Brake load ....lb	767	567
Time of start	12·08	12·21
Time of stop	12·18	12·31
Duration of test ....min.	10	10
Full barrel "A" ....lb.	304	257
Empty barrel "A" ...."	100	100
Full barrel "B" ...."	302	257
Empty barrel "B" ...."	91	100
Vacuum ....in.	....	....
Temperature of discharge ....deg.	....	....
Water per hour ....lb	2490	1884
Leakage per hour ...."	34	34
Brake radius ....in.	27·75	27·75
Initial pressure ....lb.	98	98
Terminal pressure ...."	9	6
Ratio of Expansion	4 71	5·38
High-pressure M.E.P. ....lb.	51·	42·1
Low-pressure M E.P. ...."	19·1	12 9
Indicated horse power	106·94	80·89
Brake horse power	98·67	72 97
Loss by friction ....H.P.	8 27	7·92
Percentage of loss	7·73	9·79
Gross indicated water rate ....lb. per H P. per hour.	23·6	23·71
Gross brake water rate ....lb. per H P. per hour.	25·58	26·28
Spring ....lb.	40	40

REMARKS.	SIGNATURES OF TESTERS.
Indicated by ....Bole.	W. A. Bole.
Water weighed by ....Wilson.	Nilson C. Wilson.

The original indicator diagrams, taken during the test, are pasted on the opposite page, and the signatures of the men conducting the test are subscribed to each record. The manufacturer, therefore, becomes positively insured as to the duty which the engine which he is about to purchase will give, and takes no chance whatever. The thoroughness of this system will strike every careful investigator.—*Western Machinist.*

The Institution of Civil Engineers.—At the ordinary meeting, on Tuesday, the 3rd of December, Sir John Coode, K.C.M.G. (President), in the chair, it was announced that 18 *associate members* had been transferred to the class of *members*, while 53 candidates had been admitted as students. The first ballot of the session, 1889-90, resulted in the election of 10 members, 109 associated members, and 1 associate.

THE MANUFACTURE OF WROUGHT-IRON AND STEEL TUBES.

By J. E. Blandy, A.M.I.C.E.

(Concluded from page 844.)

Lap Welding.

The next process to be described is lap welding, by which pipes 2in. and upwards are most expeditiously made, and by which the weld is formed by rolling.

Under this heading it will be convenient to sub-divide the description of the treatment of tubes from say 2in. to 4in. or 5in. diameter to those of larger dimensions. For although in all cases the weld is made by the tube passing over a mandrel through rolls which press the metal on the mandrel, yet the smaller tubes are treated differently in forming their skelps, and are also all worked from the front of the furnace; but with larger tubes some assistance to the operation is given from the back of the furnace. Before the skelp is formed the strip is prepared by having each edge bevelled; the operation being performed by the strip being pulled by an endless chain through a headstock, on a frame with two cutting tools, one on either side. The strip is first just nicked at the corners to give it a lead, then brought by the tongs on to the mandrel before being drawn through the roll. These bevelled strips are then put into a heating furnace, from whence they are either formed into skelps by being drawn through dies of an American pattern, or, as is generally the case for tubes of larger diameter, by manipulation under a crocodile, which presses them into an appropriate shape.

With steel tubes, after the skelp has cooled, it is usual to assist the welding by painting the seam with a flux.

At a convenient distance from the mouth of the furnace strong cast-iron rolls are placed. Adjoining these a bench is erected about the height of the bed of the furnace, and set in the same longitudinal direction. This bench carries a trough in which to receive the tube as it passes out from the rolls. In the trough is laid the iron stem rod, which is usually a tube itself, on account of the great weight it would have if solid in necessarily long lengths. To the end of the stem rod is attached a mandrel or stamp, which mandrel is to be placed in the centre of the two rolls. When adjusted to the stem rod, which has lugs on it near the other end, and in this position between the rolls, the high pressure of the stem would bear against the back support of the bench.

If the tube sticks at all when entering the rolls, quick blows with a hammer are given at the end of the stem rod which projects beyond the trough, causing the pipe to move forward.

The man in charge of the operation guides the skelp just over the round part of the mandrel until the rolls grip the metal of the tube on the mandrel, when the tube passes forward its whole length through the rolls and over the stem rod into the trough.

The weld is made by the pressure of the rolls on the mandrel.

The mandrel is then detached from the stem rod, and usually falls down into a little recess just by the rolls; the rod is drawn out by being run over a little reel on the support at the end of the bench, the hot tube is set free, reversed, and placed again into the furnace to repeat the operation. In the case of the smaller sizes the tube is then let down on to the floor of the mill, dragged by tongs, and passed twice through rounding rolls, and after this process the tubes are passed on to straightening rolls. The rough ends are turned off in suitable lathes—tubes cut to lengths if necessary—and the cylindrical pipe is ready to be tested to the specified test pressure.

Tubes of the smaller sizes are well and quickly heated in a Siemens gas furnace, but larger tubes, say 6in. and upwards, are usually heated in an air furnace.

In making these larger tubes after the skelp is formed, the ends are tagged at a smith's fire. The skelps are placed in a furnace, where a welding heat is made to play upon the seam, the skelp being so placed in the furnace as to present the seam to the greatest heat. Again, it is usual to push up these large tubes from the back of the furnace until the rolls have gripped them. After the tube is welded, it is swung off the bench on to a carriage, and taken while hot to the straightening rolls, gradually cooling while the operation is being performed. After being proved to specified test, the tubes are passed on to be coated. Dr. Angus Smith's mixture is largely used for this purpose. Having now briefly described the general methods of tube making, in which Messrs. Jas. Russell and Sons, from their historic connection with the trade, the extent of their works, the excellence of their manufactures, and large variety of them, hold an eminent position, it may be interesting to note that other firms are developing processes which are well adapted for special classes of pipes.

For instance, in making large tubes for gas or water mains, Messrs. Thomas Piggott and Co. and Messrs. Lloyd aad Lloyd apply this heat by Mr. W. S. Sutherland's process. This consists of a nice admixture of gas and air, which is forced forward in pipes with a pressure of from 1in. to 2in. of mercury, and ignited so that a direct heat is obtained immediately over the part of the pipe to be welded. The seam to be welded is placed uppermost, the pipe is placed under the tuyere and a welding heat applied; it is then drawn back a little on rollers, and the heated part welded by a small drop hammer or steam hammer on suitably arranged anvils.

Weldless tubes, such as made by the Credenda Tube Company and the Weldless Tube Company, are rolled out of round steel ingots. These are first drilled through their centre cold. The hollow cylinders are then heated, and the tube expanded by driving a mandrel through it. The required size of hole having been obtained, the hollow cylinder is drawn out by a process of rolling with gradually reducing rollers, which extend the metal and bring it down to within say $\frac{1}{8}$th of an inch of its required diameter, after which it is drawn cold, similarly to copper tubes. Then, again, Messrs. Duncan Brothers, now connected with the Steel Pipe Company, build up mild steel pipes in lengths about 24ft. 6in., by riveting sheets from 6ft. to 8ft. together. When great care is exercised in the manufacture, and a well-arranged distribution of rivets has been given, these pipes will sustain a considerable water pressure, and are well adapted for water and gas mains in sites where cast iron would be too expensive to use on account of its much greater weight for equivalent strengths.

LINDNER STARTING VALVE FOR COMPOUND LOCOMOTIVES.

In the case of the compound locomotive it is necessary that steam should be admitted to the low-pressure cylinder in order that heavy trains may be started with facility, when the crank pins of the high-pressure cylinder are at or near a dead centre. One of the latest devices for the proper regulation of the admission of high-pressure steam to the low-pressure cylinder is illustrated herewith. It is in use on the Saxony state railroads in Germany, and has in operation given most excellent results. With equally good operation its simplicity recommends it. With the device illustrated herewith, the steam, by means of a small pipe leading directly from the high-pressure steam pipe, fresh boiler steam is admitted directly to the receiver, and from thence to the low-pressure cylinder through the valve A, as shown in fig. 1, in which B is the high-pressure cylinder, C the receiver, D the steam pipe to the high-pressure cylinder, E the short pipe making connection between the main steam pipe and the receiver. Fig. 2 is a plan of the same, showing the connection to the low-pressure cylinder. Fig. 3 is the longitudinal section of the admission valve, and fig. 4 is a cross section of the same. E in these figures is the steam entrance pipe, and G the discharging passage into the reservoir C. H and I are passages connected with each other and at right angles in the plug J, which is rotated by the arm K, connected with an extension on the reach rod, as clearly indicated. When the reverse lever is in full forward gear, the passage H is in connection with G and the receiver C, and when in full backward gear, the passage I forms the connection. This is accomplished by regulating the length of the crank K until it will move 90 degrees, when the link motion is reversed. This is the manner in which the fresh boiler steam enters the receiver, from whence it reaches both the high and low-pressure pistons. In order that the locomotive may be properly started, when both ports of the high-pressure cylinder are covered by the steam valve, it is best that the counteracting pressure on the high-pressure piston, brought about by the admission of steam to the receiver, be relieved at the time of starting. To accomplish this a very ingenious plan has been adopted in the construction of the high-pressure steam valve. Fig. 5 and fig. 6 show a section and plan of the steam valve in the high-pressure steam chest. In this valve are passages L and M. These passages connect the exhaust port of the high-pressure cylinder with the steam port of the same, as clearly shown on fig. 5, whenever one of the steam ports is closed. The width and location of the small ports L and M are such that when the edge of the valve touches the edge of the steam port, as at cut off, they commence to open, and when fully open the distance which the steam valve overlaps the edge of the port is just equal to their width. Thus whenever the steam valve covers a steam port the steam in the receiver can pass over through the small passages L and M, and through the steam port that is open with the receiver, and allow practically the same pressure to exist on both sides of the high-pressure piston. That is, these ports are so arranged that steam from the high-pressure steam chest cannot go over into the exhaust pipe, yet the steam which is let into the receiver through the pipe E, and which would otherwise act to prevent the starting of the engine by entering on the wrong side of the high-pressure piston, through the exhaust port N and steam port O, can thus reach both sides of that piston by reason of the proper arrangement of the passages L and M. In the illustration it is the passage L that is in the acting position, and is admitting steam from the receiver through the port P, resulting in the same pressure on both sides of the high-pressure piston, when, as in the position shown, the ports to the high-pressure cylinder from its steam chest are closed, this being the most difficult position in which to start a compound locomotive.

In starting the ordinary locomotive it is customary to throw the reverse lever full forward, and this is the position in which this starting gear is put into action, and through the small pipe E boiler steam is gradually, not suddenly, admitted into the low-pressure cylinder, and because of this slow admittance there is no danger of fracture of what, by reason of their size, needs to be lightly-built reciprocating parts, as a result of the sudden impact of heavy pressures. It will be readily understood that the most difficult position in which to start a compound locomotive, even when provision is made for the entrance of high-pressure steam into the low-pressure cylinder, exists when the steam valve covers the ports into the high-pressure cylinder. It is at this time that this starting gear becomes most useful, as hereinbefore stated, by balancing the pressure on both sides of the high-pressure piston, and admitting fresh boiler steam to the low-pressure piston. As soon as the locomotive starts, and the high-pressure cylinder exhausts, it will commence to work compound regardless of the fact that the admission valve may continue to admit high-pressure steam into the receiver. This continued admission is in nowise detrimental, occasioning only a very small loss, if any. As soon as the locomotive is hooked up ever so little, and the cut-off thereby decreased to a very small extent, the admission valve is closed by reason of the closing of the ports H or I, as the case may be. Such construction as this recommends itself because of the simplicity of all the connections, the accessibility of the parts, and the ease of placing the device. No additional handles are required in the cab, and, while it is automatic, it yet has no complication of parts to require frequent repairs. In the case of the reversal of the engine while going ahead, steam is immediately admitted to the receiver, and therefrom enters the high-pressure cylinder, and acts as a lubricant, and also as a brake upon the engine by reason of its action on the piston of the low-pressure cylinder. The receiver has a safety valve which does not allow the pressure to rise above one-half of that of the boiler. The small steam channels in the high-pressure steam valve shown at L and M, fig. 5, are so minute as in nowise to affect the appearance of the indicator card except at the slowest speed, and consequently they are practically ineffectual after the locomotive has commenced to work compound. The effect of the action of these ports is further decreased by their location, which is such that at the time when they act the valve is moving with the greatest rapidity, thus reducing the time of their action.

Fig. 1 shows the position, by dotted lines and full lines, of the crank positions at which the small auxiliary passages L and M are efficacious in assisting the driving of the engine. These points lie not far from 50 degrees distant from dead point. An interesting advantageous feature of the operation of this mechanism results from a peculiar action of link gears in full throw. A slight change in the position of the reverse lever, and consequently the reverse shaft, when the links are about in full gear, produces little or no change in the cut-off, yet such a slight change is more than sufficient to close the entrance ports through the admission valve A. In cases actually tried the admission valve was arranged to be fully opened when the cut-off was 80 per cent, and it was found to be fully closed when the cut-off had been reduced to 75 per cent.—*The Railroad Gazette,*

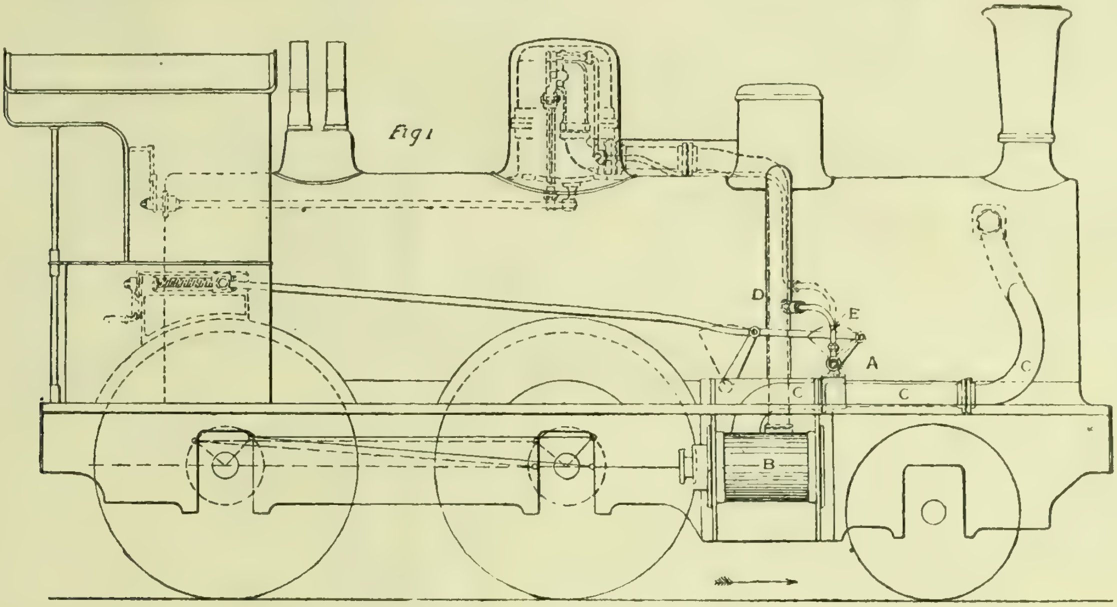


Fig 1

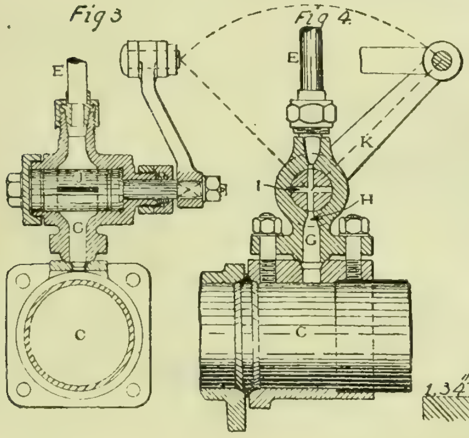


Fig 3
Fig 4

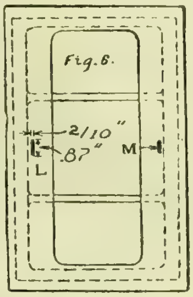


Fig. 6.

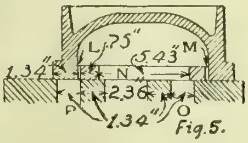


Fig. 5.

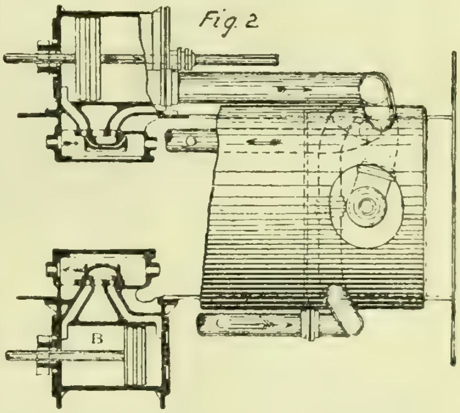


Fig. 2

BOILER FITTINGS.

MANUFACTURED BY MR. BALDWIN, KEIGHLEY.

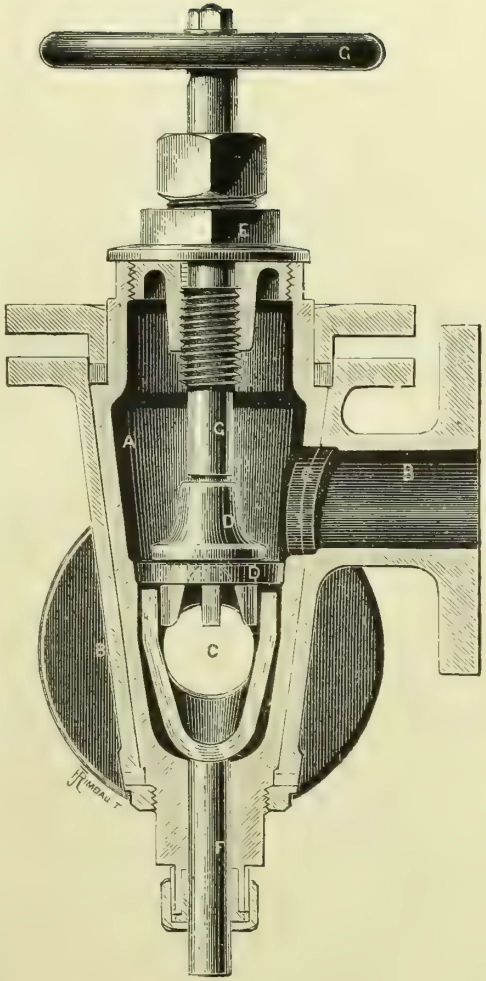


FIG. 1

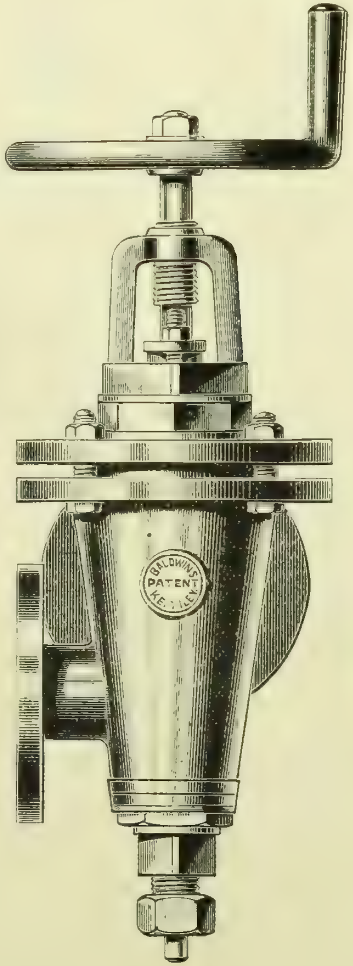


FIG. 2.

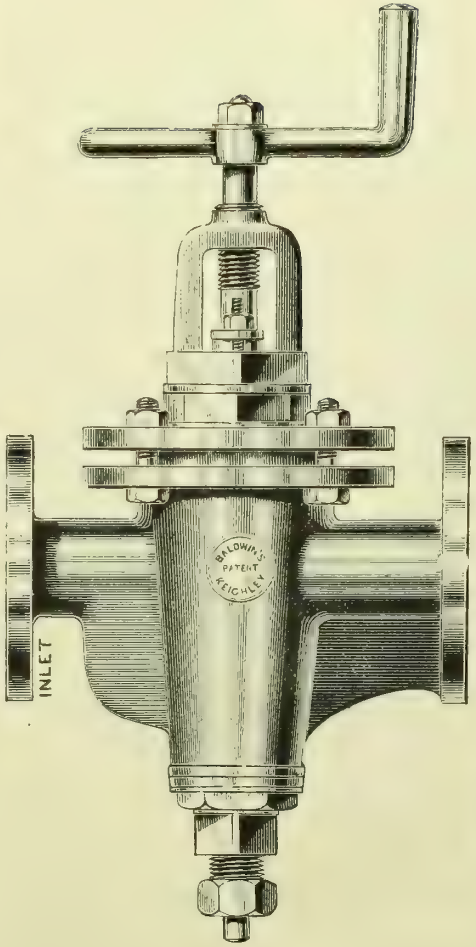


FIG. 3.

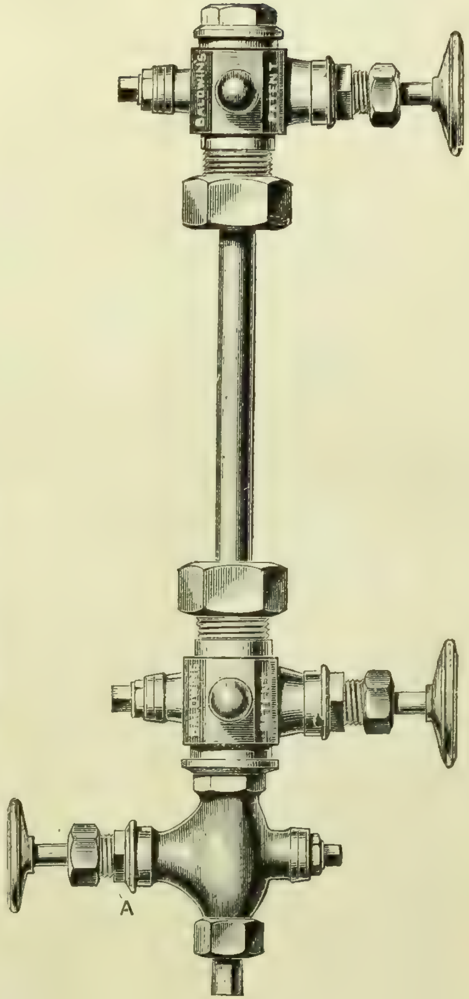
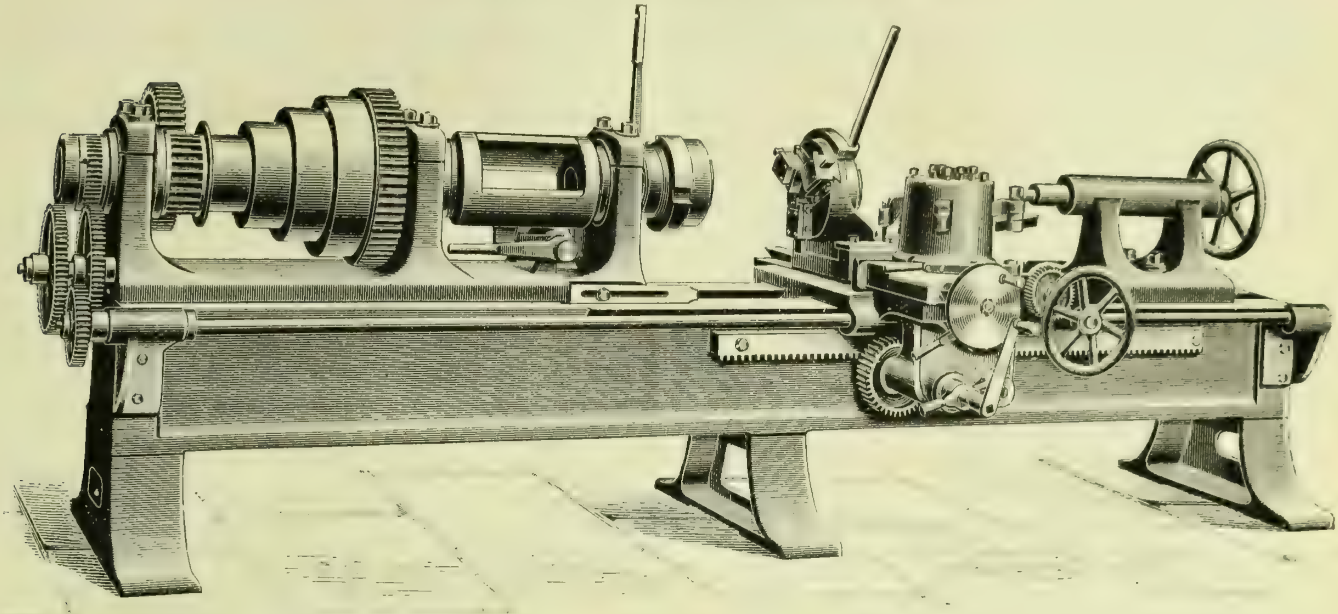


FIG. 4.

OPEN HOLLOW SPINDLE CAPSTAN REST LATHE.

CONSTRUCTED BY MESSRS. JAMES SPENCER AND SONS, HOLLINWOOD.


PRACTICAL ENGINEER.

THE lathe which we illustrate above, has been specially designed to meet the wants of engineers and machinists for finishing various kinds of single and double ended studs, joint pins, screws, and bolts, from the straight bar, to save the expense of forging and cutting off by the smith, and centreing; also to prevent the loss of time in changing and re-setting tools necessary to produce a stud in the old way. With a lathe of this type double-ended studs can be turned, pointed, and chased at one end and with one setting. The chasing and pointing of the other end requires another setting. The latter consists of a pair of 12½in. centre double-geared fast and loose headstocks, on a straight bed 12ft. long, supported on three standards, with a bottom cast in to form a trough. The fast headstock spindle is of forged steel of extra large diameter, with parallel necks, running in gun-metal bearings, and has a hole right through it, to admit bars up to 4in. diameter. A cone chuck is carried in the spindle nose, to grip the bars quite true, ready to be turned. The carriage has a self-acting traverse from the shaft along the front of the bed, and a quick hand traverse by rack and pinion. The transverse slide of carriage is fitted with a revolving capstan rest, to hold five tools of various shapes, to suit the work required to be done; also a screwing apparatus with three concentric dies or chasers, drawn to or from the centre simultaneously by a lever.

The screwing head is worked by the same lever as the capstan rest, with a fixed stop to bring it against, so as to be in an exactly central position for screwing. When not in use, it can be run over to the back of the slide, and disengaged from the screw by a lever in front of the carriage. It has also a graduated index and movable stop, so that it can be set for any number of screws to be made exactly the same diameter. An adjustable stop is also provided on the bed, for regulating the thickness of both heads, nuts, collars, &c., and a bolt for locking the carriage to the bed in any position when surfacing. With the loose headstocks and an ordinary Clements driver, the lathe can be used as an ordinary slide lathe for turning and chasing between the centres.

The lathe is very strong throughout, and is adapted for turning bars from 2¼in. to 4in. diameter, and for screwing from 1¼in. to 2½in. diameter screws, with the ordinary Whitworth threads.

The machine described is one recently made for Mr. Benj. Goodfellow, engineer, of Hyde, and a similar one has been supplied to Messrs. Buckley and Taylor, engineers, Oldham.

SHIPBUILDING CONTRACT.—Messrs. Fleming and Ferguson, engineers and shipbuilders, Paisley, have received an order from Mr. J. R. Wood, New South Wales, to build for him a steel steam yacht, of about 450 tons, yacht measurement. She is to be fitted by the builders with a set of their patent quadruple expansion-engines, to indicate about 1,000 horse power such as those recently described in our columns.

BALDWIN'S IMPROVED BOILER FITTINGS.

WE illustrate upon the opposite page some improved boiler fittings which have been introduced by Mr. Baldwin, and which, of course, are of great interest to all steam users and boiler-makers generally. Fig. 1 is a sectional elevation of a check and feed valve for stationary boilers. The valve has an outer casing or shell B, with an internal conical plug A, the end of which plug is screwed to receive a collar nut and washer for securing it in position; the inlet and outlet are provided for as indicated at C C. When the plug A is turned half-way round, the communication between the boiler and the pump is shut off, and the valve proper D can be removed for repairs or examination without stopping the boiler. To remove the valve D the cover E is unscrewed, which carries with it the spindle G. The valve seat D is removed by striking the projecting lower spindle F. Fig. 2 is an elevation of another type of this valve, but with the thread upon the spindle outside. Fig. 3 is a marine-type valve, arranged for convenience of a straight-line passage through. The water gauge, shown at fig. 4, has the steam-water and blow-through valves made with an internal plug, as in fig. 1, so that those valves can be examined and cleaned without difficulty.

HEAT ENGINES OTHER THAN STEAM.—III.

(Continued from page 848.)

IT seems to me that some such form of compound gas engine as this is the one which will, in the near future, increase the efficiency of the present "simple gas engine," in a manner somewhat similar to that in which the efficiency of the "simple steam engine" was increased by development of the "compound steam engine."

You will realise that there is, incidentally, an advantage with such an engine as this, for in it the regularity of turning effort on the crank shaft approximates to that which we found to exist in double-cylinder steam engines.

No record of the gas engine would be complete unless mention were made of the late Sir William Siemens. The patents taken out by him in connection with the gas engine—the "internally-fired" engine, as I have called it—form of themselves a most complete and compendious record or statement of the progress and development of the theory and practice of gas-engine construction.

Most of you know it was due to his genius and perseverance that the regenerator suggested by Stirling has been developed, and has been utilised to such a great extent in the arts and manufactures. In fact, among engineers the name of Siemens is almost invariably associated with the thought of the "regenerator."

The application of this apparatus to the gas engine has been the subject of many patents, and has commanded the attention and thought of many minds, the idea being to allow the heat of the exhaust, as it leaves the engine, to be absorbed, or "picked up," by the regenerator, this heat being once more given up to the fresh incoming gaseous charge, thus allowing some of the heat to again pass into the engine, and to some extent preventing the enormous loss due to the heat passing away in the exhaust.

I will only trouble you with diagrams illustrating one of Sir William Siemens' later ideas for the utilisation of this waste heat in gas engines by means of a regenerator. Diagrams Nos. 22 and 23 are taken from his patent drawing of 1881, No. 2,504, which was for "Improvements in Gas Motors and Producers."

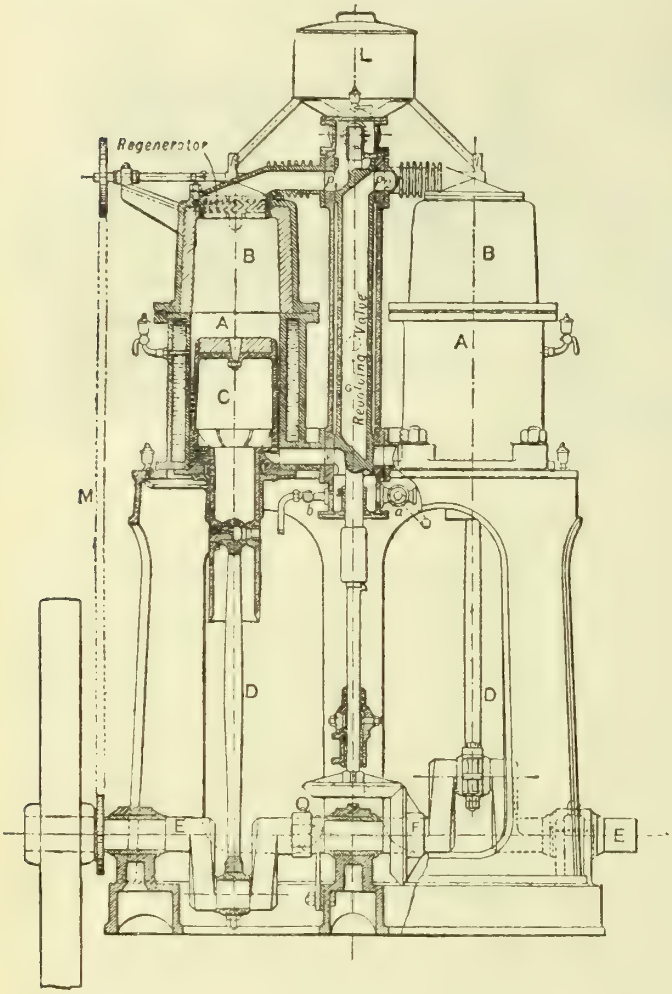


FIG. 22.

He states in his patent that the object of his improvements was, "To simplify the construction and operation of the apparatus, and to utilise more fully the heat developed by the combustion of the fuel employed."

You will see, according to the two views, that this was a vertical engine, having two cylinders, AB, AB, the lower part of each cylinder being cooled by water circulating through the water jacket surrounding it, the upper part, in which combustion took place, being lined with some material refractory to heat, such as fire-clay. There are two cylinders, each having a piston and connecting rod, these being attached to cranks at opposite angles on the crank shaft. Between the two cylinders there is a revolving cylindrical valve, driven from the crank shaft by means of bevel gear.

The valve as it revolves admits the explosive mixture, and allows of the exhaust of the products of combustion from both cylinders. You will see that the pistons are deep, and that the bearing portion of them is on the metal at the lower portions of the cylinders where they are water-jacketed.

The explosive mixture is drawn in at the bottom of the cylinders, and below the pistons, as they move upwards, and is compressed by them as they come downwards, being delivered into the vertical reservoir R, at the back of the engine. From this reservoir the explosive mixture is allowed to pass by the revolving valve into the top end of each cylinder alternately, through the various thicknesses of wire gauze which form the regenerator, and which block the top ends of each cylinder.

The mixture when admitted to the top ends of the cylinders, being already compressed, as it is, is fired, and the idea was that the flame of combustion would not be communicated through the wire gauze of the regenerator to the explosive mixture under pressure in the reservoir.

In this engine the non-absorbent refractory material lining the upper portions of the cylinders should not absorb the heat produced by the explosions, and, if combustion was not communicated through the wire gauze regenerator to the mixture under pressure in the reservoir, then a most satisfactory ignition should take place in the cylinder.

You will see that in this engine Sir William Siemens proposed to utilise the principle embodied in the "Davy" lamp, and thereby to be enabled to burn in the working cylinders an explosive mixture, without the explosion being communicated to the mixture which was under compression in the reservoir.

The ignition in this engine was performed by means of an electric spark from a dynamo, the armature of which was secured to the crank shaft of the engine itself. Whether an engine in exact accordance with the design in this patent was ever made, and whether, if it was made, it worked satisfactorily, or was capable of being made to work satisfactorily or not, I cannot say. It seems to me, however, it illustrates that which was in the mind of Sir William Siemens as late as the year 1881; after he had been designing, patenting, and experimenting with heat engines for many years, and when, therefore, remembering, as we must, his great and profound knowledge of the science of heat, and the vast experience which the large amount of practical work he had done must have given him, his mind must have been ripe and ready to produce an engine which should contain within it the germs of successful and of economical working.

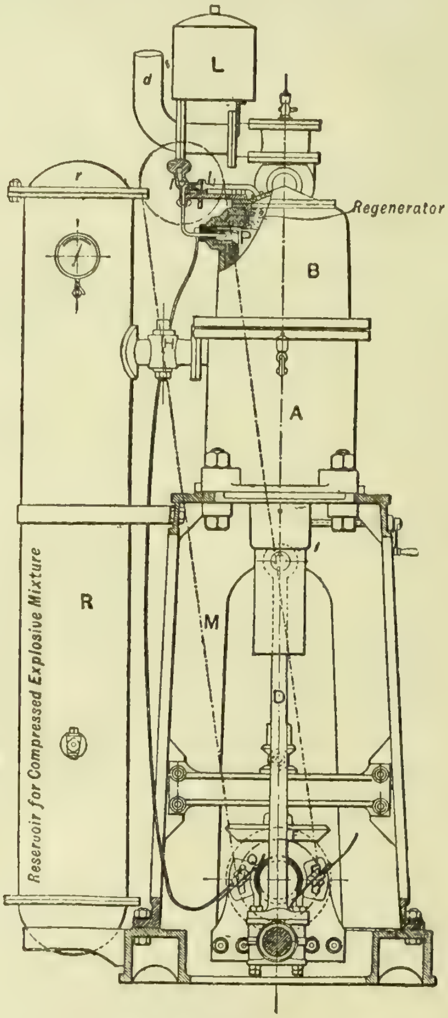


FIG. 23.

Further, some of the improvements shadowed forth in this patent of Sir William Siemens are improvements which there is no doubt will, one day, be successfully utilised in practical work.

I have invariably, in speaking of the efficiency of the gas engine, as compared with that of the steam engine, used this same black cube to represent the fuel put into the boiler in the case of the steam engine, and also to represent the heat units supplied to the gas engine; and I have from this deduced the relative efficiencies of 11 per cent of the steam engine, and of 22 per cent of the gas engine, shown you by the red cubes.

I am now going to suggest that I have again treated the steam engine unfairly in making this comparison between the two forms of engine. I do not think that it is at all fair that the amount of heat put into the coal when it is in the gas retort, in order that the gas may be distilled from it, should be neglected.

The heat of this coke—the coke burnt under the gas retort—is really the latent heat of gasification of the solid coal, and is of as much effect in enabling us to obtain our gas-engine efficiency as is the equivalent portion of the heat of the solid fuel put into the boiler furnace to vaporise the water. We should remember this when dealing with a gas from which we afterwards produce motive power in our gas-engine cylinders.

I will not attempt to put this into figures, but will ask you to bear it in mind when you feel inclined to condemn that good old servant—the steam engine. But economy in the gas engine can be obtained by the use in that engine of some other form of gas than the ordinary lighting coal gas supplied by the gas companies. I do not mean economy in the sense of a lessening of the quantity consumed, but only economy in the cost of the working agent for each indicated horse power.

(To be continued.)

ANCIENT AND MODERN PUMPING MACHINERY.*

By G. C. Marks, A.M.I.C.E., M.I.M.E.

There is probably no more interesting subject which an engineer can select upon which to address an audience of engineers than that connected with the means and methods adopted for supplying to mankind the indispensable commodity of water. The whole of our relations in private and business life, are immediately concerned with an uninterrupted and reliable supply of water, either as a domestic agent for drinking purposes, or for the more commercial needs of the community when used for producing steam, and thus giving to the world mechanical power.

It would be somewhat of an affront were I to ask you to accompany me into an examination of the purely historical questions relative to the ways and means employed in ages long since past for raising and distributing water, seeing that, however interesting such a research might be, it would scarcely conduce much to our benefit to follow all the crude devices and somewhat amusing instruments then employed. Suffice it for us to admit that in no branch of engineering can so early a claim, and so extensive use and universal application, be established by such complete records as in this particular direction of water supply. Great as were the efforts of the early and ancient hydraulic engineers to provide reservoirs, aqueducts, and conduits, which are monuments of their constructive skill and ability, it remained for the introduction of steam to vastly extend the sphere of their usefulness, and to wonderfully enlarge the magnitude of their commendable undertakings.

I shall therefore, with your permission, to-night endeavour to trace the subject of my text in the events which have led up by the agency of steam power alone to the present great position that the pumping engine now occupies. It thus becomes necessary to dismiss all kinds of appliances, useful in their limited application, whereby water is raised by hand or by purely mechanical means, and to confine our attention to steam pumping engines and steam pumps alone.

The earliest attempts at producing an aid to power by means of the agency of steam were directed towards some device whereby water could be raised without the expenditure of actual manual effort, and whereby the tardy and difficult labour of hand-pumping should be obviated and ultimately displaced. The first actual effort in this direction of the application of steam to raise water, apart from experimental and introductory efforts, was that of Porta, of 1606, (1) where a boiler was mounted over a fire, and the steam escaping from this boiler ascended in a pipe and then pressed down upon the surface of the water in another vessel, thus forcing the water to issue out of another tube or pipe dipping into it. Another application was made by Papin, 1704, (2) who employed a boiler of globular form, having its steam conducted away from the upper surface by means of a pipe leading it into another vessel, which we may term the steam cylinder and pump combined. We notice that upon the surface of the water a metallic disc floated, so that in effect we have the first application of a piston-moved column of water. The steam itself did not directly come in contact with the whole surface of the water column, but acted upon the floating piston instead, and an air vessel was also provided.

(3) Worcester's engine, of 1656, was a double-acting steam-pumping contrivance, where one boiler served to supply steam alternately to two cylindrical vessels immersed in a tank, these vessels communicating with one rising pipe, so that water could be urged from either of the vessels to the pipe by means of the valves. The steam in this case pressed directly upon the surface of the water, and forced it out through one valve, and at the same time closed the inlet valve which allowed the water to flow from the tank or cistern into the vessel.

(4) Savery constructed an engine, 1702-1704, wherein he introduced the principle of applied condensation; that is to say, arrangements were provided for cooling the outer surfaces of the steam vessels. These vessels were pear-shaped, and served the triple functions of steam cylinder, pump chamber, and condenser. The two vessels permitted, by alternate condensation, of a fairly continuous flow, for as the one served to draw in the water ready for the next inrush of steam, the other at the same time had received the steam within it, so that the water was being forced out. Perhaps we may see a prototype here of the present modern Pulsometer.

(5) Newcomen's pumping engine, of 1705, was a natural advance upon all that had preceded it, from the fact that he utilised old principles that had been demonstrated by Huyghens, Papin, and Savery, and combined these known principles in a novel manner in one machine or pumping engine. The combination was made more valuable for mine pumping than any of the predecessors' works by the addition of an overhead beam, from which the steam piston was suspended at one end, and the water pump rod at the other. By the combination of Newcomen it became possible to proportion the area of the steam piston to suit the requirements upon the pump rod necessary for any particular height of lift to which the water was to be delivered. A small pump of this make is recorded as being 8in. in diameter with a lift of 162ft. The weight of the column of water to be raised was 3,535lb. To accomplish this a steam piston, 2ft in diameter, having an area of 452 square inches, was employed. The net working pressure was assumed at 10¾lb. per square inch, giving a total pressure of 4,859lb. upon the piston, as against a load of 3,535lb. on the pump. One half of the excess or difference between the two pressures was counteracted by the weight of pump rods and beam weights, leaving, therefore, a surplus of 662lb. to produce the requisite speed of the engine. Fifteen strokes per minute were made, giving a speed of piston of 75ft. per minute, and the power exerted usefully was almost exactly 8 H.P.

Smeaton considerably improved the Newcomen engine by correctly proportioning the parts, arranging the valves to be controlled mechanically, instead of by hand, and, by improvements in the arrangements of the flues and the construction of the boiler, obtained a far higher duty from the engine than had been possible before.

Smeaton's improvements, when compared with those made subsequently by James Watt, sink into insignificance, yet he introduced correct ideas and true reason into every part of the engine and boiler. He converted the boiler from being an exaggerated model of an old retort or alchemist's furnace into a new heat-saving construction, which bore no resemblance whatever to those previously in use. He also introduced that which remains until to-day as the standard and most simple regulator of speed and preventer of shock, viz., the water cataract.

Smeaton reduced the power of the engine to a measurable and determinable standard. The number by which he denoted the power of the engine was obtained by multiplying together the number of feet through which the piston travelled per minute by the square of the diameter in inches, and the number of feet of water to which the pressure driving the piston was equivalent. Thus, if the condensation was such as to reduce the steam under the piston to 180 deg. temperature, or half the atmospheric pressure, which he found was about the best degree, the pressure acting to depress it was half an atmosphere, or equivalent to about 17ft. of water. Then, if the speed was 80ft. per minute, while the diameter of the piston was 20in., or 400 circular inches area, he called the power of that engine $17 \times 80 \times 400 = 544{,}000$. This implied that the maximum amount of work that could be obtained, disregarding friction, would have been to lift a column of water, 20in. diameter and 17ft. long, to a vertical height of 80ft. in one minute, or a column of water 1in. in diameter and 1ft. long to a vertical height of 544,000ft. per minute.

The engine of Newcomen in model form aroused the ingenuity of the immortal James Watt, who developed it into a far more perfect machine, and subsequently, by the indomitable energy and business assiduity of his co-partner, Matthew Boulton, converted that which had been but a poorly appreciated branch of industry to the very first and foremost rank of mechanical science, which was to become the indispensable agent wherever power was to be obtained. The general principle of most of the early engines about 1770 for pumping purposes was to employ steam only upon one side of the piston, and to allow the up or return stroke of the piston to be made by placing each side of the piston in communication, one with the other, for the purpose of obtaining equilibrium, and then allowing the excess weight of the pump, rods, beam, &c., to overbalance the piston, and thus to draw it to the top of the cylinder. This type of engine is still extensively used, and is designated the Cornish pumping engine.

(To be continued.)

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* Lecture delivered before the Sheffield Society of Engineers.

THE COMPARATIVE MERITS OF MAIN DRIVING BY SPUR OR BEVEL GEARING BELTS AND ROPES.

(*Continued from page 834.*)

Some of the principal points to be noticed in this mode of transmission are the following : The ropes should not be too large in diameter ; it was much safer to use 25 $1\frac{3}{4}$in. diameter ropes than 20 2in. diameter ropes. The tension in the several ropes should be kept as low as possible. The power should be subdivided to different points. The centres of the several shafts should be kept well apart. The pulleys should be large in diameter. The best speed for the ropes was from 4,000ft. to 6,000ft. per minute. Care should be taken in turning the V groove pulleys ; the best angle for these is now found to be 45 degrees. The first cost of ropes was no doubt less than for leather belting. The cost of the maintenance of ropes per 100 indicated horse power might be taken at £10 per annum, though some authorities give more than this sum, and some much less.

Rope gearing was, of course, perfectly noiseless and steady. The co-efficient of a rope in a V groove was higher than for a plain belt on a smooth surface; this varied from ·5 to ·8 according to different authorities, and was rather a variable quantity. He ought to say, in conclusion of this rather discursive address, that this form of transmitting power for considerable distances and to different points solved many a difficulty for the engineer, and placed in his hand a means of transmitting power which those who had gone before never knew.

Mr. G. Goodfellow said they were all much indebted to Mr. Rea for speaking upon the different systems of transmitting power. As the president had kindly remarked, he (Mr. Goodfellow) had had some experience in rope driving, and he certainly believed in its adoption. At the same time he was not prejudiced so far in favour of it as to say that it was the only system of driving which was successful, but, on the contrary, he was of opinion that under certain circumstances spur gearing would hold its own. He did not know, however, of any wheels working at the speed which was mentioned by Mr. Rea, and certainly as a millwright he should be much afraid of recommending anyone to work wheels at so great a speed, whether made of iron or steel. Under circumstances where such a speed of periphery was required he should have recommended ropes. Rope driving, it appeared to him, was very often brought into practice to get over millwrights' bad work, and he thought it was up to the present the most successful way of doing so. The old rules for working out the strength of wheels were for them to increase in strength according to increase of speed, but from his own experience he found that after a certain speed the wheel became weaker. The teeth of wheels had broken in many cases through what might be termed the force of impact with which the teeth came together. He quite concurred with Mr. Rea that the method of keying up the wheel by wood and iron wedges was the best of the two methods shown, on account of its being able to compensate for the more severe shocks. This he had personally proved at a mill where there was considerable trouble with the wheels ; he tried them first with indiarubber wedged in, then iron keys, and eventually the old-fashioned plan of keying them up with timber, and the wheels had worked successfully ever since. That admission might seem out of date ; still he had come to the conclusion that it was the best way simply because it had proved most satisfactory. Mr. Rea had alluded to the working on fixed centres, and of course that was a difficulty millwrights had to contend with when repairing or interfering with work already in existence, but with moulding machines and a little careful calculation, wheels could be made with teeth of a broken pitch so as to go exactly into the centres required, and thus get over that difficulty with a reasonable amount of care. Regarding bearing surface of the teeth of wheels, he agreed with Mr. Rea that there should not be too much bearing on the face of them, and that they should never be allowed to wear out the points of teeth. Referring to the remarks about helical teeth, and the necessity for allowing for the movements in the crank shaft of the engine, he said that this action was certainly more perceptible with helical teeth than with the ordinary straight tooth, and the best way to gear was to have the centres between the shafts in the same line as the pull and thrust of the engine. If that were not done, the wheels were sure to work cross gear on account of the movement of the main shaft. A horizontal engine should have two main shafts on a horizontal line, and a vertical engine on a vertical line. Still there were objections to putting wheels either directly above or below one another on account of the wearing of the bearings, but considering the stresses on the teeth alone it was certainly the correct position, because it only produced the sliding motion on the face of the tooth, instead of it impinging on different ends at different parts of a revolution. Referring to rope driving, Mr. Goodfellow observed that undoubtedly it was the most suitable method of transmitting power for most textile manufacturers. In cases of slow speeds he should adopt toothed gearing, and in great speeds he should invariably use ropes. A great deal was said about the friction of rope gearing over and above wheel gearing, but that could be considerably minimised by thinking the work well out before it was commenced, and further by having the pulleys carefully turned, the ropes as near one size as possible, and the shafts well carried in efficient bearings. He first adopted ropes of 2in. diameter in 1874, and those worked successfully ; they had gradually come down to $1\frac{3}{4}$in., and in some cases to $1\frac{1}{2}$ in. His firm had one job working with $1\frac{1}{4}$in. ropes, and they seem to work more satisfactorily than the heavier ropes, and he thought that it was reasonable that such should be the case, since they did not stretch so much consequent on having less weight between the centres. In cotton mills there was often a great length of rope between one pulley and another, and a considerable weight was thereby hanging in the case of large ropes between the two pulleys ; by having lighter ropes there was less weight in motion, and, further, less power was required to bend the ropes round the pulley. That all meant a gain in power by having less loss in what is called friction, also again in the life of the rope, because the more power it took to bend the rope and the greater the wear in the centres of it. He had ropes now working to perfect satisfaction that had been run in Manchester, roughly speaking, for the last ten years, and he had no hesitation in saying that for high speeds there was no class of driving which would equal it. Let them imagine some of their mills, say with 80,000 spindles and preparation machinery in four storeys ; that meant, say 1,200 horse power, roughly speaking. In an ordinary Oldham spinning mill, divided into four storeys, the cardroom would perhaps take a third of that, namely, 400 H.P., leaving 800 H.P. to be divided into three rooms. There would be one shaft in each of those rooms, running at from 250 to 300 revolutions per minute. Under these circumstances he should like any gentleman to imagine the wheel which would work successfully at such a speed and turn such a load. It amounted to this, that they must have a very small wheel to keep the speed of the periphery down, or a large wheel which would break in consequence of its own speed. With reference to the length of the bearings, Mr. Rea recommended them to be three to four times the diameter of the shaft, but he might say that he never made them more than twice the diameter, as he found that with long bearings, unless they had a very strong shaft, it was liable to bend in the centre where the pulley came, and so cause the shaft to cross bind in the bearings. If the shaft was made sufficiently strong to overcome any bending propensity, then a shorter bearing equal to twice the shaft diameter was sufficient, and in his experience he had never had occasion to make bearings longer than double the diameter. In conclusion, Mr. Goodfellow said that one or two points yet remain to be decided regarding rope driving, especially the angle of the groove, and the most advantageous size and speed of ropes.

The discussion was then adjourned to the 23rd inst.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

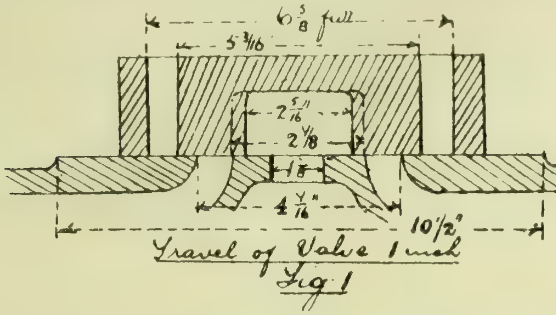
INDICATOR DIAGRAM PRACTICE.

To the Editor of "The Practical Engineer."

Sir,—Your correspondent, "Cast Iron," was not far off the mark when he suggested that the malformation of the diagrams referred to in my letter of October 11th, and illustrated in *The Practical Engineer* of that date, would probably be found to be due to the exhaust port of the small engine not being opened sufficiently and being closed far too soon, and that there was excessive lap on the exhaust edges of the valve. I am now in a position to give full particulars of the valve and ports, and I also send you diagrams taken after alteration of the valve, by cutting off the exhaust lap.

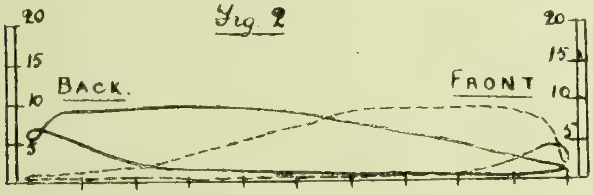
It will be observed from the figured dimensions that the measurement of the valve across the steam edges is $5\frac{3}{16}$in., and the distance between the outer edges of the steam ports is $4\frac{7}{16}$in., so that the lap on each side is $\frac{3}{8}$ths of an inch. The width across the inner edges of the steam ports being $2\frac{7}{8}$in., and the exhaust cavity of the valve only $2\frac{5}{16}$in. wide, there is thus $\frac{9}{32}$in. lap on the exhaust side of the valve. The full traverse of the valve being only 1in.—that is, $\frac{1}{2}$in. on each side of its middle position—the steam port will be open $\frac{1}{8}$in. only, and the exhaust port $\frac{7}{32}$in., or less than a quarter of an inch at its widest opening, and the latter port will be closed again immediately after half stroke of piston, which accounts for the excessive compression shown on the diagrams.

As previously stated, the engine could not have worked at all under these conditions had it had anything but a very light load to drive. The engine was developing 72 I.H.P., but is large enough to drive three times that load under proper conditions—such as laid down by "Cast Iron." The valve was taken out and the lap on the exhaust side cut off, thus enlarging the exhaust cavity from 2$\frac{5}{16}$in. to 2⅞in., as shown by dotted lines on fig. 1.



The result of this alteration is shown in the diagrams fig. 2, which are taken to the same scale as the previous diagrams, for the sake of comparison. Instead of a pressure in the cylinder of 86lb., as shown in the previous diagrams, owing to compression, with an available boiler pressure of 70lb., the highest pressure shown in the diagrams after alteration of the valve was not more than 9½lb.

The cut-off plates have been dispensed with, and when the eccentric has been moved so as to give a little earlier admission of steam, the diagrams will probably be as good as can be expected where the engine is so badly proportioned for the very small amount of work it has to do.



"Cast Iron" will see that it would be difficult to put lap on the steam edge of the main valve, as this would block up the port in the main valve leading from the cut-off valve. The load is so ill-apportioned to the size of the engine that it would not be possible to produce a diagram such as "Cast Iron" has sketched without increasing the load on the engine, which is not, under present circumstances, practicable.

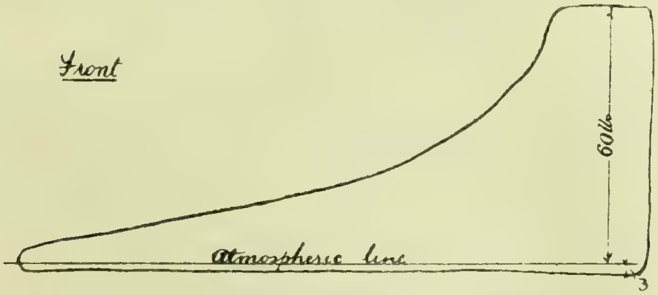
It may be added that such a difference in the running of the engine was made by simply cutting off the exhaust lap, that some workmen near by, who were in the habit of starting work on hearing the noise made by the exhaust when this engine started, wasted nearly half an hour after the usual time on the morning after the alteration, as they could not hear that the engine had started work.—Yours, &c.,

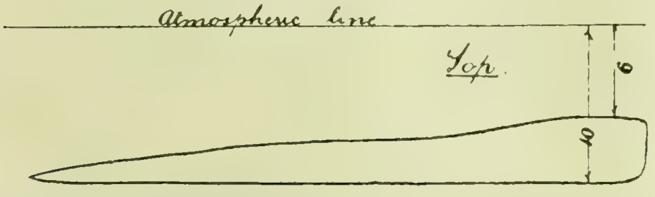
Wrought Iron.

EQUALISING POWER IN COMPOUND CYLINDERS.

To the Editor of "The Practical Engineer."

Sir,—In your issue of Nov. 29, 1889, replying to questions on the power of compound engines, your correspondent "I. H. P." says that it is a comparatively easy matter to so set the valves as to equalise the power in the two cylinders. I herewith enclose two indicator cards taken from a pair of compound engines in my charge. The high-pressure engine is horizontal, with a cylinder 18in. diameter by 4ft. stroke, fitted with *automatic* cut-off gear regulated by a "Porter" governor. The low-pressure engine is a beam with a cylinder 30in. diameter by 5ft. stroke, and fitted with a simple slide valve. As the valves are at present arranged, the high-pressure engine is turning 108 horse power, whilst the low-pressure is only turning 36 horse power.





Will "I. H. P.," or any other of your talented correspondents, kindly inform me as to the best method of equalising the load on these two pistons?—Yours, &c.,

Compound.

QUERIES AND REPLIES.

141. Power of Hoisting Block.—It is found by trial that when P is on the point of lifting W by means of a single fixed pulley, $P = (1 + m)\ W$, where m is a fraction depending on the friction of the parts of the machine. If three such pulleys are combined into a "block and tackle," find the power requisite to raise a given weight by means of it.—Student.

Answer.—If the three pulleys are so arranged that one of them is fixed and two movable, then, neglecting friction, the power is a fourth of the weight, or, $\frac{W}{4}$ = strain on every part of the rope when the weight is hanging at rest. When the weight is being raised, the weight on the fixed end of the rope remains unaltered, but on the second single of the rope, after the latter has passed round one movable pulley, the strain by the formula given is $(1 + m)\frac{W}{4}$. This, which is the power when referred to the first single, is the weight when referred to the third. Therefore the strain on the third single

$$= P = (1 + m)(1 + m)\frac{W}{4} = (1 + m)^2\frac{W}{4}.$$

Again, in reference to the fourth and last single, this power, or P, becomes the weight, or W; and the final pull, or P, on the free end of the rope is, by the same rule, $(1 + m)^3\frac{W}{4}$.—C.

143. Consumption of Fuel.—Will any reader kindly supply me with the following information, taken from the most modern practice of our principal engine builders? 1. What is the consumption of coal per I.H.P. for (*a*) ordinary high-pressure steam engines working expansively; (*b*) ditto condensing; (*c*) ditto compound non-condensing; (*d*) ditto compound condensing; (*e*) ditto triple-expansion non-condensing; (*f*) ditto triple-expansion condensing. 2. What difference does steam jacketing make in coal consumption? 3. Is there any material difference in the consumption of coal per I.H.P. shown by engine, in multitubular, Lancashire, and Cornish boilers? Any information relative to the above, also *re* consumption of coal per I.H.P. for direct-acting steam pumps, such as Worthington type, will be esteemed by—F. J.

Answer.—Reliable information upon the coal consumption of engines is difficult to obtain. The following, however, may be taken as good average working, and, where possible, results of actual tests are given, although it is needless to remark, such results are rarely reached under ordinary working conditions. (1) In engines of class *a* the consumption per I.H.P. ranges from 2½lb. to 3½lb., according to the boiler pressure, while in the R.A.S. tests in 1887, the mean of the three best engines under trial gave the low figure of 2·15lb. In class *b* the average is from 2½lb. to 3lb., but have been unable to lay hands on any trial data. In class *c*, 2¼lb. to 3lb. is about the average, though, under exceptional conditions, much better results are obtained, such as 1·8lb. at the R.A.S. trials already referred to. In class *d*, 2lb. is about the average, though Mr. Marshall, in 1881, gave 1·82lb. as the mean of about 30 engines (marine), and Mr. Hall, in 1887, gives 1·95lb. as a mean of several engines (marine) over lengthy periods. Engines of type *e* are few in number, so cannot quote from experience, but should place them at about 1¾lb. Of class *f*, 1½lb. is an ordinary average, this been borne out by Mr. Hall, who gives 1·51lb. as the mean of a number of engines. The writer has heard of the consumption being as low as 1·3lb., but such low figures are generally under special conditions. (2) Respecting the influence of jacketing upon the efficiency, and, consequently, the consumption, there is great diversity of opinion among leading engineers, but from a table in Major English's recent paper, the mean efficiency of ten trials unjacketed over eight jacketed trials is 8 per cent in favour of the latter. (3) From the account of the Wigan evaporative tests of marine (tubular) and Lancashire boilers, the former evaporated 14 per cent and 7 per cent more water per lb. of the same quality of coal than the latter, without and with an economiser respectively. The Cornish was not experimented upon. Lastly, in a description of a Worthington compound pumping engine, of 130 I.H.P., which appeared in the current volume of *The Practical Engineer*, page 123, the consumption was stated to be 1·7lb. per I.H.P. per hour, with the high efficiency of 92 per cent.—Orion.

144. Curvature of Rim of Pulley.—How do you find the proper curvature to give to the rim of pulley? Does it simply depend on the width of the belt, or does it also depend on the thickness of belt, speed of belt, and diameter of pulley? A leather belt, about ¼in. thick, is to travel at about 3,000ft. per minute over a 27in. pulley of 8in. face. What should be the difference between the diameter of pulley at the centre of the rim and at the edge?—Raw Hide.

Answer.—A wide pulley requires a less curvature than a narrow one. From three to five times the width of pulley is the usual radius allowed for the curvature of rim. The thickness of belt does not affect the result, nor does the diameter of pulley, except that a small pulley usually runs at a high speed, in which case the shorter radius would be used. There is, for instance, considerable rounding on the pulley of a centrifugal fan, the shorter radius being there used. In the case stated in query, a radius of from 2ft. to 2ft. 6in. would be the best. The readiest way of getting the true diameter is to draw the pulley to scale and measure the diameters.—C.

145. Thickness of Cast-iron Pipe and Proportion of Engine Cylinders.—Would any engineer inform me the thickness of cast iron for 8in. diameter steam pipes to be safe from bursting with 80lb. of steam per square inch in the boiler, and what diameter of cylinders would you recommend to work compound side by side? Corliss high-pressure cylinder, short slide valve for low-pressure cylinder, to drive 200 I.H.P., 44 turns per minute, 4ft. 6in. stroke, 80lb. of steam in boiler per square inch. Information will oblige.— J. C.

Answer.—Let P = the working pressure per square inch, d = the diameter of pipe in inches, t = the thickness of pipe in inches, and f = the working stress allowed per square inch of material, say 1,400lb. for cast iron, then from the equation $Pd = 2\,tf$ we get $t = \frac{80 \times 8}{2 \times 1400} = \cdot 228$in., from which "J. C." will see that it is not merely the theoretical conditions which have to be considered, but the practical. The pipe should therefore be about $\frac{3}{8}$in. thick. Turning to the second portion of his query, let it be assumed that the engine is condensing and 200 I.H.P. are required in ordinary working; consider the mean pressure reduced to the L.P. cylinder is 27lb. per square inch, then the area of L.P. cylinder will be $\frac{200 \times 33000}{27 \times 44 \times 4\cdot 5 \times 2} = 617$ square inches, or say 28in. in diameter, taking 70 per cent as the efficiency, the theoretical mean pressure will be $\frac{27}{70} = 38\cdot 5$lb. per square inch, the total range of expansion R must therefore be arranged to give this. Allowing for a drop of 5lb. in pressure from the boiler to the engine, we get $(80 - 5) + 15 = 90$lb., the absolute pressure of the inlet steam, and $\frac{38\cdot 5}{90} = \cdot 427$ as the value of $\frac{1 + \text{hyper. log } R}{R}$, by trial, or from a table it is found that when $R = 6\cdot 8$, the value of $\frac{1 + \text{hyper. log } R}{R} = \cdot 428$, so that cutting off steam in the H.P. cylinder at ·45 of the stroke, the ratio of $\frac{LP}{HP} = 6\cdot 8 \times \cdot 45 = 3\cdot 06$; hence, $\frac{617}{3\cdot 06} = 201$ square inches as the area of the H.P. cylinder, equal to a diameter of 16in. The theoretical terminal pressure would be $\frac{90}{6\cdot 8} = 13\cdot 2$lb., and the actual about 11lb. per square inch. An earlier cut-off than that taken will increase the H.P. cylinder diameter, and a later cut-off decreasing it.—Orion.

149. Grinding Steel Knives.—In our establishment we use steel knives, bolted on to a metal pulley, for chopping rope, &c. They have to go through the process of grinding twice a week, which takes two men, one at the end of the lever, and one to stand by the knife; in some mills similar it is done by one. I send sketch of our present system, fig. 1, and also an idea of the principle of the one-man system, fig. 2, one hand on knife and one on lever, which might be greatly improved. Would any of your readers suggest an idea applicable with little expense? The one-man system is very simple, but, in my opinion, dangerous.—Primrose.

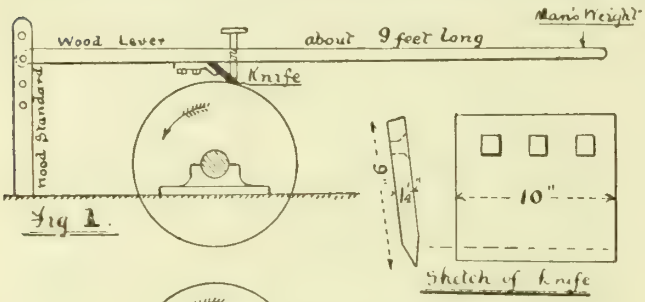


Fig 1.

Sketch of Knife

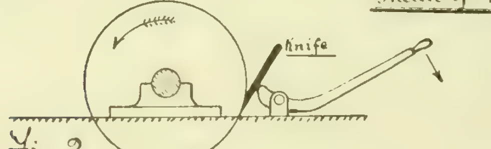
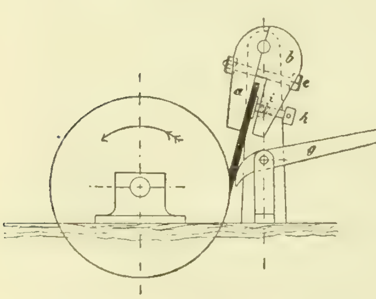
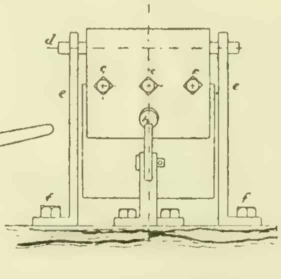


Fig 2.

Answer.—I beg to submit the following sketches of apparatus for grinding rope-cutting knives, as requested by "Primrose." I think he will find it simple of construction, inexpensive, and effective. The method of holding the knife is one that guarantees absolute safety, and enables one man to accomplish the grinding with ease and certainty. The knife clip is made in two parts *a* and *b*, and held firmly together by the three bolts *c*, *c*, *c*. It may be made of beech or other tough wood, and have a spindle *d* through it, to be carried in its supports *e*, *e*, which may be held in place by coach screws *f*, *f*; also the bracket supporting the lever *g*. The part *b* of the knife-clip has a square nut *i* let into it, through which the set screw *h* passes to fix the knife firmly in the clip. If the spindle *d* were screwed, and a handle fixed at one end, the knife could be given a transverse motion, which would be an improvement.—J. R.





Answer.—Revolve the stone the other way round. I ground plane irons on a stone going away from edge, and had no difficulty. Certainly a feather edge is often left, but comes off if the edge is drawn across a piece of wood. —W. H. B.

150. Leather Belting.—I wish to know the width of double leather belt to transmit 200 I.H.P. Belt flywheel 14ft. diameter, 72 revolutions per minute; driven pulley 10ft. diameter, 30ft. centre to centre. Please give formula.—Anxious.

Answer.—The rule is as follows:—

H.P. = horse power transmitted by belt.
V. = velocity of belt in feet per minute.
W. = width of double belting.

$W = 831\cdot 6 \times \frac{H.P.}{V.}$ where 0·4 of the driven pulley is embraced by belt. (*a*)

$W = 701 \times \frac{H.P.}{V.}$ where 0·5 of the driven pulley is do. do. (*b*)

$W = 642 \times \frac{H.P.}{V.}$ where 0·6 of the driven pulley is do. do. (*c*)

Or by formula (*a*) W = 52.5 inches.
" " (*b*) W = 44·8 do.
" " (*c*) W = 40·5 do.

C.

Answer.—In answering this query it will be well at first to determine the safe working tension we may put on the belt. The ultimate strength of leather used for belts is about 4,000lb. per square inch; but this value is reduced by about 50 per cent if the belt has riveted splices; and when there is a laced joint, we can only reckon on about 30 per cent of 4,000, or, say 1,200lb. Then, taking 4 as a factor of safety, we get 300lb. as our working tension per square inch; and taking $\frac{5}{8}$ as the thickness of our double belt, then working stress per inch width of belt in pounds $W = 300 \times \cdot 625 = 187$. Then, if P represents the resistance at the circumference of the driven pulley, given by the formula

$$P = \frac{550 \text{ I.H.P.}}{V};$$

in which V = the velocity of the belt in feet per second. In the case under consideration, V = 53; therefore—

$$P = \frac{550 \times 200}{53} = 2075\text{lb.}$$

And to obtain width of belt B we have—

$$B = \frac{P}{W} \times x;$$

in which x, if we assume the co-efficient of friction at ·3, and as our belt embraces 170 deg. of the driven pulley, then $x = 1\cdot 7$. So that, putting in our values we get—

$$\text{Breadth of belt} = \frac{2075}{187} \times 1\cdot 7 = 18\cdot 8$$

or, say 19in.—I. H. P.

Answers to the following queries are unavoidably held over: 141, 150, 151, 152 153, 154, 155, 156, 157, 158, 159, 160, 166, 167, 169, 171, 172, and 173.

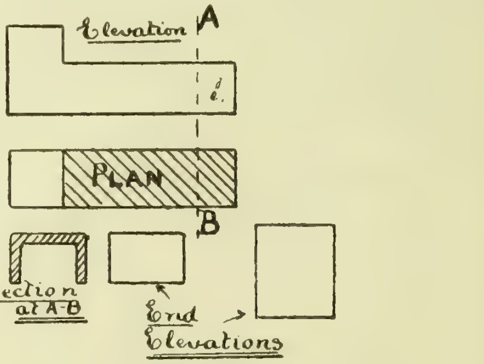
138. Solid-drawn Tube.—I wish to make a number of lengths of solid-drawn copper tube $\frac{3}{8}$in. internal diameter and $\frac{7}{16}$in. external. I shall feel obliged if anyone will give a description of the necessary tools.—L. M.

148. Automatic Vacuum Brake.—Can any reader inform me the reason why, when the brake is applied from the engine, it always takes hold of the last carriage first? It always seems strange to me why it should do, and I shall be extremely obliged for any information on the subject.—W. G.

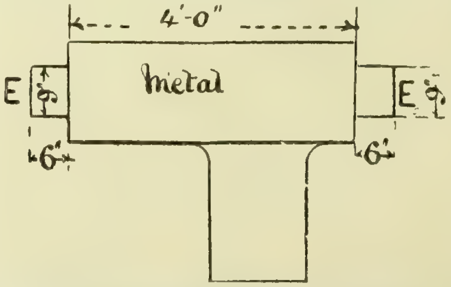
161. Engine Connections.—Will any reader kindly furnish me with a formula, or explain how to determine the following, viz., distance between centre of connecting rod, length of piston rod, depth of piston, and distance between centre and face of crosshead under various conditions of pressure?—Anxious.

162. Method of Boring out a Rod.—Could any of my fellow-readers inform me on the following: I have a rod of bell metal, 6ft. long, and 2¾in. diameter, through which I want to bore a hole 1½in. diameter. I wish to know the best way to hold it in the lathe, and also the best method of boring it. There is a cut to come off the outside; should I take this off first or last, and what tool will best do for the job?—Heavy.

163. Turning Casting.—I give a sketch of a piece of cast iron, and wish to know the best way of holding it in the lathe to turn it. The part section-lined requires turning.—Heavy Turner.



164. Facing Forging.—Could you, through your paper, inform me how to do this job, of which I give sketch? The ends E have to be made true, and as I have no lathe large enough, I wish to know of another method. I have a boring machine. Could it be done on that? If so, a sketch of the tool required would greatly oblige.—Truth.



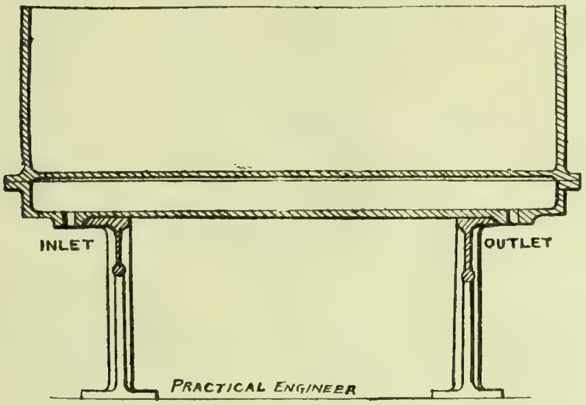
165. Cast-iron Piston Rings.—Will you kindly inform me the correct width and thickness of piston rings, cast-iron split, for a cylinder 10in. diameter, 16in. stroke?—Fitter.

170. Brake Power of Gas Engine.—I have a small gas engine, about 5 H.P., and wish to know the brake H.P. of it. I have an indicator, and should be glad of sketch of brake, and other particulars that would assist me in the trial.—Novice.

174. Injectors.—(1) Does an injector pump more or less water than can be accounted for by simply considering the momentum due to the pressure of steam and head of water which work it? (2) Would air at any velocity pump any water against a pressure? If so, would equal weights of air and steam, having equal momentum, produce the same effect? (3) What is the efficiency of an injector as a pump compared with other pumps in a case where a low temperature of discharge is desirable?—R.D.

175. Oilless Bearings.—Can any reader advise me as to carbonated bearings? I have two journals continually dipping in water. Will carbonated bearings suit, and keep from wearing when thus working?—J. B.

176. Strength of Cast-iron Pan.—Please give me formulæ to calculate the strength of pan as per sketch: 1st, plain bottom; 2nd, with screwed stays (screwed in both plates). The formulæ to be applicable to any size of pan and pressure of steam.—H. L. C.



177. Friction Brakes.—Would any reader kindly give the following information?—In a brake of the flexible band type, the band being of wrought iron and the drum of cast iron, what is the best and usual proportion in practice of width and thickness of band to diameter of drum, so as to be both strong enough, and to have sufficient area of surface to prevent overheating for different arcs of contact. Also width of block, when the brake is of the wood block type, as generally used on winding engines. The above information will greatly oblige.—Overheated.

PATENTS AND INVENTORS' QUERIES.

43. Can I patent a machine for making an existing article by means of a new arrangement of moving parts, although each part is an old idea in itself?—S. B., Bristol.

Answer.—If your combination has not been set up as a whole in the way you have now constructed your machine, you can obtain a valid patent, provided there is some actual advantage by the new combination.

44. Will a registration of a peculiar form of driving gear protect me, or must it be patented?—W. H., Salford.

Answer.—Registration will only cover the outward configuration or shape, and possibly many could evade your registered shape by slightly altering it. A patent is safer for your purpose, we imagine. Tell us your idea, and we will then advise you by letter, if you enclose stamp.

45. I want to sell my part of a patent, and my co-patentee will not buy it from me. Can I do anything with it?—G. S. R., Smethwick.

Answer.—You can make the articles without paying royalty to your partner, and you can sell out your share.

TO CORRESPONDENTS.

W. Reid, Glasgow.—We have prepared a block of the diagram, and it will appear in next week's issue.

MISCELLANEA.

The electrical factory just erected in the Paris markets is in the cellars, at the most central point. There are two installations. The first has six generators. The cellars are lighted with 450 incandescent lamps of 16-candle power, and 180 arc lamps of a lighting power of 30 candles. In the market and the adjoining streets there are 2,000 lamps. The entire works have cost the City of Paris £40,000, of which £1,800 was spent on the main chimney, which rises to a height of 147 feet.

White Lead.—A new method of manufacturing white lead is proposed by a M. Thibaut, according to which the workpeople are not to be brought in contact with the vapours from the metal. Instead of manual labour, M. Thibaut has a machine for "dividing the lead and preparing the mixture" *(qui divise le plomb et opère le melange)*. With this machine he says that two men can make 3,500 kilos of white lead in two hours, whereas by the ordinary method it takes two men a whole day of 10 hours to make 4,500 kilos. Those familiar with white lead making will be the best able to estimate the value of this contrivance, if it have any. Many methods have been introduced, having in view, in addition to economy, the decrease of lead poisoning and Saturnian paralysis.

Trial Trip.—On the 21st ult., the screw tug "Rex" made her trial trip on the Thames, developing 230 I.H.P. with a mean speed on four runs over the measured mile of 10·221 knots. The hull, built by Messrs. Samuda Bros., has a length of 72ft., a breadth of 14ft., and a depth of 8ft. 4½in., draft in working trim is 7ft. 9in. aft, and 5ft. 6in. forward. The engines, built by Messrs. Young and Son, are inverted compound screw engines, with cylinders 15½in. and 28in. diameter, by 16in. stroke, working at a pressure of 80lb. per square inch. The whole of the work was carried out from the specification and under the supervision of Mr. Henry Adams, M.Inst.C.E.

At the dinner of the Leeds Association of Foremen Engineers and Draughtsmen, on Saturday last, Mr. W. L. Jackson, M.P., threw out a hint on the utilisation of our sources of power which should one day receive practical application. He is greatly impressed with what he saw of the working of the electric railway between the Giant's Causeway and Portrush, a distance of eight miles. The whole motive power comes from the application of a pressure of water to the generation of electricity, and it is obviously a very economical method of working a railway. In the West Riding of Yorkshire, and especially in the North-West, many advantages are offered by our streams to obtain mechanical force. No electrical engineer would hesitate about devising some plan of turning to account the head of water at Fewston, or in the Washburn. The day must come when this power will be utilised, and let us hope the borough would have the benefit of any scheme that is devised. Some moorland streams might become quite profitable to landowners when the electrical engineer takes them in hand.

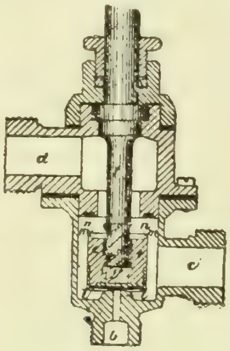
Yorkshire College Engineering Society. — At the meeting of this society, held on Monday, December 2nd, Mr. W. H. Wickstead presiding, a paper was read by Mr. Wilson Hartnell on "Priestman's Petroleum Engine." This was said to be virtually a gas engine burning the vapour of petroleum instead of gas. Several engines have been made to burn the lighter hydro-carbons, such as benzine; but the feature of Messrs. Priestman's is that it burns an oil with a flashing point of 150 deg., and is thus perfectly safe. The construction of the engine was explained, and its manner of working described. The petroleum is contained in a tank, and has air pumped above it. The air and the oil are then by two pipes taken into another chamber, transformed into spray, and vaporised. The difficulty of getting the air and the petroleum into the spray-producer under the same pressure is thus overcome. The "cycle" is similar to that of the Otto gas engine, the outward stroke drawing in vapour and air, which is compressed by the return stroke, then exploded by an electric spark, expanded in the forward stroke, and cleared out by the return. The exhaust gases pass round the spray producing chamber, heating it to 400 deg. or 500 deg., and any vapour which has not been ignited afterwards condenses again into petroleum. The advantages of the engine were stated to be—its independence of place, it can be used anywhere; its superior efficiency as a heat engine, utilising 9 per cent of the value of its fuel, a small steam engine not utilising more than 2 per cent of the value of coal; its lightness, being the lightest motor yet made; and the small amount of attention it needs.

Civil and Mechanical Engineers' Society.—The first ordinary meeting of the Civil and Mechanical Engineers' Society for the new session was held at the Westminster Palace Hotel, on Wednesday evening, December 4th, when Mr. Henry Adams, M.Inst.C.E., Professor of Engineering at the City of London College, delivered his opening address. He reviewed the work of the society during the past year, indicating the chief points of merit in the papers which have been read, and using each as the text for practical remarks. With regard to technical education he laid down the qualifications for good engineering draughtsmen, and said that although the supply was commonly thought to be greater than the demand every engineer at times found considerable difficulty in getting competent assistants. In connection with the visit to the London and South-Western Railway works the president gave some results obtained with the vortex blast pipe of which he is joint inventor and patentee with Mr. W. Adams, the locomotive superintendent. By its use this railway company alone, he stated, had saved nearly £50,000 on its coal bills, in addition to reaping other advantages. The position of the society, financially, was stated to be sound, and a hope was expressed that the roll of members would be largely increased during the coming year. Looking beyond the limits of the society the state of the labour market called for some remarks, and in this section the president concluded by saying, "Union is the right of all, intimidation an outrage upon the first principles of liberty and justice." The chief features of the three most memorable structures of the day, the Forth Bridge, the Paris Exhibition, and the Eiffel Tower, were described, and many interesting particulars given, and the address was brought to a close by an exhortation to the younger members of the profession who possessed opportunities undreamt of by former generations, but these very opportunities called for corresponding zeal on their part, "to whom much is given of him much shall be required."

ILLUSTRATED PATENTS.

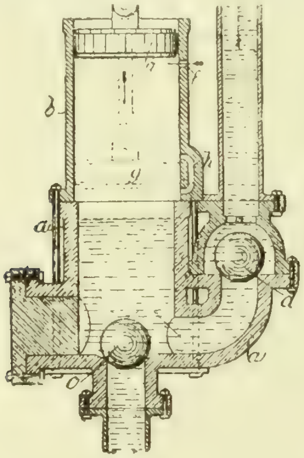
7705. **Three-way Valve.** A. Bruce, Glasgow.

The inlet *b* terminates in a projection *i*, against which the valve *e* is forced by a quick-threaded screw-spindle *l*. The valve is packed underneath by a cushion *f* of rubber or the like, supported by a plate *g*, and is prevented from turning by feathers. The top of the valve has preferably an upwardly projecting flange *m*, which is forced against a packing ring *n* when the valve is lifted. Communication can thus be established either between the inlet *b* and the outlet *c*, or between the outlet and an exhaust or waste pipe *d* communicating with the cover of the casing. The spindle can be operated in any suitable way, and is packed by a stuffing box.—May 26th, 1888. [8½d.]



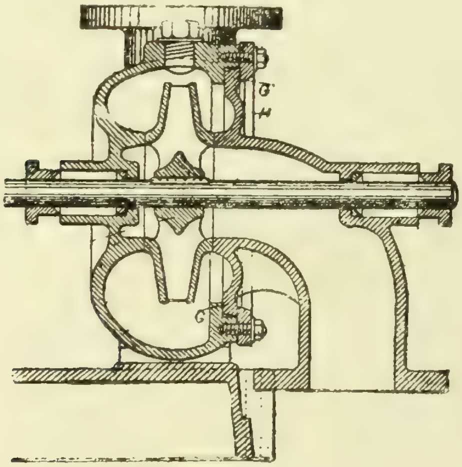
7768. **Acid Pump.** S. Spencer and J. S. Lord, Victoria Engineering Works, near Manchester.

To prevent corrosion of the piston *g* and barrel *b* of the pump, a cushion of air is interposed between the surface of the liquid and the piston. The liquid is drawn into the receiver *a* through the inlet valve *c*, and forced out through the valve *d*. Air enters the cylinder *b* by the hole *f* when the piston is up, and is discharged through the passage *k* when the piston is down. A plunger with a groove for the escape of the compressed air may be used instead of a piston.—May 28th, 1888. [8½d.]



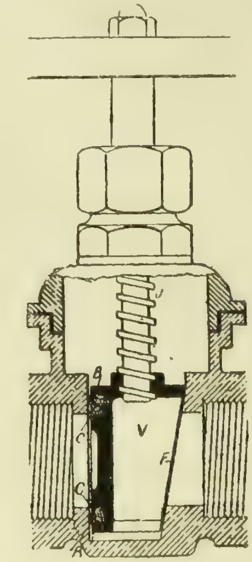
8119. **Pumps.** C. L. Hett, Brigg, Lincolnshire.

Centrifugal.—Consists in the mode of attaching the suction pipe bend to the pump, so that it can be readily swivelled through any desired angle. For this purpose it is made in one with the cover, which fits into a faced recess in the casing, as seen at G, and is held therein by means of a clamped ring H.—June 4th, 1888. [6½d.]



8431. **Valves.** W. Hartley and W. H. Rose, Bradford.

Relates to screw-down sliding valves. The valve V is actuated by a screw J, and is wedge-shaped on the pressure side F. The face of the valve is vertical, and is provided with a groove, one of whose sides is undercut. The groove receives a packing ring B of asbestos, white metal, or other suitable material, which is held in its place by a ring C screwed to the valve face. The packing may also be held in a dovetail groove without the aid of the ring C, or the ring C may be replaced by one fitting round the circumference of the valve. The seat may be packed instead of the valve.—June 8th, 1888. [8½d.]



Copies of these specifications may be obtained on application to H. Reader Lack, Esq. *Comptroller-General, Patent Office, Southampton Buildings, London, W.C., by remitting published price, together with postage. Sums exceeding one shilling must be sent by Post Office Order.*

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

November 21st.

18660 Forging Metal, C. Davy, London.
18662 Railway Signals, J. P. O'Donnell and W. Smith, London.
18669 Machinery for Boring Rock, F. Ulrich, London.*
18680 Dynamo-electric Machines, H. Hauser, London.

November 22nd.

18694 Gas Engines, J. F. Shaw and R. H. Shaw, Manchester.
18702 Valves, M. Syer, London.
18714 Gas Producers, G. Scott, Glasgow.*
18717 Lubricators, J. Samson, London.
18718 Bleaching Yarn, P. Thomas, London.
18728 Purification of Steel, A. S. Ramage, Liverpool.
18732 Steam Generators, J. M. Newton, Manchester.
18738 Percussion Fuses, A. Martin, London.
18743 Electric Conductors, S. Pitt, London. (A. Dey, United States.)
18745 Registering Mechanism, R. Jewell, London.
18746 Igniting Apparatus, C. D. Abel, London. (The Gas Motoren Fabrik Deutz, Germany.)
18747 Signalling Apparatus, W. Andrews and W. H. Parker, London.

November 23rd.

18761 Moulds, M. Cockburn and P. Taylor, Glasgow.
18765 Brick-making Machinery, G. Hall, London.
18794 Fire Extinguishers, W. P. Thompson, Liverpool. (V. A. Harder, United States.)*
18802 Vices, C. Wies and J. M. Lockey, South Dakota, United States.
18803 Boilers, C. D. Yates, London.
18805 Crank and Treadle Motion Apparatus, C. T. Lee, London.
18812 Torpedo-launching Apparatus, E. Kaselowsky, London.
18813 Motors, W. Schmidt, London.
18816 Grinding Mills, H. Birkbeck, London. (J. Jones and A. J. Jones, Canada.)*
18819 Measuring Liquids, R. Brown, London.*
18820 Steam Engines, H. Staps, London.*
18830 Thrashing Machines, J. Lutz, London.
18841 Submarine Cables, G. Draper and P. L. Isaac, London.
18846 Mortising Machines, F. V. Phillips, London.*
18847 Gas Engines, M. M. Barrett and J. F. Daly, London.
18848 Signalling Apparatus, J. H. A. Child and J. Emery, London.

November 25th.

18867 Driving Belts, J. Taylor, Manchester.
18871 Printing Machines, E. A. Pallister, Leeds, Yorkshire.
18880 Valves, W. le P. Webb and G. M. B. Mackay, Cheltenham, Gloucestershire.
18903 Bronzing Machines, H. Shilton and H. May, London.
18920 Lubricators, J. S. Chapman, Glasgow.

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Contributors are requested to write on one side only of the paper. Sketches should be sent on separate sheets.

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THE

PRACTICAL ENGINEER,

DECEMBER 27TH, 1889.

PENALTIES UNDER THE BOILER EXPLOSIONS ACT, 1882.

THE prognostications we have ventured to indulge in at different times, in these columns, as to the probability of what may be termed the penal clauses of the Boiler Explosions Act, 1882, being more rigidly enforced as time went on, are at the present time being abundantly verified. Seven years after the passing of the Act, only one Formal Investigation had been made, and in this instance no penalty was imposed.

A Preliminary Inquiry has hitherto been found sufficient in almost every case which has been investigated to elucidate the cause of the so-called explosion, and the elaborate and more expensive Formal Investigation has been unnecessary. A Preliminary Inquiry, however, can be conducted by one Engineer Surveyor of the Board of Trade alone, and is a comparatively inexpensive matter, so that in the event of blame being found to attach to anyone in connection with an explosion, the charge of the cost of such an inquiry to culpable parties would be merely nominal, considered as a penalty. Hence, in every case where it has been found desirable to impose a pecuniary fine, it appears to have been considered necessary to institute a Formal Investigation, by a properly constituted Court, consisting of not less than two Commissioners, appointed by the Board of Trade, one o whom must be an engineer, and the other a lawyer, so that the costs and expenses of this tribunal, or some proportion of them, can be charged to any persons summoned before it as parties to the Inquiry.

Three such formal investigations have been made within the past few weeks, and in each case the boiler owners have been censured, and have been ordered to pay fines of from £40 to £75 towards the cost of the inquiry. Of the three cases above referred to, one official report only has as yet been issued, the other two inquiries having been concluded during the past fortnight. The report which has been issued refers to the explosion of a boiler at Wallsend Forge, Wallsend-on-Tyne, on August 26 last, whereby three men were scalded or otherwise injured, but all of whom have since recovered. The boiler in this case was of the ordinary Cornish type, 5ft. diameter, 20ft. long, with a furnace tube about 3ft. diameter, constructed of $\frac{5}{8}$in. plates, and fired by the heated gases from a balling furnace. It was insured with a local company, the Newcastle-on-Tyne Steam Boiler Insurance Company Limited, in the sum of £200, the stipulated pressure being 40lb. per square inch. The large furnace tube was a plain one—that is, it was unstrengthened in any way by hoops, &c.—and it collapsed from end to end, a portion being blown out, and the boiler moved bodily a distance of about twice its own length, the buildings and fittings being wrecked. No suggestion to strengthen the tube, although of so large a diameter, and constructed of plates of such light section, seems to have at any time been made by the insurance company's engineer. The Commissioners attribute the failure of the tube to overheating from shortness of water, one of the upper water-gauge cocks having been found choked up with a fibrous sediment. They consider "there was gross neglect in the general management and upkeep of this boiler," which was left to the charge of a lad 15 years of age, whose duty it was also to work a steam hammer, and "occasionally, when he found time," to look at the water gauges. Strong comments are made by the Commissioners on the working as well as the inspection of this boiler; the owner is held to be greatly to blame, and has been directed to pay £50 towards the cost and expenses of the investigation. The Insurance Company comes in for a large share of censure, but escapes a monetary penalty beyond what it has to pay to the owner of the boiler for the damage done by the explosion. The Commissioners, however, consider that "the inspections that were assumed to have been made by the company were little better than a farce," and the inspector who examined the boiler about two months prior to the explosion is described as "an entirely unfit person to be entrusted with the inspection of boilers."

The report deals with the rates charged for boiler insurance, but this is a comprehensive question we cannot at present enter into, but about which we hope to have something further to say very shortly. We can merely add here that the Newcastle-on-Tyne Boiler Insurance Company, following the example of several others, which have collapsed immediately after they have experienced a disastrous explosion, has since wound up its affairs, and its business has been taken over by a new company, having its headquarters in Manchester. This company is, we believe, the most recent competitor for boiler insurance business, and in view of the remarks made by the Board of Trade Commissioners in the above-mentioned report, as to the rates at which boiler inspection can be efficiently carried on, it is significant to note in the prospectus of the new company, which we have before us, that prominence is given to the fact that "it is not intended that the Society should become connected with any combination of companies for maintaining excessive rates." It remains to be seen whether this most recent competitor in a business in which competition has for some years been notoriously and undesirably keen has anything more attractive to offer to secure a share of boiler insurance business than still lower rates, or even greater risks than those which, unfortunately, at present obtain, and which, to all appearances, are already too low for efficiency.

The second of the inquiries we have referred to was concluded at Winsford, on the 16th inst., and concerned the explosion of a boiler on board the steam flat Development, of Liverpool, in Saltersford Lock, on the river Weaver, at Barnton, Cheshire, on October 19th last. This vessel, which belonged to the Salt Union, was sunk by the explosion, and the engine-driver died within a few hours afterwards from the scalds and other injuries he had sustained. The boiler was of the marine multitubular type, about 12 years old, with a single furnace tube, which had been extensively repaired. It was proved that the safety valve, which was of the ordinary lever type, had been wedged down and rendered inoperative by the insertion of a wooden wedge between the top of the lever and the guide, so that the tube collapsed from over-pressure, and the attendant who had been guilty of so tampering with the safety valve paid the penalty for his ignorant or reckless foolhardiness with his life.

The boiler was not considered suitable by one eminent authority for a higher pressure than 30lb. per square inch, but was actually loaded to 68lb., and the superintending engineer for the Salt Union acknowledged to having seen the steam blowing off at a pressure of from 65lb. to 70lb., but had never taken the trouble to inquire if the boiler was suitable or strong enough to withstand such a pressure. Further particulars of the case will be found in another column, and we would only add here that the Commissioners considered the Salt Union to blame, and they were ordered to pay a fine of £40 towards the cost of the formal investigation. In this case the boiler was not insured, and does not appear to have been subjected to any competent supervision or regular inspection.

The latest investigation, which was concluded on the 18th inst., at Charlesworth, near Glossop, referred to an insured boiler, which exploded from internal corrosion on the 1st of November last, killing one of the owners and his manager. This boiler, which was of the Cornish type, 4ft. 6in. diameter and 10ft. long, was bought second-hand some fifteen years ago, and had worked continuously since that time without ever having been inspected or examined in any way until the month of May of the present year, when an insurance was effected upon it for the sum of £300. The most remarkable and important feature about this explosion is the fact that at the time of its failure the boiler had been insured several months with a well-known boiler insurance company, although it had never been thoroughly inspected, and the occurrence is one which will furnish a powerful argument to the advocates of the principle of "no inspection no insurance," to which we recently referred in these columns. The Commissioners held the insurance company blameless in the matter, as there was nothing to prevent their accepting any risks they thought proper, and they said they might, if they chose, "insure a boiler absolutely rotten," but they considered the way in which such business was conducted was practically a premium on carelessness. It should be noted, however, that the boiler insurance company had made strong representations as to the desirability of having the boiler examined both externally and internally, and had repeatedly pressed for such examination. This investigation throws a new light on the question of boiler insurance, and affords room for grave reflection to the intelligent steam user. Most boiler owners, we are inclined to think, are under the impression that when they have effected an insurance of their boilers, they are relieved of any responsibility for their safe working so long as they comply with the conditions and carry out the suggestions made by the insuring company. Such, however, is not the case. The Charlesworth investigation has made it clear that the policies of boiler insurance companies do not transfer a steam user's responsibility to the shareholders of the company, but merely provide pecuniary compensation for any damage caused by explosion. In this case Messrs. Booth, the owners of the exploded boiler, one of whom was killed by the explosion, are censured in the most sweeping manner, the Commissioners denouncing the whole management of the boiler as disgraceful in the extreme, and pronouncing it "a case of utter recklessness and incompetency," evincing "an utter disregard of human life"; and in view of the culpability of their conduct, the firm are ordered to pay the sum of £75 towards the costs and expenses of the inquiry. Not only steam users and boiler owners generally, but boiler insurance companies also, would do well to ponder over the whole of the circumstances of the foregoing investigations, the most important, without exception, which have been made since the passing of the Boiler Explosions Act, 1882. The issues raised by the Commissioners' reports are so numerous, and of such importance, that we purpose reverting to the subject at an early date, and will at present therefore only add one observation, which is, that it is quite certain the public safety will not be allowed to be jeopardised—competition or no competition—in order that a few companies may make profits.

COPPER PIPES AT THE DEPTFORD ELECTRIC CENTRAL STATION.

We were much interested to learn the other day the expedient which has been adopted at this central station since the explosion of the large copper supply steam pipe discussed by us some time ago. The company, instead of constructing one large copper pipe, have grouped together a number of small solid-drawn copper pipes, the ends of which are expanded into tube plates. The steam passes through these, and so high pressures may be safely borne. This plan will, no doubt, prove safe; but surely the loss by condensation will be much greater than with one pipe, and we can hardly think it beyond our engineers to construct tubes which will be perfectly safe as well as economical.

THE GASHOLDER ACCIDENT AT SALTLEY.

The sad accident which occurred at the Saltley Gasworks last week, by which two poor fellows lost their lives, proves, if proof were required, the great danger incurred by entering old gasholders for the purpose of examination and repair, even by men of great experience, and after long blowing through of air to displace the coal gas. Of course the difficulty of displacing the gas lies in the fact of its copious absorption by the water in which the gasholder works, and in the deposit upon the sides of the gasholder of matters which absorb or occlude gas, and give it off again for a long time after. And this being so, it is difficult to see any real remedy except the use in such interiors of the diving dress, properly supplied with air by an efficient pump. The very fact that sometimes men can enter with comparative safety adds seriously to the risk, but this condition is so uncertain and so liable to be changed by slight variation in the barometer or temperature that men may be imperilled at any moment. We are accordingly distinctly of opinion that engineers and boiler-makers engaged in hazardous repairs of this kind should invariably adopt a proper diving dress, supplied with air from the exterior. So long as such men are unfamiliar with the diving dress and the precautions in its use, so long will there be serious fatalities such as that of last week.

A PNEUMATIC LINE-THROWING GUN.

Considerable interest has been occasioned in Birmingham recently by a vehicle on which an altogether strange machine has been mounted being driven through the streets. The machine—for it is that which has attracted the attention of the passers-by—is a pneumatic line-throwing gun, which is intended to reinforce or replace the rocket apparatus which at the present time forms the chief means of communication between vessels in distress near to the land and the shore. The presence of the machine in Birmingham is accounted for by the fact that Messrs. Taunton, Delmard, Lane, and Co., of Heneage Street, are manufacturing it for the inventor, Commander J. D'Arcy-Irvine, R.N., of Dublin, and experiments have taken place at Edgbaston reservoir recently. Many advantages are claimed for the apparatus. In the first place, compressed air is substituted for powder, with an altogether satisfactory result; and secondly, the portability and ease with which the gun can be worked compared with the rocket apparatus are features that are exceedingly valuable. Without dealing with the technicalities of construction, it may be stated that the largest guns are capable of an air pressure from 200lb. to 300lb. per square inch, but the pressure for the shoulder guns, which are intended for other than cases of danger at sea, is much less. The invention also possesses a commercial value, inasmuch as it is claimed that by the use of the apparatus a towing-line can easily be carried from a tug to a ship that cannot enter port for the heavy sea. The projectile to which the line is attached can be propelled a distance of 400 yards with accurate aim, whereas the rocket apparatus is difficult to work against an opposing wind and from the shore. On Dec. 11th several experiments took place, and although in one instance the projectile carried a distance of 350 yards, the rope by some means became detached. A line, however, was successfully thrown a distance of 250 yards. When the inventor has perfected his apparatus for use at sea he will turn his attention to adapting it to be used in cases of fire, for aiding in escapes from high buildings.

TRIPLE-EXPANSION ENGINES AND ENGINE TRIALS.

At the meeting of the Institution of Civil Engineers, on the 10th of December, the President (Sir John Coode, K.C.M.G.) being in the chair, the paper read was "On the Triple-expansion Engines and Engine Trials in the Whitworth Engineering Laboratory, Owens College, Manchester," by Professor Osborne Reynolds, LL.D., F.R.S., M.Inst.C.E.

The modern theory of the steam engine, as founded on the discoveries of Joule, had rendered the experimental investigation of it one of the most important and most interesting branches of science. This theory revealed in the most certain manner the objects to be aimed at in designing engines, as well as the results to be expected; but only experimental investigation of the engines showed how far these results had been realised, and to what circumstances any failure in such realisation must be attributed. For this purpose, ordinary steam engines, doing ordinary work, were about as good as ordinary animals, in their ordinary occupation, were for subjects of physiological experiment. In certain particulars both could be accurately observed, as, for instance, how much coal or food was necessary during the performance of a particular operation; but to ascertain how all the separate organs were performing their several functions was impossible with an ordinary steam engine, without subjecting it to a species of mutilation which left it about as fit to continue ordinary work as an animal that had been the subject of physiological study. By the patient expenditure of great ingenuity in adapting measuring instruments to the engines, as well as by securing provisions, during the construction of the engines, for the use of these instruments, much had been done. Engines of every class had from time to time been subjected to experimental examination as complete as practicable, and the knowledge thus gained was of immense value, although it left much to be desired. It had been found by these experiments that the actions in the several organs did not even approximately conform to the simple primary actions aimed at; but that the primary were obstructed by secondary actions, which in some cases amounted to as much as 40 or 50 per cent of the total action. The analysis and evaluation of the secondary actions thus revealed, although recognised as objects of primary consideration in engine trials, were still very incomplete, demanding for attainment engines much more fully adapted to the purpose of experiment than those hitherto available. It was evident that the engines and apparatus for operating upon should be such that each organ, while similar to and performing the part of the corresponding organ in an ordinary engine, should be so arranged with respect to the other organs as to admit of the manner in which it performed its part being completely gauged; and that this should be done simultaneously with all the organs, both those corresponding to the ordinary engine and such special organs as should be introduced to admit of access to the others, so that the action of these latter might be accurately discounted. The engines in the Whitworth engineering laboratory had been throughout specially designed and constructed with a view to the fulfilment of the foregoing requirements. The committee, consisting of Mr. John Ramsbottom, Mr. John Robinson, and the author, having, after consultation with Mr. William Mather, been released from all considerations of expense, felt that a great opportunity would be lost if the facilities offered were not taken advantage of to the utmost; and unless every effort was made so that the engines, while as far as possible representing in their principal members the most approved existing practice in steam-engine construction, should be thoroughly available for experiments on the use of steam throughout, and if possible beyond, the range hitherto attained in practice. If this was accomplished, not only would appliances, costly almost beyond the range of private effort, be secured, but the conduct of what would otherwise be a very expensive and laborious research would afford the most desirable work for the laboratory—work which, having all the advantages of reality, would yet afford the students the best possible opportunity, while acquiring facility in the use of the instruments and methods of reduction, of gaining an insight into the action of each part of the engine. There were three separate inverted-cylinder engines working on separate brakes, having the following dimensions:—

Engine.	Cylinder. Diam.	Cylinder. Stroke.	Crank-shaft Diam.
	Inches.	Inches.	Inches.
No. I. (high-pressure)	5	10	2¼
No. II. (intermediate)	8	10	2¾
No. III. (low-pressure)	12	15	4
Air Pump on No. III.	9	4½	..
Feed Pump ,, ...	1½	2	..

All the engines had their cylinder walls and both covers separately jacketed, and so arranged that they could be worked with or without steam in any or in all of the jackets. Each engine was designed to carry a pressure up to 200lb. on the square inch, to run at any piston speed up to 1,000ft. per minute, and had expansion gear to cut off from zero up to 0·8 of the full stroke. One engine was furnished with a surface condenser having 160 square feet of surface; the other two engines were furnished with alternative exhausts, either into the atmosphere or into steam-jacketed receivers supplying the next engine, each receiver having an alternative supply of steam from the boiler. The boiler was of the locomotive type, with 5 square feet of grate, 200 square feet of heating surface, and carried 200lb. of steam per square inch. It was set in a hot chamber, with an economiser having 50 square feet of heating surface, of which an area of 40 square feet was kept clean by scrapers, and was so arranged that the gases moved in the opposite direction to the water. The furnace was worked either with chimney draught or with forced draught on the closed stoke-hold system, and burnt fuel up to 160lb. an hour. The specialty of the system consisted, mainly, in the provisions made to render possible the accurate determination of the manner in which each part performed its work, as well as to make the performances of each organ, as far as practicable, independent of the performance of the rest. To accomplish this, the boiler and three engines had been separated by intervals of 20ft., 7ft., and 12ft., and the steam distributed by five systems of pipes, while the engine shafting extened over a length of 36ft. This spreading out of the engines entailed greatly increased radiation and additional friction. These quantities, however, being differently measurable, did not confuse the results. The investigation commenced in March, 1888, had been continued at the rate of two trials a week during the session, a trial occupying six, four, or two hours, and being conducted as regular work in the laboratory. As the trials were intended eventually to cover all possible systems of using steam, each system was fully investigated in a series of trials, giving consistent results, before proceeding to another system. After the first twenty-four trials, a scheme was drawn up, commencing with a series of trials of triple-expansion at 200lb. boiler pressure per square inch, with and without steam in the jackets. This series, involving thirty-two trials, was commenced in October, 1888, and completed in April, 1889. Several trials were made at each speed, and the results were found to agree within 1 per cent., so that three trials with steam in the jackets and three without were taken as illustrating the results obtained. The conditions under which this series of trials had been made were, if anything, more favourable to economy than any which prevailed in practice; and although the purpose of these engines was to elucidate the causes of inefficiency rather than to realise the utmost economy, yet it was very desirable that the results obtained should not, whether on account of the comparatively small size of the engines, or from other causes, fall greatly behind what might be expected from high-class engines in actual practice. Hence it was eminently satisfactory to find that, notwithstanding the drawbacks already mentioned, the economic results compared favourably with anything yet obtained in practice, even with the largest engines. The lbs. of coal and of water per I.H.P. per hour were :—

	With Steam Jackets.	Without Steam Jackets.
Coal—Total	1·50 to 1·[illegible]	1·81 to 1·62
Discounting radiation	1·30 to 1·21	1·77 to 1·54
Water—Total........................	14·10 to 12·68	17·50 to 15·90
Discounting radiation	12·59 to 11·90	16·60 to 15·10

Although these results were extremely good, the sources and extents of the various losses were clearly shown. Thus, of the total heat received by the engines exclusive of radiation, with jackets 19·4 per cent had been converted into work, and without jackets 15·5 per cent—the greatest amount which would have been converted had there been no secondary actions being 23 per cent; so that with steam jackets there were losses through secondary actions amounting to 17 per cent, and without jackets to 34 per cent. The manner of the distribution of these losses was also apparent. One important source of loss, which with jackets accounted for 5 per cent of the loss, had been brought to light for the first time. This was the heat carried away from the surfaces of the cylinder and passages, in consequence of the expansion after release. The effects of cylinder condensation were clearly shown in the mean diagrams taken from the trials. Although these trials were not in themselves sufficient to determine anything like a complete law of this action, they exhibited in a striking manner its dependence on certain circumstances. One circumstance in particular, which had not previously received much attention, was here shown to be of primary importance in the action of steam jackets. These diagrams showed that with the temperature of steam in the jackets of No. I. engine the same as that of the initial steam, the effect of the jackets on the cylinder condensation was very small. In No. II. engine, with 80 deg. Fah. difference in the temperature of the jackets and that of the initial steam, the condensation was reduced from 30 per cent to 5 per cent; and a difference of temperature of 180 deg. Fah. between the jackets and the initial steam in engine No. III. entirely prevented condensation. Thus, in these trials, with steam at boiler pressure in the jackets, low-pressure diagrams had been obtained, apparently for the first time, in which the curve of expansion coincided exactly with the curve for saturated steam.

STATE OF THE SKILLED LABOUR MARKET.

THE following memorandum has been prepared for the *Journal* by the Labour Correspondent of the Board of Trade: Although much unsettled and disturbed by the prevalence of strikes and other disputes during the past month, the skilled labour market has, on the whole, continued to show signs of general improvement. That this is so is clearly testified by the various societies of workmen sending in returns. The extent of the disturbance referred to may be gathered from the statement that not less than 92 strikes have been recorded as commencing in November. Many of these were of short duration, but some of the more important still continue. Of these stoppages of work, 17 were in the woollen trade, 14 in the cotton trade, 15 in the coal trade, 6 in various branches of the iron trade, 5 in the shipbuilding trade, 8 among dock labourers, and the balance among miscellaneous industries. Still, in spite of the special causes of increase in the number of unemployed members, the returns of most of the societies reporting show a diminution in the numbers of those out of work. The only notable increase is in the engineering trade, in which one or two important disputes are still pending, and these have had the effect of sending up the proportion of unemployed in this trade from 1·5 to 2·1. On the other hand, the trades which have shown most improvement are the cotton and printing trades, the decrease in the number of those out of work in the former being represented by a fall from 13·8 last month to 2·8 for the present month. The shipbuilding trade remains remarkably steady, and the demand for the various classes of labour required is greater than ever before. The chief society in this branch of industry has increased its membership considerably during the year, as have most of the large trades unions in the engineering and other allied trades. The iron shipbuilders' society has now a total of 33,000 members, of whom only 501 are returned as unemployed. As yet the building trades have suffered but little from seasonal causes, and the demand for labour has been well sustained. The coal, iron, and steel trades are also very fully employed, and seem likely to remain so for some time to come. Summarising the returns, it may be said that, in all, 21 trades unions have reported. These show a total of 207,952 members, of whom 3,173 are unemployed, a proportion of 1·5. The figures of the same societies for last month were 3,665, a proportion of 1·8 per cent. Considering the season of the year, these figures indicate a remarkably prosperous condition of the skilled labour market. The statements of these unions as to the general state of their labour market sum up as follows :—"Very good," 13; "good," 6; "moderate," 2.

EXPERIMENTS ON THE REMOVAL OF MINE GAS BY EXHAUSTION.*

AT the King's mine at Grevenberg, near Aachen, a series of experiments was carried on between the year 1886 and 1888, by the late manager, Mr. D. Hilt, having for their object the direct removal of the gas given off by the coal by means of an exhauster. The seam on which the trial was made varies from 6ft. to 6½ft. in thickness, with a dip to the south varying from 20 deg. to 50 deg. The coal is got in pillar work, the pillars, 50ft. high (measured to the rise), being separated by levels of 16½ft., which are further divided by a middle wall made of stone partings and small coal into two roads of 6½ft. each, an arrangement that allows the air to be carried well into the front of the heading.

The ventilation of the mine is considered to be very good, from 100 to 140 cubic feet per minute of fresh air being provided for each of the fifty-five to sixty men working in the district under consideration.

The removal of the gas was effected by a disused compresser, which, by an alteration of the valves, was made to do duty as an exhauster. The cylinder was 471 millimetres in diameter, with a stroke of 936 millimetres, giving a capacity of 0·16 cubic metre per stroke, which, at 15 revolutions per minute, correspond to 6,912 cubic metres (244,000 cubic feet) per twenty-four hours. From the engine a main pipe of 3¾in. diameter was carried down the pit and for a distance of about 1,300 yards, when secondary pipes of 2in. were placed for about 300 yards in the main levels. Finally, smaller pipes, of 1in. bore and terminated by plate suction roses, were extended into the front of the headings, and kept to the top of the level by clamps attached to the timbering. The roses were at first made of tin-plate perforated with fine holes on both sides, but these were found to admit too much air on the under side, especially in a weak gas current, so that ultimately the under side was closed and the perforations on the top surface were correspondingly enlarged. In places where the dip of the seam was comparatively low, the roses were made of a long rectangular form, and covered with wire gauze like that used in safety lamps. Vacuum gauges were inserted at different points in the tubes to measure the effective rate of exhaustion. This, during the period of the principal experiments in February to May, 1887, varied from 235 millimetres water column near the pit bottom to 40 millimetres at the end of the main pipe of 1,330 yards, and 30 millimetres at the end of the secondary main. In the inch pipe it varied from 25 millimetres to 2 millimetres at the most distant suction rose, which was about 325 yards away. For a short time a Körting steam-jet exhauster was tried, but it did not prove equal to the work, the depression at the measuring station No. 2, being only 10 millimetres, instead of 40 millimetres realised by the pump. The flow of the exhausted gases was regulated by a double-bell gasholder, so arranged that while one bell was being filled the other was delivering. This, however, did not work satisfactorily, and was abandoned, the gases being forced directly by the pump into the delivery pipe. Several small gasometers were used for experimental purposes and testing, the latter being done every twelve hours.

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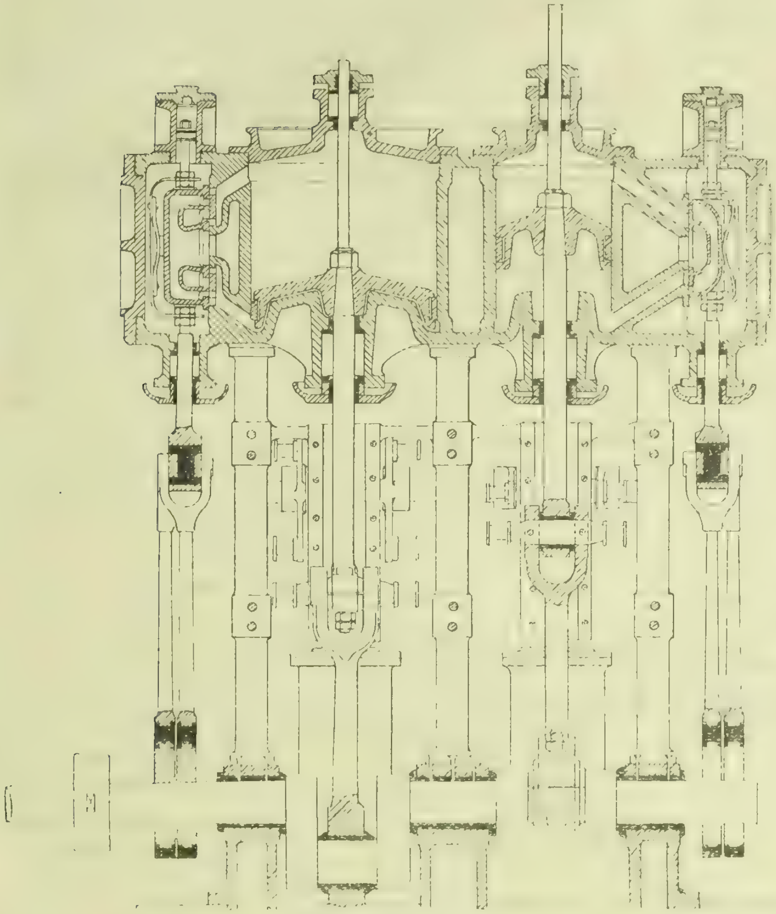
* By H. Brenner, Inst.C.E., Foreign Abstracts.

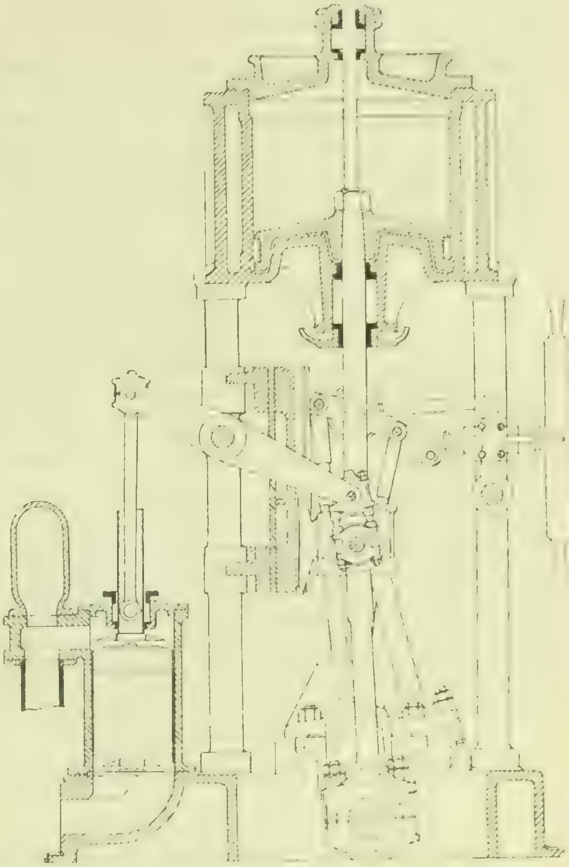
COMPOUND MARINE ENGINES OF 100 I.H.P.

CONSTRUCTED BY MESSRS. E. C. CRAVERO AND CO., ENGINEERS GENOA.

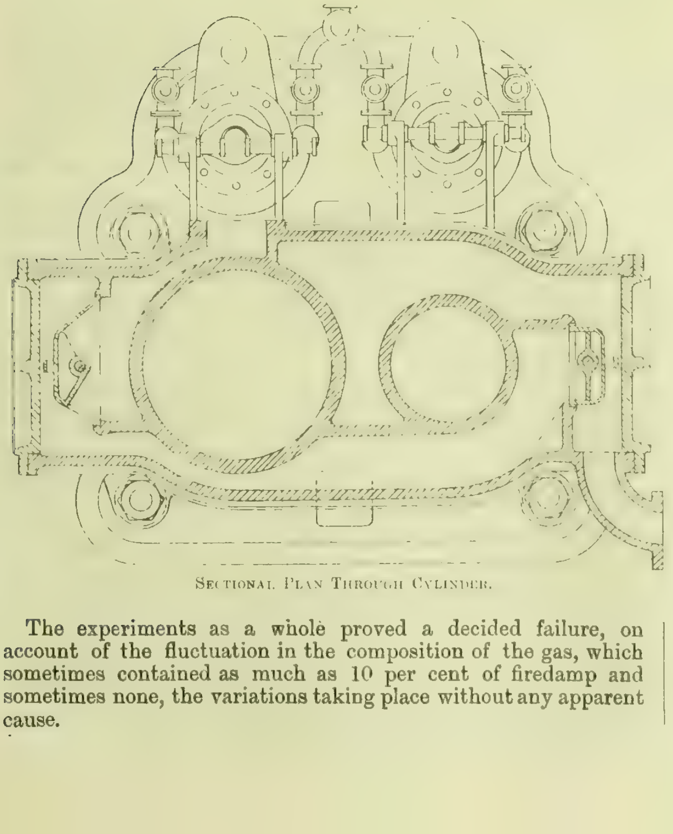
(For description see page 876.)



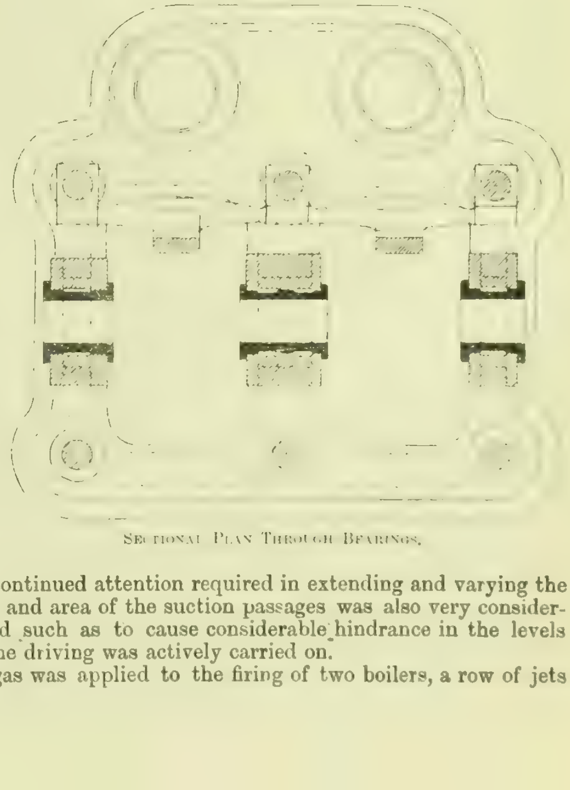
Longitudinal Section.



Transverse Section.



Sectional Plan Through Cylinder.



Sectional Plan Through Bearings.

The experiments as a whole proved a decided failure, on account of the fluctuation in the composition of the gas, which sometimes contained as much as 10 per cent of firedamp and sometimes none, the variations taking place without any apparent cause.

The continued attention required in extending and varying the position and area of the suction passages was also very considerable, and such as to cause considerable hindrance in the levels when the driving was actively carried on.

The gas was applied to the firing of two boilers, a row of jets being introduced below the firebars from a tube which was connected with the main by a safety U tube sealed with water, and at all the joints of the pipes wire-gauze diaphragms similar to those used in safety lamps were inserted.

The boilers were experimented on for some time, but neither a more active evaporation nor any saving in fuel was obtained. The gas was also tried with the magnesia comb burner of Fahnjehelm, but only the lower third of the bars could be brought to the proper degree of incandescence. The third suggested application of the gas, viz., for driving gas engines, was not tried.

H. B.

COMPOUND MARINE ENGINES OF 100 I.H.P.

We illustrate on page 875 a marine engine of the compound type, constructed by Messrs. E. C. Cravero and Co., engineers, of Genoa, which is of neat design and well arranged for lightness and strength. The cylinders are supported from the bed plate on six steel pillars, three of which are stayed together by brackets carrying the crosshead guides, and the reversing gear is worked from the front.

The cylinders are respectively 265mm. (about 10_{16}in.) and 435mm. ($17\frac{1}{8}$in.) diameter; while the stroke is 275mm. (about $10\frac{13}{16}$in.). The ratio of high to low pressure cylinder is thus 1 to 2·7. The surface condenser is entirely separate from the engine, but the air pump, which is single-acting, is driven from a lever at the back. The condenser contains 324 tubes, of 324mm. length (about 45·6in.), and 16mm. ($\frac{5}{8}$in.) internal diameter, and 18mm. ($\frac{11}{16}$in.) external diameter. The total condenser surface is 21·25 square metres (about 228 square feet), or 0·2125 square metres per I.H.P. per hour.

The air pump is 180mm. in diameter ($7\frac{1}{8}$in.), with a stroke of 190mm. ($7\frac{7}{16}$in.), and the ratio of pump to low-pressure cylinder capacity is as 1 to 8·7. The circulating pump is slightly smaller in diameter than the air pump, but with the same stroke.

The crank shaft is 100mm. ($3\frac{15}{16}$in.) diameter, and is of steel, while the piston rod and crank are also steel. The air pump is placed below the low-pressure cylinder, and the circulating pump below the high-pressure cylinder. Trick valves are used upon both high and low pressure cylinders, and the reversing gear is of the usual link type.

STEAM ON COMMON ROADS.—IV.

(Continued from page 842.)

In August, 1841, the General Steam Carriage Company was formed for working Hill's patents. It was urged by the promoters that the demand for additional accommodation on some roads really existed, because it was desirable that road locomotion should counteract the exorbitant charges made by the gigantic railway monopoly for conveying goods short distances. The company state in their prospectus that "while they confidently believe the improved steam coach which they have engaged and propose to employ in the first instance to be the most perfect now known in England, they do not bind themselves to adhere to any particular invention, but will avail themselves of every discovery to promote steam coach conveyance." Instead of making short and showy trips on good suburban roads, Mr. Hill selected for his curriculum those roads which, from the peculiar difficulties they presented, were likely to point out every variety of provision that need be made, or circumstances that were to be guarded against. The Windsor, Brighton, Hastings, and similar roads, had been traversed with uniform success. Perhaps no more satisfactory performance could be cited of a common road steam carriage making a trip to Hastings and back, a distance of 128 miles, which was performed in one day, it being accomplished in half the time occupied by the stage coaches. The editor of the *Mechanics' Magazine* said: "We accompanied Hill, about a year ago, in a short run up and down the hills about Blackheath, Bromley, and neighbourhood; and we had again the pleasure of accompanying him in a delightful trip, on the Hastings Road, as far as Tunbridge and back. The manner in which his carriage took all the hills, both in the ascent and the descent, proved how completely every difficulty on this head had been surmounted; Quarry Hill rises 1 in 13, River Hill, said by coachmen to be the worst hill in the country, rises 1 in 12." We illustrate Hill's steam carriage by figure 4. It will be seen from the engraving that the whole of the coach and machinery were erected upon a strong frame mounted upon substantial springs; the hinder part was occupied by the boiler, furnace, and water tanks, with a place for the engineer and stoker. In front of these was a coach body capable of holding six people inside, three on the box, and the conductor in front. The front part of the carriage was suspended upon springs also, making the motion delightfully easy and agreeable. The carriage was propelled by a pair of 10in. cylinders and pistons, lying horizontally beneath the carriage, which acted upon two 9in. cranks on the main axle, which were coupled to the main axle through the compensating gear already referred to; the two 6ft. 6in. diameter driving wheels had the full power of the engines passed through them, yet in case of any differential velocity required by either wheel when turning corners the compensating bevel wheels revolved, and thus allowed the engine to turn about any way. The weight of the boiler when empty was 23cwt. When filled it held about sixty gallons of water, and one hundred gallons more were contained in the tanks which surrounded it. The quantity of water taken in at each of the stations (which were arranged as nearly as possible in eight-mile stages) was about eighty gallons. The total weight of the carriage, including water, coke, and twelve passengers, was less than four tons. When working on heavy and rough roads the steam pressure was seventy pounds per square inch, but on good roads sixty pounds was amply sufficient. The average travelling speed was sixteen miles an hour; on a level road a speed of twenty miles an hour has been realised. In long journeys, however, on public roads, the speed was regulated more by the casual obstructions arising from the ordinary traffic than by the power of the steam. Mr. Hill's long experience proved to him that passengers could be conveyed by steam coaches at half the expense, and at double the speed of the stage coaches.

Anderson.—Sir James Anderson, Bart., of Buttevant Castle, Ireland, as far back as 1827 was engaged in the steam-carriage enterprise in connection with Mr. James, of Holborn, the former, doubtless, finding the money to enable James to patent his inventions and carry out many experiments, until Anderson fell into pecuniary difficulties, which caused a dissolution of partnership, which was shortly followed by the discontinuance of James's experiments. But ten years afterwards we find the Baronet of Buttervant Castle engaged in steam-carriage construction on a grand scale on his own account. In 1838 he says: "I have spent two apprenticeships to this undertaking, and have expended £30,000 on experiments."

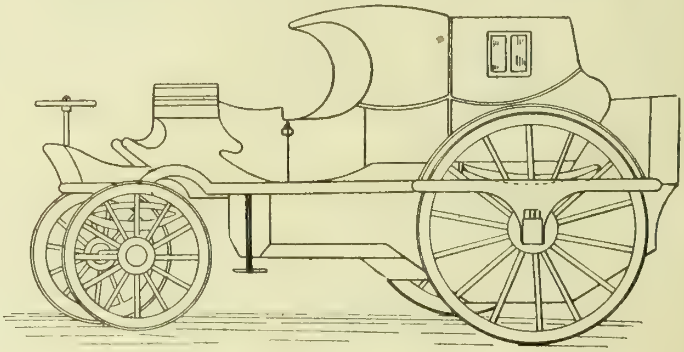


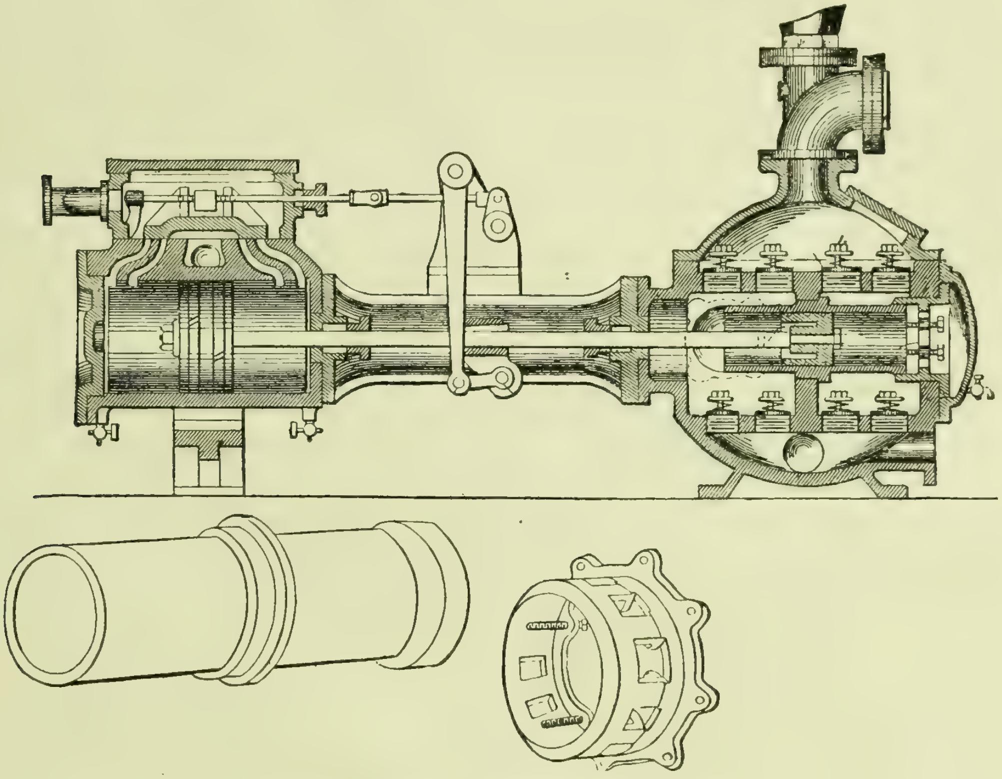
Fig. 4.

Sir James Anderson first of all patented a boiler suitable for steam carriages, which we are told was a poor copy of Hancock's boiler. Maceroni says: "Sir James Anderson's plagiarism on Hancock's boiler will bring steam road travelling into contempt." While Hancock says: "The flat chambers, as arranged, cannot succeed, and really are an infringement of my patent;" but he says, "the boiler is sure to fail, so he need take no further trouble respecting it."

A joint-stock company was launched, having for its object the introduction of Sir James Anderson's steam carriages on common roads, termed the Steam Carriage and Wagon Company. The prospectus intimated that several steam drags were in course of construction in Dublin and in Manchester, which, when completed, were to convey goods and passengers at double the speed and at half the cost of horse carriages. Sir James Anderson says: "I produce and prove my steam drags before I am paid for them, and I keep them in repair; consequently, neither the public nor the company run any risk; the first steam carriage built for the company is nearly completed. It will speak for itself." His friends said he had failed in twenty-nine carriages to succeed in the thirtieth. In the *Mechanics Magazine*, June, 1839, a Dublin correspondent writes: "I was fortunate enough to get a sight of Sir James Anderson's steam carriage, with which I was much pleased. It had just arrived from the country, and was destined for London in about three weeks. The engine weighs 10 tons, and will, I dare say, act very well. I shall have an opportunity of judging that, as the tender is at Cork. It has a sort of diligence, not joined, but to be attached to the tender, making in all three carriages. I talked a great deal about it to one of his principal men, who was most lavish in its praises, especially as regards the boiler." In July, 1839, it was announced by the papers that the vessel, having Sir James Anderson's steam carriage on board, sailed from Dublin for London, and was hourly expected, and upon arrival would be put together as quickly as possible, and submitted to such a trial as the directors of the Steam Carriage Company shall direct. In August, the long-expected carriage had at last arrived, and was undergoing the finishing touches of a London engineer, previous to its essay at locomotion on the roads of the metropolis. Meanwhile, Hancock's "Automaton" was kept in readiness to compete with the long-vaunted powers of the machine of the Knight of Buttervant Castle. Colonel Maceroni was also preparing to take the road with his never-failing fountain of vapour. So we may judge that the result of the competition was awaited with interest, but the event does not appear to have taken place. In 1840, Mr. J. Rogers says: "Several steam carriages are being built at Manchester and Dublin, under Sir James Anderson's patents, and one has been completed at each place. At Manchester the steam drag had been frequently running between Cross Street and Altrincham, and the last run was made at the rate of twenty miles an hour, with four tons on the tender, in the presence of Mr. Sharp, of the firm of Sharp, Roberts, and Company, of Manchester, and others." The *Morning Herald* for 30th June, 1840, contained a long account of the doings of these steam drags, from which we gather the following particulars: An experimental trip of Sir James Anderson's steam drag for common roads took place on the Howth Road, Dublin. It ran about two hours, backing and turning about in every direction—the object being chiefly to try the various parts in detail. It repeatedly turned the corners of the avenues at a speed of twelve miles an hour, the steam pressure required being only forty-six pounds per square inch. No smoke was seen, and little steam was observed. The whole machinery was ornamentally boxed in, so that none of the moving parts were exposed to view, and it was found that the horses did not shy at this carriage. The directors of the company were to assemble at Manchester, in order to witness a trial of the steam carriage constructed there, after which a meeting was to be called at Dublin for the purpose of forming a company in conjunction with the one already established in England, for opening up a communication by means of these drags between the chief towns in Ireland, as soon as a few of the steam carriages were finished. It was proposed that the united company should, in the first instance, in conjunction with the railway trains from London, run from Birmingham to Holyhead, the passengers to be thence conveyed to Dublin by steamer; from Dublin to Galway the steam drags were to be employed; and thence to New York per vessel, touching at Halifax; thus making Ireland the stepping-stone between England, Nova Scotia, and the United States of America. It will be seen that Sir Jas. Anderson purposed great things with his steam carriages, but judging from the paucity of the literature dealing with his public trials, we fear that little practical running was accomplished.

Want of success, however, does not appear to have caused him to relax his energies, for in addition to the carriages we have referred to, many more schemes were proposed and patented, the latest bearing the date of 1858, showing that Sir James Anderson, Bart., devoted no less than thirty-one years of his life to the furtherance of steam locomotion on common roads.

(To be continued.)



IMPROVED WATER CYLINDER FOR STEAM PUMPS.

IMPROVED WATER CYLINDER FOR STEAM PUMPS.

The accompanying illustration shows the design of steam pump manufactured by the Buffalo Steam Pump Company, and fitted with their improved water cylinder. The improvement consists of an auxiliary sleeve, which supports and holds the removable water barrel or sleeve. It is bolted against the head of the water cylinder, and is bored to receive the end of the water barrel. Lugs cast on the inside of the sleeve are tapped for set screws, which are set up against the water barrel, holding it firmly against the partition in the water cylinder, which is bored and faced to receive it. It will be seen from this that the water barrel has two points of bearing, thus giving rigidity to the barrel, and holding it in line. It is a well-known fact that all working barrels wear on lower side first. The improved barrels can be easily turned, so that the wear will be alike on all sides. They are made of iron, unless otherwise ordered. The makers recommend composition when used for pumping acid. The pistons, working barrels, and auxiliary sleeves can be removed without disconnecting the piping.—*Master Mechanic.*

THE FORTH BRIDGE.

The present year, now rapidly drawing to a close, will be memorable among the years of the nineteenth century as having seen the practical completion of the greatest work of constructive engineering which the history of the world has witnessed. We allude, of course, to that mighty structure—a characteristic product of modern daring, knowledge, and practical engineering skill—the Forth Bridge. Perhaps no structure which engineers have yet attempted marks so definitely the enormous extension of human power and control over nature, while at the same time contrasting so forcibly the advance in liberty and humanity with the comparative disregard for human life and limb which was formerly so common among civilised races where constructive works were concerned.

When compared with ancient civilisations, the extreme economy of human effort and relative safety in carrying out this daring work are most striking. We are told, for example, by the best Egyptian authorities, that a single large stone of one of the temples occupied two thousand men for three years in conveying it from the place where it was quarried to its destination, and that the Canal of the Red Sea alone cost the lives of a hundred and twenty thousand Egyptians, while to build one of the pyramids required the labour of three hundred and sixty thousand men for twenty years. The boasted pyramids presented no engineering difficulties under conditions such as these, and the insignificance of result produced by lavish expenditure of life in the old civilisation may well be contrasted with the stupendous result attained by the labours of the comparatively few men employed in modern constructions such as the Forth Bridge.

This bridge is a grand example of the extension of men's feeble power by invention and thought. In the course of its construction we have repeatedly published accounts of the work in its various stages, and illustrated many of its details. We here give an illustration of the completed work, as now seen in its massive entirety, in the hope of enabling our readers to realise its general appearance and huge proportions, however imperfectly.

Mr. B. Baker and Sir John Fowler, the distinguished engineers to whom the inception and perfect design of the structure are due, have very modestly disclaimed originality of principle, and have informed us repeatedly, in speeches and lectures, that the cantilever principle is many hundreds of years old, and was adopted at least 230 years ago in a wooden bridge of 112ft. span, in a country so remote as Thibet. The Chinese, also, who seem to have anticipated all inventions if historians are to be credited, are said to have used the principle. These, however, cannot be considered real anticipations. They are bridges, no doubt, just as Newcomen's crude contrivances were steam engines; but, nevertheless, they do not diminish, but rather enhance, the boldness of design and execution which enabled the engineers to see in such crude materials the germ of a really great departure. The departure is quite as great and extended in its consequences as the development of the beautiful modern engine from the crude machine of Newcomen.

Even engineers can scarcely realise the efforts made, and the absolutely continuous exercise of constructive ingenuity, as well as inventive skill, imperatively required in meeting the difficulties of execution perpetually cropping up. Those of us who have had experience in the shops of difficulties of detail in new departures of comparatively small moment, can appreciate, though probably not fully realise, the ability and success with which this great undertaking has been carried through, and the small number of men employed, as well as the comparatively slight loss of life incurred. In 1884, the preliminary arrangements of necessary workshops, and a jetty, run out into shallow water, about 2,000ft. long, were complete, and the real work of the structure began.

The contractors, Messrs. Tancred, Arrol, and Co., had made most extensive and complete preparations in the way of large workshops, latterly covering some fifty acres, fitted with all the appliances and tools which ingenuity could suggest and experience construct. There the whole metal work of the bridge was constructed, and the huge caissons for the cantilever piers were built ready for launching. The novel portion of the bridge consists of three huge cantilevers or brackets, each of which springs from a central tower. Each tower consists of four great riveted columns of steel, each column 12ft. in diameter, and springing in the air to a height of 370ft. above the water level. Each group of four forms a tower, and similar but smaller inclined columns tie each pair together, while ties and cross pieces firmly hold them transversely. Each column rests upon a separate foundation, so that for the three towers twelve piers in all have been constructed. Six of them were comparatively simple in construction, being either on the land or in shallow water.

The island of Inchgarvie, in the Firth, was utilised for the piers of one tower, and the north or Fifeshire cantilever was built on the shore. Six piers, however, required to be constructed in deep water, and in accomplishing this much special skill was required. Six huge iron caissons were built upon launching ways like a ship, each 70ft in diameter and 60ft. in height. The bottom of each was set up 7ft. above the lower edge, leaving a cutting edge to bear upon the clay, and forming a chamber 70ft. in diameter and 7ft. high, capable of being pumped full of compressed air, and making, when required, a huge diving bell in which men could work. The ironwork weighed about 500 tons, and when launched they were floated to position with concrete and brickwork added, bringing up the weight to 2,700 tons.

When in position additional concrete was filled in, and when the weight reached 3,300 tons the caisson grounded in the sea bottom, where a bed had been prepared for it with sand bags. The workmen then entered from above by air locks, and the rock excavation was proceeded with under electric light, and with a continuous supply of compressed air forcing out under the edge, and keeping out the water. For this purpose Italian workmen were employed, who had been long inured to work under pressure of 72in. mercury. By digging out the hard boulder clay, or excavating the rock, the caisson slowly settled, and was firmly bedded in its required position. It was then completely built up, and upon it there was built a granite superstructure, firmly bolted to the foundation by attachments, whose ends were visible high above water. At the beginning of 1885 a serious accident occurred to one of the caissons on account of an unusually high tide and severe gale, which caused it to slip on the clay and cant to one side. This took more than 12 months to put right, and it was not till the spring of 1886 that all the cantilever piers were ready for the erection of their respective towers.

The towers were rapidly built, and the great projecting arms of the cantilevers were slowly built out, the whole construction being carried on symmetrically from each side of each tower, so as to keep the opposing weights in perfect balance. The tension upper members were also riveted in position, and the whole structure gradually grew to completion, more like a plant than a mechanical construction. The total weight of the steel work of the bridge is 50,000 tons, and this material was delivered at the works and shaped before being placed in position, marked, drilled, and riveted up.

Mr. Baker conveys an admirable idea of the magnitude of the bridge in comparison to the Britannia Tubular Bridge across the Menai Straits, which has a span of 455ft., while the Forth Bridge is 1,700ft., just three and two-third times as great. Now, the increased dimensions are not merely lineal, but height and breadth necessarily go together, Mr. Baker reminds us that a medium-sized horse is just about three and two-thirds the size of a medium-sized dog, and our largest ironclad only three and two-third times larger than a torpedo boat, so that we get a tolerably clear comprehension of the enormous comparative bulk.

When the cantilever arms were built out, a gap of 350ft. remained between each outside cantilever and the ends of the central one. These spaces are each spanned by a hog-backed girder, weighing 800 tons, which was formed by building out from the ends until the two parts met in the middle. Bolt attachments were then inserted into holes, and the temporary fastenings serving to build out from were undone. These central girders rest upon the cantilever arms, and most ingenious arrangements are made to permit of free expansion of the whole structure under varying temperatures.

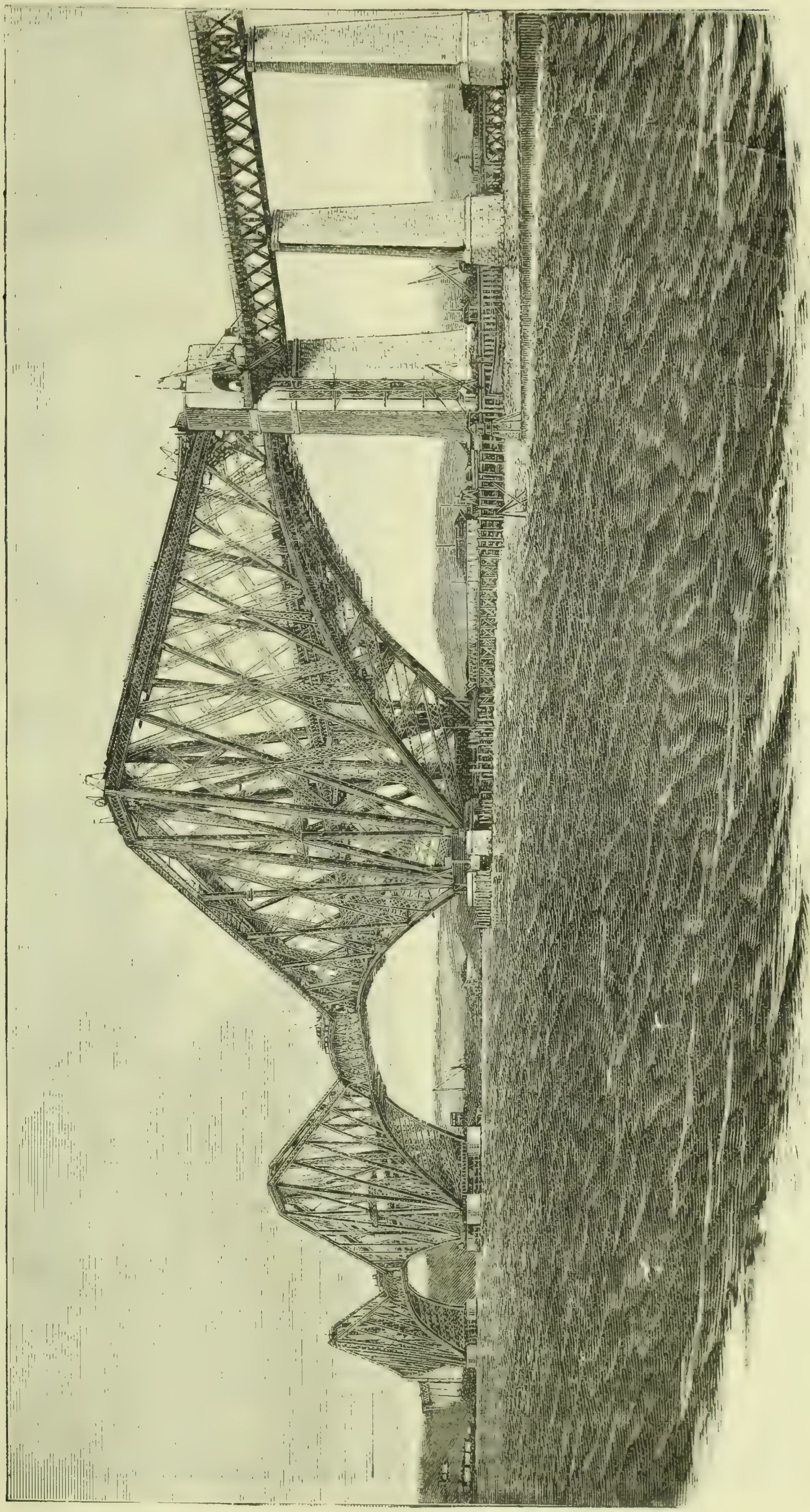
The bridge is constructed to withstand an average wind pressure from any angle of 56lb. per square foot, and a rolling load of 2,200 tons, while the highest wind pressure ever registered in the worst gale in this country was 41lb. per square foot, and that only for a limited area, while the rolling load the bridge will have to bear is only some 800 tons.

The horizontal pull upon the brackets is 10,000 tons, while the pressure upon their base is 100,000 tons. The brackets are enormously strong, and capable of having half a dozen of the largest ironclads hung upon them. The tensile strength of the steel used varies from 28 to 37 tons per square inch, while the maximum actual strain nowhere exceeds 7½ tons, and where the strain is subject to rapid change or alteration, 4 tons.

The problems which have been met and successfully solved in this bridge are of the most momentous kind, and a minute study of the varied mechanism and modes of work employed will well repay the practical engineer.

It has a beauty peculiarly its own, and the light tracery of the tension members contrasts strikingly with the heavy tubes in the towers and lower portion of the brackets.

The much-vaunted Eiffel Tower is a mere toy compared to this



THE FORTH BRIDGE.

FROM THE SOUTH-EAST.

great work, as one can readily see on understanding that two Eiffel Towers, placed base to base, barely make one complete cantilever, and would be insufficient to support their own weight in a horizontal position.

Other countries, including America and France, seem inclined to follow our lead in this respect, as they have often done in other engineering matters; and it is a matter for some congratulation to Britain that such a work originated with us, notwithstanding all the supposed advance of foreign engineering.

DISASTROUS BOILER EXPLOSION NEAR GLOSSOP.

Board of Trade Inquiry.

A formal Inquiry, instituted by the Board of Trade, under the provisions of the Boiler Explosions Act, 1882, was held at Charlesworth, on Wednesday week, into the circumstances attending the explosion of a boiler at Lee Vale Mill, Charlesworth, near Manchester, on the 1st November. Considerable importance was attached to the inquiry owing to the peculiar circumstances under which the explosion occurred, and the case excited great interest, not only in the immediate locality, but throughout the district generally. The Commissioners appointed by the Board to conduct the inquiry were Mr. Howard Smith, barrister-at-law, and Mr. W. C. Lang, civil engineer. Mr. E. Gough conducted the case on behalf of the Board of Trade; Mr. W. L. Hockin, solicitor, Manchester, appeared for the Engine, Boiler, and Employers' Liability Insurance Company Limited, Manchester; and Mr. Crosse, solicitor, also of Manchester, appeared for Mr. John Booth, of the firm of Messrs. George Booth and Sons, on whose premises the explosion occurred; Mr. Booth and the Insurance Company having been made parties to the inquiry. Mr. Michael Longridge, chief engineer to the above-named company, and Mr. John Booth were personally in attendance.

The facts of the case, as brought out in evidence, were briefly as follow: Messrs. George Booth and Sons are cotton band manufacturers and reelers, carrying on business at Lee Vale Mill, Charlesworth. The firm originally consisted of three brothers, Robert, William, and John. After the death of Mr. William Booth the business continued to be conducted by the surviving partners, Mr. Robert Booth attending to the practical working, and Mr. John Booth spending most of his time in promoting the business of the firm at Manchester, as buyer and seller of goods. In November, 1874, the firm purchased a boiler from a Mr. Joseph Brammah for £41. Mr. Brammah told them it was about a year old, and that it had been worked at a pressure of 120lb. Messrs. Booth thought they had got a good bargain. The boiler was of iron, and of the Cornish type. The cylindrical part of the shell, which was 4ft. 5½in. in mean diameter, and 10ft. 2in. long, consisted of three rings, each formed of three plates three-eighths of an inch thick. The flue was also composed of three rings, each made up of two plates of the same thickness. For some time after the boiler had been fixed at the mill it was only used for about five months in each year—for the purpose of heating the mill during the winter months. In the year 1888, however, fittings were put upon the boiler, and it was brought into regular use, but it did not appear that at any time during the period it was in Messrs. Booth and Sons' possession there was a thorough examination of the boiler. On two occasions it was repaired, but the man who did the work stated that he had no instructions to test or examine the boiler, and accordingly he did not examine it. In May of the present year Messrs. Booth effected an insurance of the boiler with the Engine, Boiler, and Employers' Liability Company Limited, for the sum of £300, the premium being £1 10s. per annum. The insuring company pressed upon Messrs. Booth the desirableness of a thorough inspection of the boiler, but time went on without this work being done. At length, in the month of August, an arrangement was made to have the boiler thoroughly overhauled by one of the company's inspectors. The post-card sent from the company's offices stated: "It is essential that the boiler should cease working the day previous, and that it be thoroughly cleaned, both internally and externally. Where there are brickwork flues all soot and flue dust should be removed, and grates and bridges should also be taken out, otherwise it is impossible to make a satisfactory examination." When the inspector arrived he complained that the work of preparation was not sufficiently complete to admit of his making a thorough examination, and so no examination was made. Matters went on as before, and on the afternoon of the 1st November the boiler exploded, and caused the deaths of Mr. Robert Booth and Mr. George Harry Booth, a youth who was employed at the mill, and related to the proprietors. It transpired that Mr. Robert Booth attended to the boiler himself almost constantly, and it was urged by Mr. Crosse that this was a proof of his belief in the soundness of the boiler, and that he had not subjected any employé to a risk which he was not himself willing to run. It should be stated also that the insurance company, after the fruitless visit of their inspector, brought under the notice of Mr. Booth certain facts relative to the condition of the boiler, which, it was urged, ought to have placed him on his guard and made him realise the need for a proper examination. Attention was called by Mr. Gough to the following statement in the prospectus issued by the company: "The insured are under no obligation to adopt any suggestions that may be made, nor will the non-adoption of such suggestions in any way affect the validity of a policy, so long as the stipulated pressure on the piston of the engine or on the safety valves of the boiler is not exceeded." Forty pounds was the amount stipulated in the policy of insurance, and the boiler went off at about 28lb.

At the conclusion of the examination of witnesses Mr. Gough put the case for the Board of Trade before the Commissioners in the form of questions as follow:—As regards Mr. Booth: What was the date of the purchase of the boiler, and what was its cost? What measures were taken by Messrs. George Booth and Sons from the time the boiler was purchased to May, 1889, to satisfy themselves that the boiler was in good and proper working order, and that it could be used without danger to the lives of their workpeople? Was the working and management of the boiler always or at any time entrusted to a competent person? By whom and how frequently was the boiler examined by a person or persons competent to find out defects therein? For what purpose was the boiler insured in May last, and what were the conditions of the policy? What were the circumstances in which Messrs. Booth neglected to have the boiler examined after receiving the report from the insurance company in May until August? Was the boiler in a fit and proper condition for examination in that month, and were Messrs. Booth justified in working the boiler after receiving the report of the insurance company on the 22nd August last? Were Messrs. Booth justified in neglecting to take any action with a view to a thorough examination of the boiler after they received the report (with the printed notice at foot thereof) last referred to? As regards the Engine, Boiler, and Employers' Liability Company or Mr. Michael Longridge, their chief engineer, the following questions arise: Did the company cause a proper and sufficient examination to be made of the boiler before insuring it, and, if not, were they justified in insuring it without a thorough examination? Was a proper and sufficient examination made of the boiler in August last? Was the report issued by the company on the 22nd August last, with the printed notice at the foot thereof, such as would be likely to mislead persons to whom it was addressed, and did such report mislead Messrs. Booth? Was the inaction of the insurance company in not pressing for further opportunities for examination after issuing the report of the 22nd August last misleading and likely to create a false sense of security in the owners, who possessed but little practical knowledge of boilers, or of the conditions under which they may safely be worked? Is the court of opinion that the examinations were made by this company entirely in their own interests? Did the insurance company clearly state that the inspections ordinarily made on their behalf were no guarantee of the safe working condition of the boiler insured by them, and, if not, were they justified in neglecting to impress this fact upon the owner? Finally, whether blame attaches to Mr. Booth as representing the firm of Messrs. George Booth and Sons, and to Mr. Longridge as representing the Engine, Boiler, and Employers' Liability Company? The court are also desired to report whether, in the interests of public safety, it would be desirable for insurance companies to state clearly and prominently that the inspections ordinarily made on their behalf are no guarantee of the safe working condition of boilers insured by them.

Mr. Hockin and Mr. Crosse having addressed the Commissioners in the interests of their respective clients.

Mr. Howard Smith, in giving judgment, recapitulated the facts of the case, and commented in strong terms on the conduct of Messrs. Booth and Sons in not having a thorough examination of the boiler made at any time during the fifteen years they had had possession of it. Commenting on the visit of the inspector on the 20th August, he suggested that the man might with very little trouble have satisfied himself as to the rotten condition of the boiler plates, although he might not have been able to make the complete examination he desired. Still, the examination that was made enabled the company to inform Messrs. Booth that the brickwork was very wet, "owing to rain finding its way into the bottom flue," that many of the plates were corroded and the boiler evidently of great age, and that it was considered very desirable to have the boiler thoroughly examined externally and internally. Nothing more was said or done apparently until November 1st, when the boiler burst. These being the facts of the case, the Commissioners had to consider whether Mr. John Booth, as representing the firm, was to blame, and they had come to the conclusion that he was very much to blame. They thought that it was a disgraceful case—the most disgraceful one that had come under their notice. Here was a boiler in the vicinity of Manchester, where there was every facility for an inspection by the best mechanics in the country, and yet for 15 years there was no thorough examination. And after the report of the insurance company in August, calling the attention of the firm to the unsatisfactory features, nothing was done. The Commissioners had come to the conclusion that the whole management of this boiler was disgraceful in the extreme. It was a case of utter recklessness and incompetency, and, as far as he could make out, one of utter disregard of human life. If a man did not know anything about boilers, he had no right to take upon himself the management of them. And in this case, supposing two servants had lost their lives, he did not see what defence the proprietors could have to a charge of culpable negligence. With reference to the insurance company, the Commissioners found that they did not make at any time a thorough examination, as of course they did not pretend to have done. Then it was asked, "Was the report which was sent by the company on the 22nd Aug. likely to mislead?" On that point the Commissioners had come to the conclusion that the report ought not to have misled a reasonable man. Then the question was asked whether the examinations were made in their own interest by the company? The Commissioners thought they were, and it was difficult to see what other interests they would make them in. Their object was to make the best they could of their business, and they got a premium sufficient to give them a profit from the different people whom they insured. Another question was as to whether the company were justified in accepting risks without a thorough examination. There was nothing to prevent their doing so. There was nothing to prevent a company insuring any boiler they liked; they might insure one that was absolutely rotten. But then came the question, which was aimed at by the Board of Trade, whether the action of the company conduced to prevent accidents, and whether they had in mind the great importance of, if possible, minimising these accidents and reducing loss of life. The Commissioners did not think, under the whole circumstances of the case, that the way in which the business was conducted was likely to induce people to keep their boilers up to the best possible conditions. On the contrary, they thought it was rather a premium on careless owners—careless and immoral owners. He was not suggesting that Messrs. Booth were immoral, but they were grossly and recklessly careless. At the same time, they thought that if a person could insure his boiler, and the company were willing to take the risk when they had reasonable grounds, or some grounds, for thinking it was not safe, it would be detrimental to the interests and the preservation of human life. At present companies could do that, there being no statutory enactment against it; but the Commissioners were of opinion that for companies thus to take up risks was somewhat of a premium on the negligence of owners, and conduced, or might conduce, in some measure to the risk on the lives of the employés. The insuring company were not held blameable in this matter, and therefore no part of the costs of the inquiry would fall upon them. In view, however, of the conduct of the Messrs. Booth, the Commissioners directed that they should contribute the sum of £75 towards the costs and expenses of the inquiry.

BOILER EXPLOSION AT NORTHWICH.

Formal Investigation by the Board of Trade.

A formal Inquiry was held at Winsford, Cheshire, on Monday week, by Commissioners acting for the Board of Trade, in accordance with the provisions of the Boiler Explosions Act, 1882, into the circumstances attending the explosion of a boiler on the steam flat Development, in Saltersford Lock, Barnton, Cheshire, on the 19th October last. The Commissioners appointed to conduct the inquiry were Mr. Howard Smith, barrister-at-law, and Mr. C. Lang, civil engineer. Mr. Gough represented the Board of Trade, and Mr. Cooke appeared for the Salt Union Limited, the owners of the vessel upon which the casualty occurred. Mr. Joseph Verdin, managing director of the Salt Union, and other officials of the company, were present at the inquiry.

The explosion, which was of a very violent and destructive character, took place about six p.m. on Saturday, October 19, whilst the flat was passing through the Saltersford Lock, on the river Weaver, on her way from Northwich to Acton Bridge. The vessel was sunk by the explosion, and the engine-driver was so seriously scalded that he died within a few hours after the accident. The skipper was also slightly scalded. The boiler was of a single-furnace tube, horizontal, multitubular, marine type, and about twelve years old, the furnace having been extensively repaired by the introduction of new plates. An examination of the safety valve, which was of the simple lever construction, revealed the fact that it had been gagged. A wooden wedge had been inserted between the top of the lever and the top of the guide. As the guide was closed at the top, the effect of the wooden wedge would be to hold the lever down and keep the valve from blowing, while no doubt the valve had been gagged in this way to obtain a higher pressure of steam. The condition in which the safety valve was found suggested the conclusion that the cause of the collapse was simply excessive pressure of steam, due to the safety valve having been tampered with by the boiler attendant. The safety valve was loaded to a pressure of 68lb. on the square inch, whereas in the opinion of Mr. Fletcher, of the Manchester Steam Users' Asssociation, it ought not to have exceeded 30lb. The actual extent to which the engine-driver was allowed to go by the rules enforced by Mr. Herman E. Falk, his employer, prior to the formation of the Salt Union in November, 1888, was 45lb. The engine-driver, a young man named Penny, paid for his temerity with his life. It transpired in the course of the investigation that whereas steamers carrying passengers are required to have a safety valve under lock and key which cannot easily be tampered with by the attendant, no such statutory obligation rests upon the owners of steamers carrying merchandise only. Mr. Falk stated that during the time the vessel was under his control he issued a notice to the effect that any man who was caught carrying over 45lb. of steam would be discharged. He did not attach much importance to the locking of safety valves, because many men who were placed in charge of engines were reckless enough to secure for themselves duplicate keys and overload the boilers, in spite of all risk or remonstrance. In the case under notice a boiler-cleaner, named Dean, on one occasion observed that the safety valve was gagged, and called Penny's attention to the fact, but Penny only laughed. On another occasion Mr. Stubbs, the superintending engineer for the Salt Union, saw the steam blowing off at a pressure of from 65lb. to 70lb., yet took no trouble to inquire if the boiler was fitted to stand such a strain. Mr. Stubbs admitted, also, that from a fact which had come to his knowledge the plugging of safety valves was not an unknown thing, and he simply cautioned the offender, but did not report the case to his superiors. For this omission he was held by the Commissioners to be greatly to blame.

At the conclusion of the evidence, Mr. Gough, on behalf of the Board of Trade, asked for the decision of the Commissioners on the following points: Whether, after the Salt Union took over the vessel from Mr. Falk, they took proper measures to ensure that the boiler was being worked under safe conditions? 2. Whether the Salt Union employed persons who were properly qualified to manage and examine the boilers from time to time? 3. Whether the Salt Union and their superintending engineer adopted the regulations issued by Mr. Falk to the engine-drivers in his employ, and were these regulations issued with a view to prevent the drivers from subjecting the boilers to dangerous pressures, or were they issued for the purposes of evading liability? 4. Were measures taken to ensure the regulations contained in the circular being observed; and, if so, what were they? 5. Were proper and sufficient measures taken by Mr. Stubbs to ensure that the safety valve was not loaded beyond the working pressure of 45lb.? 6. Did Mr. Stubbs caution Penny, the engine-driver of the Development, as to tampering with the safety valve, and was Mr. Stubbs justified in neglecting to report this circumstance to the Salt Union? 7. Was it reported to Mr. Ward, the manager of the Salt Union, that the engineer of the Development, and other engineers in the employment of the union, had been guilty of tampering with the safety valve; and if so, was Mr. Ward justified in neglecting to alter them so as to prevent this practice? 8. What was the cause of the explosion? 9. How did it happen that the safety valve of the Development was found loaded by weight to 68lb. after the explosion? 10. And, finally, whether blame attaches to the Salt Union, Mr. Verdin, Mr. Ward, Mr. Stubbs—all or either of those gentlemen?

Mr. Cooke having addressed the Commissioners on behalf of his clients, the Salt Union and its officials, urging that they had done all that could reasonably be expected of them, the Commissioners found that the Salt Union were somewhat to blame in the matter, and particularly Mr. Stubbs, for not reporting to the directors what had come to his knowledge, or testing for himself the capacity of the boiler when he saw it blowing off at 68lb. pressure. Under these circumstances, the Commissioners ordered that the Salt Union pay the sum of £40 towards the cost of the investigation.

THE EIFFEL TOWER RIVALLED.

According to the *Irish World*, it remained for an Irish-American, Timothy Bernard Powers, of 129, Henry Street, New York, to invent a design which, it is said, completely eclipses that of the great Frenchman, and throws the designs of his American competitors into the shade. It consists of an immense swinging tower, 1,000ft. long, which is intended to describe a complete semicircle, passing from a horizontal to a vertical position, and continuing its course until it again assumes a horizontal position. At the extreme end of the tower will be a platform or car, capable of accommodating 1,000 people, and so constructed that it will adjust itself to the motion of the tower, and always retain a horizontal position. Thus, in its course, the tower will describe a semicircle, the diameter of which will be 2,000ft., constituting what, without exaggeration, may be termed "a thrilling aërial flight." And when the tower is in a vertical position the passengers on the self-adjusting platform will be something more than 1,000ft. from the ground, which is a greater height than they can ascend by means of the Eiffel Tower. To put the comparison in a nutshell, the Powers Tower will carry people to a greater height than the Eiffel Tower, and give them in addition an aërial ride unheard of in the history of the world. Of course the mechanism will be so arranged that when the tower reaches a vertical position its motion can be suspended for any desired length of time, to give the passengers an opportunity to take in the scene, which, from such an altitude, will certainly be impressive. The swing tower will also serve the additional purpose of transporting people from one part of the grounds to another. An idea of the mechanism of the tower may be gained from Mr. Power's own description of it: "It consists," he says, "in the application, on a colossal scale, of the leverage system. The swinging arm rests on a heavy steel axle in the centre of the base or truss-work pedestal. At the shorter end of the arm is a huge cylinder to counterbalance the weight of the longer arm, at the end of which is attached the self-adjusting platform. The motor power for working the tower will be furnished by a steam engine situated near the base of the tower, and connected with it by a heavy cable turning on a large wheel, which is attached to the tower and revolves with it. I fully realise," he continued, "the magnitude of the undertaking, but that it is practicable I am certain. It will require a large expenditure of money, and will involve some nice mathematical calculations; but as an engineering feat it can be accomplished, and nowhere so well as here. Regarded as an investment, I believe it will pay well. It would certainly prove a stupendous advertisement for the fair, and would be the means of attracting thousands who otherwise might not visit it. I am a practical mechanic, and I feel confident that I can answer all mechanical objections that may be urged against the scheme." We are amused at Mr. Powers' easy reliance upon his judgment in this absurdly wild proposal. He has little idea of the magnitude of the problem involved in such a swinging lever, and the enormous strains to be provided for. The Forth Bridge problem was insignificant compared to this.

KOYL'S PARABOLIC SEMAPHORE.*

THE Committee on Science and the Arts, of the Franklin Institute, have reported on the system of railroad signalling devised by Professor C. Herschel Koyl. The arm of the semaphore is not flat, as usually constructed, but is approximately parabolic in plan, and is partly covered with glass, slightly corrugated, in order to scatter the light reflected from its surface. The arm itself is from 7in. to 11in. in width, and is painted bright red, with the exception of the medial band of corrugated silver glass, which is 4in. wide. It can be seen during the day in a horizontal position as clearly as the ordinary flat semaphore arm. But the parabolic surface is illuminated at night by a lamp placed at the focus of the paraboloid. The lamp is protected on the plane of the horizontal arm by red glass, and shows a long red band upon the line of the way, and for a considerable distance on each side of the way, so as to be visible to the man on the engine when approaching the signal on a curve of the road. The lower part of the lantern used to illuminate is made of clear glass; and the arm, when dropped to, say an angle of 45 deg., passes from the red rays of the transmitted light, and is made to reflect the direct light of the lamp, so presenting a strong contrast to the red signal of danger visible when the arm is in a horizontal position. When, during the day, the arm has fallen to the position of safety, the glare from the strip of glass, lighted by the sky only, causes the signal to be more striking than the arm in common use.

The parabolic semaphore is found to be specially useful in the neighbourhood of cities, where lights are numerous; in wooded or hilly countries, with dark backgrounds; and near curves. During winter, dry snow never lodges on the blade; wet snow and frozen snow are found to be themselves excellent reflectors.

The communication is illustrated by photo-lithographs.

CORRESPONDENCE.

We do not hold ourselves responsible for the opinions of our Correspondents.

COMPOUND LOCOMOTIVES.

To the Editor of "The Practical Engineer."

SIR,—Will you allow me a few lines in reply to "Loco"? He begins by saying that I ought to know that compounding "is the right thing to do." I reply, such no doubt is the theory, but it rests with "Loco" and others to prove that a compound engine can work the traffic of an English railway with better results than a non-compound; and this, I maintain, is not yet the case, whatever may happen in the future. As to copying the designs of other locomotive superintendents, "Loco" must remember that there are other systems of compounding besides the Webb and Worsdell, which are practically unknown in England, and which the gentlemen in question might have adopted, had they seen fit, without any loss of "dignity."

Again, he advocates a trial between various classes of engines. Here I am thoroughly at one with him, and believe that if carried out on a sufficiently large scale, it would prove of great value; but he must remember that when the London and North-Western engine Compound was borrowed by the South-Western, some years ago, the trial, such as it was, left the South-Western directors very well satisfied with their own engines. The same company has also converted one of their 7ft. expresses, 446—exactly as "Loco" suggests—to the Worsdell system, and Midland Hants local trains seem about as much as it can manage; so seeing that 446 is considered to have been altered distinctly for the worse, "Loco" will see the wisdom of other companies refusing to waste even "a pair of cylinders."

He then goes on to suggest that my comparison between the Midland singles and Experiment was unfair. Now, the Leeds expresses are undoubtedly light, but considering the extra pace and worse road, I think anyone will admit that their work is even harder than the Irish mail of 1882, and consider that the contrast was perfectly just.

At the top of page 835, "Loco" says I am "entirely incorrect in saying that Mr. Worsdell built a six-wheeled engine, 1324," &c. As in the next sentence he adds that Mr. Worsdell *did* build 1324, which *is* a six-wheeled engine, I hardly see the point of his remark. As to the pulling of 64 trucks from Darlington to Penrith, it is unnecessary for "Loco" to say that it was never done—of course it wasn't; but my point was, as "Loco" will see on reading my last letter again, that modesty was at least as valuable as dignity, and that certain stories had found their way into the daily press which it would perhaps have been better form to have left untold.

In conclusion, I may tell "Loco" that from the first day of Experiment's period of probation to the present time I have carefully read everything I have been able to find on this subject, and have watched every new type of engine I have been able to find at home and abroad, with the result that I have grown sceptical as to the value of the praise of interested parties, and, at all events as regards English express traffic, am still what "Loco" pleases to call "blind, foolish, and unconvinced."

Of course it is only natural that a patentee should believe in his patent, but if "Loco" will go to Swindon, and see engines 7 and 8 standing rusty and useless, and will learn for himself whether 446 simple or 446 compound has given more satisfaction at Nine Elms, I think even he will admit there is a dark side to compounding locomotives.

"Loco" is good enough to declare my last letter unwarrantable, and my statements incorrect. I have already referred to the 64 truck tale, and am ready to admit that it may not have been official, remembering that when the S.E. bogies were built, in 1884, the *Times* solemnly declared that they were to run to Folkestone (71 miles) in "considerably within the hour." But, allowing that to pass, the fact remains that a modest silence has *not* been observed where it would have been appropriate, rest the fault with whom it may. I see my last letter reads as an historical resumé, and shall be much obliged if "Loco" will point out a single mistake in it.

The ultimate triumph of compounding is perhaps only a question of time, but that time, I am afraid, is not yet.

I do not wish to occupy your columns again, but shall be happy to give my address if "Loco" or anyone else thinks he would care to continue this discussion.—Yours, &c.,

W. B. THOMPSON.

To the Editor of "The Practical Engineer."

SIR,—The first thing that struck me after reading the rambling letter which appeared in your issue of November 29th, from "Fairplay," was how kind and impartial you were to allow so much of your valuable space to be taken up by matter in his letter which is foreign to the subject at issue—proving nothing one way or the other. He takes up nearly a whole column with the half-yearly report of the North-Eastern Railway Company, and other figures that do not show or prove a single thing either for or against compounding locomotives, and at the close of his letter he has the audacity to tell me that he shall not reply to my next letter unless I give facts and figures.

Let me tell "Fairplay" that I am quite capable of laying my case before your readers without any prompting from one who has so much to learn in the matter of compounding locomotives, and I will leave him to please himself whether, and in what manner, he chooses to reply.

I shall not attempt to follow all his wild statements, or to give him all the information he asks for, but will only take those to the point at issue.

He states in the fore part of his letter that I evaded the question at issue—*i.e.*, a comparison of the cost of consumption of coal, repairs, &c., &c., of the compound engines as against the non-compound. Now, although I did not consider this the question at issue in my letter of November 1st, I went fairly into the matter, and I challenge anyone to show me how they can prove that renewals on the North-Eastern are unfavourable to compounding.

"Fairplay" must think your readers very ignorant when he tries to make them believe that the extra cost of locomotive power for half-year ending June 30, 1889, was solely through the compounds, and to show how ridiculous his arguments are I will give an instance: The drivers, firemen, and others have just received an advance in their wages, which will amount to a considerable sum altogether; the amount will be added to the locomotive expenses in the next half-year's report. Will "Fairplay" charge this to the compounds in his next half-yearly returns? As for repairs, I repeat that none of Mr. Worsdell's compounds had been into the works for repairs at the date when "Fairplay" took his statements, but now he says repairs can be done elsewhere outside the works, as there is such a place as the running shed. Of course there is, where both compounds and non-compounds have the benefit of it, as all locomotives are liable to fail at any time through no fault of the engine, and are termed running-shed repairs on every railway, the cost of which is so trifling in any case that I do not consider it worth mentioning; and "Fairplay" will have to produce evidence more substantial than repairs and renewals before he will be able to convince anyone unbiassed that compounding locomotives is a failure.

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*Inst. C. E. Foreign Abstracts.

"Fairplay" says it is well known on the North-Eastern what part the 901 class and Tennant express took in the railway race to Edinburgh, compared with the compounds. Now, I happen to know all about this race, as I took great interest in it at the time. I have nothing to say against the above engines, and there is no doubt about it they are as good as any non-compounds ever built. Will "Fairplay" be surprised when I tell him that in this race he speaks of the compounds were only using 26lb. of coal per mile, whilst the 901 class and Tennant's were using from 30lb. to 34lb. of coal per mile? This alone is sufficient proof that compounding locomotives is the right thing to do.

"Fairplay" may be right in saying that there are non-compounds running on the North-Eastern system with 26lb. of coal per mile daily, but I cannot take a guess statement from "Fairplay" that they would run with less (all other things equal) than compounds. Neither can I take it, without examination being made into circumstances, that some of these non-compounds have been running for four years without going into the shops for repairs.

Some years ago, one of the 901 class did not come into the shops for repairs for four years, but when the history of this engine is given, it will put a different light on it altogether, for we find that this engine was not working trains all the time, but standing pilot at the Central Station, Newcastle, and for the greatest portion of the four years never turned a wheel only to go to and from the running shed.

I cannot help noticing one part of "Fairplay's" letter, although the circumstance has nothing whatever to do with the matter of compounding—that is, where he states that the present superintendent's predecessor's engines cannot be excelled on any other railway. It makes me smile, for I know that these very engines which "Fairplay" praises were condemned all round as being too light and unfit for the work they had to do.

In the latter part of his letter he again refers to the statement I made in your issue of September 20th, viz., that one of the most powerful and fastest locomotives in the world, and built by Mr. Worsdell, at Gateshead, on his compound principle, took thirty coaches from Newcastle to Berwick and back at express speed as easily as any non-compound with eighteen coaches on. You see, Mr. Editor, "Fairplay" does not attempt to deny it, but tries to ridicule it by asking me if this identical engine took six coaches (not thirty) on a trip a few days after, and when it got to Bilton it stuck and would go no further, &c.

I will leave your readers to judge whether an engine, built by some of the most experienced men, I might safely say, in the world, would turn out, and on its trial trip take thirty coaches the distance named, and then, after running to Bilton, suddenly stick fast and require another engine to give it a start. It has been running express trains to Edinburgh and back without a single hitch until a few weeks back, when it was decided that the engine should be stopped for painting. If "Fairplay" will only go to the Central Station, Newcastle, and keep his eyes open, he will see this very engine hooked to the Scotch express, and move off quite easily with the train without any assistance. "Fairplay" says I display deplorable ignorance, because I do not know that other railway companies' superintendents are making boilers for locomotives to carry 175lb. and 180lb. pressure. I must certainly plead ignorance in this case; if such is the fact, it has only been done recently, and I am afraid the results have not been very satisfactory, or "Fairplay" would have given us the half-yearly report of the company, showing the saving effected by these high-pressure non-compounds, along with the North-Eastern report. Perhaps he will be so kind as to give us the name of the company, and how many engines they have at work with this high pressure, in his next.

I am pleased to hear that "Fairplay" has all the back numbers of your valuable paper, and hope he will continue taking it, for if he is open to conviction I hope to convert him (as I have been) into a thorough compound, and in conclusion I will refer him to my letter in your last week's issue in reply to Mr. W. B. Thompson, and to Mr. D. S. Barne's paper there referred to. LOCO.

Dec. 12th, 1889.

It has been currently reported during the past week or two, in boiler insurance circles, that the business of the South Staffordshire Boiler Insurance Company—a small local company, which has enjoyed but a short existence of about two years' duration—had been taken over by the new British Steam Users' Insurance Society Limited, Manchester. This, however, we have the best authority for stating, is not correct, the business, as a matter of fact, having been acquired by the Boiler Insurance and Steam Power Company, of 67, King Street, Manchester. This makes the sixth boiler insurance company which has collapsed during the last few years, several of these having wound up their affairs after being involved in heavy pecuniary loss through disastrous explosions of insured boilers. This is somewhat suggestive, in view of the keenness of the competition which has taken place in this class of business during recent years.

QUERIES AND REPLIES.

141. **POWER OF HOISTING BLOCK.**—It is found by trial that when P is on the point of lifting W by means of a single fixed pulley, $P = (1 + m) W$, where m is a fraction depending on the friction of the parts of the machine. If three such pulleys are combined into a "block and tackle," find the power requisite to raise a given weight by means of it.—STUDENT.

Answer.—In this block and tackle question, the weight being W, the pull on the fall end is $(1 + m) W$. Call this x. Then the pull on the next fall end is $y = (1 + m) x$; and calling the pull on the third fall end z, we then have $z = (1 + m) y$; therefore $z = W (1 + m)^3$. Put at full length, the final pull is thus expressed—

$$z = \left[\left\{ W (m + 1) \right\} \times (1 + m) \right] \times (1 + m) \qquad (a)$$

the final result being—

$$W + 3Wm + 3Wm^2 + Wm^3 \qquad (b)$$

If W is 100lb., and m, the frictional coefficient, be one-tenth, we get—

$$z = \left[\left\{ 100 \times \frac{11}{10} \right\} \times \frac{11}{10} \right] \times \frac{11}{10}; \text{ or, } (110 + 11) \times \frac{11}{10} = 133{\cdot}1;$$

or, working out (b), we have—

$$z = 100 + \frac{300}{10} + \frac{300}{100} + \frac{100}{1000} = 133{\cdot}1.$$

W. H. B.

145. **THICKNESS OF CAST-IRON PIPE AND PROPORTION OF ENGINE CYLINDERS.**—Would any engineer inform me the thickness of cast iron for 8in. diameter steam pipes to be safe from bursting with 80lb. of steam per square inch in the boiler, and what diameter of cylinders would you recommend to work compound side by side? Corliss high-pressure cylinder, short slide valve for low-pressure cylinder, to drive 200 I.H.P., 44 turns per minute, 4ft. 6in. stroke, 80lb. of steam in boiler per square inch. Information will oblige.—J. C.

Answer.—In his reply to above query, last week, "W. H. B." has made no allowance for the great loss which takes place in actual practice between the mean effective pressure referred to low-pressure cylinder obtained by theoretical calculation and the actual result, which is seldom less than 25 per cent. It has for many years been my custom to assume a final pressure of 10½lb. in large cylinders, which will work out to about 8½lb. in practice, and to allow for a loss of not less than 25 per cent from theory. "J. C." cannot expect to get the boiler pressure on his high-pressure cylinder, and if he gets within 5lb., that is 75lb. on his piston, he will not do amiss. Taking, then, 75lb. initial pressure, or 90lb. absolute and a final pressure of 10½lb., we get 8·57 expansions and $P\left(\frac{1 + H}{R}\right) = \frac{1 + 2{\cdot}1483}{8{\cdot}57} = 33$lb. mean pressure for 8·57 expansions. From this should be deducted 3lb. at least for back pressure, giving 30 and 25 per cent off this for loss from condensation, &c. $= 30 - 7\frac{1}{2} = 22\frac{1}{2}$lb. mean effective pressure, which is as much as can be relied on in practice from 80lb. boiler pressure. Then since

$$\text{I.H.P.} = \frac{\text{area of cylinder} \times \text{speed} \times \text{in. low-pressure}}{33{,}000}$$

and the I.H.P. required is 200, we have—

$$\text{Area of cylinder} = \frac{200 \times 33{,}000}{396\text{ft.} \times 22\text{lb.}} = 756 \text{ square inches};$$

and I should not advise a less cylinder with the above pressure and piston speed than 31in. diameter. The following is a good practical rule for cylinder ratio where r = ratio between first and last cylinders, and P = initial pressure in piston:

$$r = \frac{P \times 4\frac{1}{2}}{105}$$

from which we get

$$r = \frac{90 \times 4\frac{1}{2}}{105} = 3{\cdot}86$$

and area of 31in.; $754{\cdot}8 \div 3{\cdot}86 = 195{\cdot}4$ square inches area of high-pressure cylinder, or say 15¾in. diameter.—AZIM.

150. **LEATHER BELTING.**—I wish to know the width of double leather belt to transmit 200 I.H.P. Belt flywheel 14ft. diameter, 72 revolutions per minute; driven pulley 10ft. diameter, 30ft. centre to centre. Please give formula.—ANXIOUS.

Answer.—Double leather belting, ⅜in. thick, may be strained up to 120lb per inch of breadth. At low speed, of about 50ft. per second only, you may allow 100lb. as working stress, and leave the 20lb. for centrifugal stress. Now, you want 33,000 × 200 foot-pounds, therefore you will require $\frac{6{,}600{,}000}{320{,}000}$ or say 21in. breadth of belt, to transmit low power, the number 320,000 being the inch stress multiplied by the speed per minute. A belt maker, whom I know, allows 70lb. to 80lb. stress per inch of double belt, irrespective of any allowance for centrifugal action on initial stress. From my own notes on observed facts, I find that a 21in. belt drove a wire mill in Halifax at 180 I.H.P., with 60 revolutions of a 16ft. drum, or a speed of about 3,020ft. This is nearly identical with your own case of 200 H.P. at 3,200ft. Some engineers take into account the amount of embrace of the belt on the smaller pulley. This is not necessary in most ordinary cases.—W. H. B.

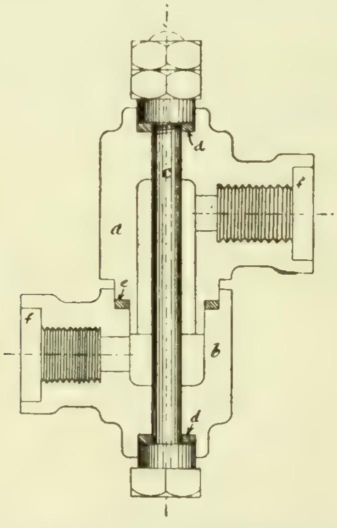
151. **MARINE GOVERNORS.**—Could any reader tell me whether there are any marine governors that work independently of the engine—that is, do not derive their motion from the engine. If there are any, I should be very much obliged for a short description of each.—MARINE ENGINEER.

Answer.—The governor of this class which seems to find most favour amongst marine engineers is that of Smith and Pinkney, which goes by the name of the Atmospheric Pendulum Governor, and consists of a heavy pendulum suspended between two fine points in such a way as to admit of its oscillating in a fore and aft vertical plane when the ship pitches, which motion is communicated to the valve of a small cylinder by means of suitable rods. The exhaust from this cylinder is in communication with the condenser, and the valve chest is open to the air, hence, as soon as the valve moves toward either end, communication is made between one end of the governor cylinder and the condenser, the other end remaining open to the air; thus, by the movement of the valve, the piston in the governor cylinder is moved backwards and forwards, by which, with suitable connections, motion is given to the throttle valve, opening or closing it as the speed of the engine requires. This governor is sometimes worked by steam, and this method is certainly an improvement on the above described pneumatic arrangement, as by that method the working of the governor seriously interferes with the vacuum when the ship is exposed to a "head sea"; and, furthermore, this air entering the condenser tends to charge the feed water with air, which acts detrimental to the boiler plates, &c. Another governor belonging to this class is the one known as Dunlop's governor, the arrangement being as follows: A vertical cylinder placed close to the stern, and as low down below the water line as possible, to the bottom of which, by means of a cock or valve fitted to the ship's skin, water can be admitted. If now the ship's stern be lifted out of the water, the cylinder is emptied of water, and the pressure in it is equal to that of the atmosphere. The effect produced when the stern dips deep into the water again will be that the water rushing into the cylinder will compress the air in it until the pressuse is equal to that due to the head of water. The top of the cylinder is in communication with a vessel in the engine room, which is closed air tight at its top by a thin corrugated circular diaphragm, the gear for operating the throttle valve being connected to the middle of the diaphragm; and its bulging, due to pressure, opens the throttle valve; but, as the water leaves the cylinder at the stern when the ship rises, the diaphragm assumes its normal position, and closes the throttle valve.—GOVERNOR.

Answer.—There are two types of marine governor which are independent of the main engines for their action: Those of the pendulum type consist of a heavy weight suspended in such a manner as to be free to oscillate in a fore and aft direction, so that when the stern rises the oscillation of the pendulum actuates a small valve, which puts a cylinder in communication either with steam pressure or the vacuum, the motion of the piston thus produced closing the throttle-valve. The chief objection to governors of this type is, that the rise of the vessel's stern must be considerable before the small valve is opened, and although the subsequent motions are quickly performed, yet by the time the throttle is closed racing will have ceased by the propeller having become fully immersed again. The other class consists of an air chamber fitted to the stern of the ship, which is connected to a small cylinder in the engine-room, the movement of its piston actuating the throttle valve as before, the said movement being caused by the variation in pressure of the air in the chamber; thus, on the stern rising, the pressure is reduced and compressed by the increased immersion of the same.—ORION.

152. HYDRAULIC SWIVELLING JOINT.—Will any of your readers kindly describe by the aid of sketches the construction of a swivelling pipe joint by which water pressure may be transmitted to a crane which revolves or has a limited travel?—HYDRAULIC.

Answer.—The following sketch and description of hydraulic swivel joint may meet the requirements of "Hydraulic." As shown in the sketch, the joint consists of the following parts: *a b* are two sockets, held securely together by the bolt *c*, and kept watertight at the ends by the leather washers *d d*. The two portions of the joint are made fluidtight by interposing a leather washer *e* in a recessed portion of the socket *b*, and setting up the nuts at the end of the bolt, just sufficient to admit of the joint swivelling freely. The screwed branches are to receive the inlet and outlet pipes, which, in addition to being screwed, must have a nut provided with a collar, not shown in the sketch. The recesses *f f* are to receive these cellars, under which must be placed leather washers to make branch joints perfectly tight. All parts of this joint are made of gun or other non-corrosive metal.—J. R.



153. SATURATED STEAM.—Why does its pressure rise in a ratio which slowly increases, referred to the temperature? And why does the amount of total heat slowly increase with the increase of temperature?—S. B.

Answer.—The pressure of saturated steam rises at a ratio increasing upon the temperature, probably because as the temperature increases the steam more nearly approaches a condition of perfect elasticity; in other words, becomes more nearly a perfect gas. And, again, the total heat increases with temperature probably from parallel reasons. As the steam becomes of greater pressure, some of it would condense, but absorb heat to enable it to maintain its form as a gas. This heat becomes "latent" in preserving the steam as steam, and though the latent heat as a whole becomes less with increase of temperature, it does not decrease so rapidly as it would do if steam were more perfectly elastic than it is.—W. H. B.

154. INJURY TO EYES BY ELECTRIC LIGHT AND LUCIGEN LIGHT.—I should be very much obliged if any of your readers could kindly tell me which is the most injurious to the eyes, a strong electric light (without globes) or the Lucigen light?—J. S. S.

Answer.—The electric light is more injurious to the eyes than the Lucigen light, owing to its greater intensity. If in an enclosed place, the fumes of the Lucigen light are, however, not agreeable. It is also best to keep out of the way of the spattering of hot oil from it; but as far as the light is concerned, it is no more injurious than any other oil lamp; while, on the other hand, the arc electric light, by its unsteadiness, as well as its brilliancy, certainly injures the sight.—C.

155. POWER AND COAL CONSUMPTION OF ENGINE.—Would any reader kindly inform me what I.H.P. engine ought to drive the following dimensions: diameter of cylinder 14in., stroke 24in., revolutions 80 per minute, automatic cut-off valve, boiler pressure 50lb., belt driving from flywheel 6ft. 6in. diameter; also what amount of coal (slack) should be used for the amount required, to work at best advantage?—YOUNG MAN.

Answer.—The power developed will depend on the rate of expansion, and Mr. Willans, from results of trials made by him with non-condensing engines, has shown that the most economical result to be obtained in this class of engine is when rate of expansion

$$= \frac{\text{absolute initial pressure}}{25};$$

or, in the case cited, 2·6; so that the cut-off will be at $\frac{1}{2·6}$ th of the stroke, which, with an initial steam pressure of 50lb. per square inch above the atmosphere, gives a theoretical mean pressure of 33lb. per square inch above the atmosphere, the formulæ being—

$$\text{Mean pressure} = \text{initial pressure} \times \frac{1 + H}{R};$$

H being the hyperbolic logarithm of R the rate of expansion. And taking 95 per cent of this value as what we may expect in practice, we get effective mean pressure = 31lb. per square inch. Then—

$$\text{I.H.P.} = \frac{\text{area of cylinder} \times \text{mean pressure} \times \text{speed of piston feet per minute}}{33,000}$$

$$= \frac{44 \times 31 \times 320}{33,000} = 13·8.$$

This power, however, could be greatly increased, but it would be at the expense of economy, by increasing the mean pressure in the cylinder by cutting-off later. Such an engine should require about 30lb. of water per horse power per hour; or, say a total of 420lb. per hour; and assuming that 1lb. of the coal used will, in the boiler supplying the steam, evaporate 6lb. of water per pound of coal at the working conditions, then coal per hour $= \frac{420}{6} = 70$lb., or 15cwt in 24 hours.—I. H. P.

Answer.—It is impossible to state the horse power exactly unless the initial pressure in the cylinder is ascertained. A long or contracted steam pipe, or ports deficient in area, may reduce the initial pressure considerably below the boiler pressure. The point of cut-off is not given, but I have assumed this to be one-fourth of the stroke, and with this cut-off, if the engine is in fair working order, it should develop 40 I.H.P., and if a later cut-off is adopted the power will be increased. It is difficult to give the coal consumption when the type of boiler is not known, nor whether the slack is fed into the fire by hand, or by means of a mechanical stoker (as is usual for such fuel). But 17 cwt. per day of 10 hours, should be sufficient, if the engine and boiler are in good repair. "Young Engineer" should have his engine indicated; he would then see if the steam was being used to the best advantage.—W. F.

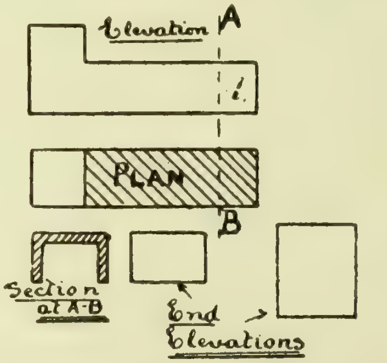
138. SOLID-DRAWN TUBE.—I wish to make a number of lengths of solid-drawn copper tube ¼in. internal diameter and $\frac{5}{16}$in. external. I shall feel obliged if anyone will give a description of the necessary tools.—L. M.

148. AUTOMATIC VACUUM BRAKE.—Can any reader inform me the reason why, when the brake is applied from the engine, it always takes hold of the last carriage first? It always seems strange to me why it should do, and I shall be extremely obliged for any information on the subject.—W. G.

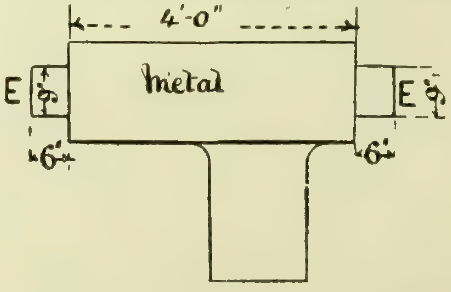
161. ENGINE CONNECTIONS.—Will any reader kindly furnish me with a formula, or explain how to determine the following, viz., distance between centre of connecting rod, length of piston rod, depth of piston, and distance between centre and face of crosshead under various conditions of pressure?—ANXIOUS.

162. METHOD OF BORING OUT A ROD.—Could any of my fellow-readers inform me on the following: I have a rod of bell metal, 6ft. long, and 2¾in. diameter, through which I want to bore a hole 1½in. diameter. I wish to know the best way to hold it in the lathe, and also the best method of boring it. There is a cut to come off the outside; should I take this off first or last, and what tool will best do for the job?—HEAVY.

163. TURNING CASTING.—I give a sketch of a piece of cast iron, and wish to know the best way of holding it in the lathe to turn it. The part section-lined requires turning.—HEAVY TURNER.

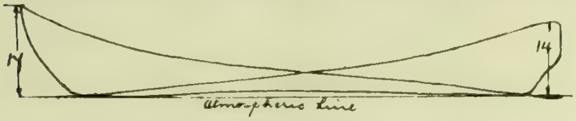


164. FACING FORGING.—Could you, through your paper, inform me how to do this job, of which I give sketch? The ends E have to be made true, and as I have no lathe large enough, I wish to know of another method. I have a boring machine. Could it be done on that? If so, a sketch of the tool required would greatly oblige.—TRUTH.



165. Cast-iron Piston Rings.—Will you kindly inform me the correct width and thickness of piston rings, cast-iron split, for a cylinder 10in. diameter, 16in. stroke ?—Fitter.

168. Engine Diagrams.—Would you, or your readers, kindly show me, through your valuable paper, how to work out the diagrams annexed, and how to determine if the slide valve is correctly set? The engine from which the card is taken is of the following dimensions: Diameter of cylinder, 26in.; length of stroke, 4ft.; revolutions, 46 per minute; steam pressure in boiler, 55lb.; scale of indicator, $\frac{1}{24}$.—W. R., Glasgow.

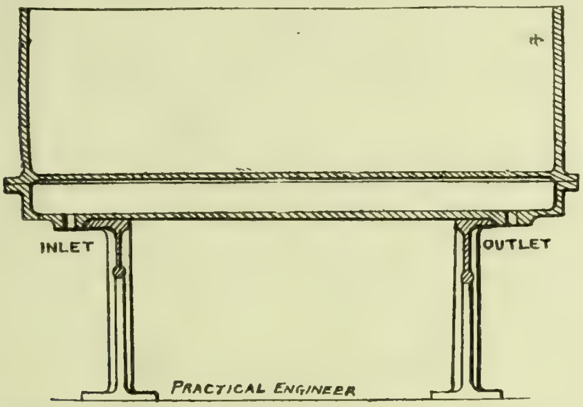


170. Brake Power of Gas Engine.—I have a small gas engine, about 5 H.P., and wish to know the brake H.P. of it. I have an indicator, and should be glad of sketch of brake, and other particulars that would assist me in the trial.—Novice.

174. Injectors.—(1) Does an injector pump more or less water than can be accounted for by simply considering the momentum due to the pressure of steam and head of water which work it? (2) Would air at any velocity pump any water against a pressure? If so, would equal weights of air and steam, having equal momentum, produce the same effect? (3) What is the efficiency of an injector as a pump compared with other pumps in a case where a low temperature of discharge is desirable?—R.D.

175. Oilless Bearings.—Can any reader advise me as to carbonated bearings? I have two journals continually dipping in water. Will carbonated bearings suit, and keep from wearing when thus working?—J. B.

176. Strength of Cast-iron Pan.—Please give me formulæ to calculate the strength of pan as per sketch: 1st, plain bottom; 2nd, with screwed stays (screwed in both plates). The formulæ to be applicable to any size of pan and pressure of steam.—H. L. C.



177. Friction Brakes.—Would any reader kindly give the following information?—In a brake of the flexible band type, the band being of wrought iron and the drum of cast iron, what is the best and usual proportion in practice of width and thickness of band to diameter of drum, so as to be both strong enough, and to have sufficient area of surface to prevent overheating for different arcs of contact. Also width of block, when the brake is of the wood block type, as generally used on winding engines. The above information will greatly oblige.—Overheated.

178. Blast for Foundry Cupola.—What should be the pressure of blast for ordinary foundry cupolas melting 3, 4, and 6 tons of metal per hour? What should be the speed of an ordinary fan, also a Root's blower, for these pressures, and about what horse power will be required in each case?—Cupola.

Answers to the following queries are unavoidably held over: 151, 155, 156, 157, 158, 159, 160, 166, 167, 169, 171, 172, and 173.

PATENTS AND INVENTORS' QUERIES.

46. Dynamo Armature.—I have invented a method of constructing a dynamo armature, for which I have applied for provisional protection. The peculiarity is that the whole armature can be slipped off the spindle without disturbing the insulation. Can you tell me if it is really novel?—H. L., London.

Answer.—We believe that several armatures of this construction have been used, but we can only advise you fully if you send drawings and full description.

47. Engine Brasses.—I cannot overcome the heating of the crank pin brasses in a new engine I have designed. Can you suggest any remedy?—J. J., Middlesbrough.

Answer.—You are probably attempting to work with too small surfaces; but we cannot advise without more complete details. Write again.

TO CORRESPONDENTS.

Engineman, North Queensland.—Books despatched December 19th. Subscription paid for years 1890 and 1891.

Engineer, Bury.—We have read your letter with interest, and thank you for your appreciative remarks. We shall deal with your interesting balanced valve, and return tracing in a few days.

J. W., Essex.—The notice of your interesting invention will appear in our next issue; it has been kept out by press of other matter awaiting insertion. Our business representatives will write you upon the question of negotiation.

MISCELLANEA.

New Electric Boat.—Mr. Sargeant is building a second electric launch for Mr. Pears. "He won't be happy till he gets it."

The new Fall River Ironworks, in Eastern Mass., have completed the largest chimney in America and the fifth in the world. It is 350 feet high, and 30 feet in its largest and 15 feet in its smallest diameter. The number of bricks used was 1,700,000.

Messrs. Fleming and Ferguson, Paisley, have received an order from Mr. F. R. Wood, New South Wales, to build for him a steel steam yacht of about 450 tons yacht measurement. She is to be fitted by the builders with a set of their patent quadruple expansion engines, to indicate about 1,000 horse power.

It has been arranged to amalgamate the collieries and blast furnaces belonging to Earl Granville at Hanley, Shelton, and Etruria, with the Shelton Iron and Steel Company. The proposed change is considered the most important that has taken place in the history of the North Staffordshire iron trade.

The Longest Telephone Line.—The longest one in Europe is that now laid between Pesth and Prague. It is 600 kilometres in length, or about 375 miles. The trials just made on this line of communication are reported highly satisfactory. It is, we may note, nearly double the distance between Paris and Brussels.

Messrs. Heenan and Froude, of Manchester, have just completed a large lattice girder bridge for the Chilian Railways. This bridge has a total length of 1,680ft., divided into ten equal spans, and is supported on double cast-iron cylinders, packed inside with cement concrete. The total weight of the bridge is about 1,140 tons, and it presents several special features in design and construction.

The Morse Elevator Works, Philadelphia, turn out an average of three elevators daily, mostly for freight purposes. No one looking through their factory can help seeing that good work is done there, all drums being turned and grooved out of the solid metal, &c. Worm gears, an improved safety device, self-closing doors, and other features, are specially noticeable. The works employ 118 men.

A Large Planing Machine.—We learn that Messrs. Dean, Smith, and Grace, Keighley, Yorkshire, are constructing a large planing machine, to be used in connection with the flood gates of the Manchester Ship Canal. They are also making a vertical cylinder boring machine, which can be attached to the cylinder without displacement, and five heavy wheel lathes. They are also making an important cylinder boring machine, with two bars boring at right angles. The last-named is for Messrs. Marshall, of Gainsborough.

The Contractor for the Forth Bridge.—On Dec. 4th, Mr. William Arrol, contractor for the Tay and Forth Bridges, was presented with the freedom of the city of Dundee in recognition of his great engineering services. In accepting the honour Mr. Arrol declared that £2,000,000 were spent on wages in constructing these undertakings. He counselled working men not to be led away by politicians who had not their interests at heart, and declared that a universal system of shorter hours would have a deplorable effect on working men.

On Saturday, December 14th, the steam hammer works of Messrs. B. and S. Massey and Co., Openshaw, caught fire, and it was found that a building 100 yards long, used as a pattern and engineers' shop, was in flames. Two jets were attached to the mains and a steamer was also brought into action, but the fire was not subdued until after the brigade had been engaged for nearly four hours. The whole of the contents were completely destroyed, and little is left of the building but the outer walls. The origin of the outbreak has not been ascertained.

The St. Clair Tunnel, under the Detroit River, is said to be progressing at the rate of 7ft. per day at each end. About 200ft. on the Canadian side, and 400ft. on the American side, are reported as complete. The approach opening is about one mile long on each side, and about 60ft. deep. The shields are being used in the hard blue clay by digging out the centre with picks, and then pushing them forward 18in. at a time by hydraulic rams. The American *Engineering News* says "the freezing process is to be used if water is met with."

The Proposed Channel Bridge.—On December 4th one of the directors of the Channel Bridge Co., visited the Bench Minister of the Interior, to whom he officially proposed the scheme, at the same time submitting the project drawn up by the engineers, MM. Schneider and Herseul, Sir John Fowler, and Mr. Benjamin Baker. It appears that in order to remove the objections brought forward against the bridge by the shipping interests in England it is proposed that a sort of harbour shall be constructed between the two banks existing in the middle of the Channel, and over which the bridge will pass.

Manchester Association of Engineers.—The annual general meeting of the members of the association, was held at the Grand Hotel, on Saturday, December 14th, Mr. S. Dixon presiding.

There was a large attendance. The minutes of the last annual meeting having been read and confirmed, seven new members were elected. On the motion of Mr. S. Dixon, seconded by Alderman Asquith, and supported by Mr. Thomas Ashbury, Mr. J. West, of the Albion Works, was unanimously elected president. A vote of thanks was then accorded to Mr. Dixon for his past services. Mr. H. Mainwaring was re-elected treasurer; the trustees were also re-elected; and Mr. Marshall was elected on the committee of management in the place of Mr. S. Boswell. The other officers were elected, and the proceedings terminated.

Institution of Civil Engineers' Association.—At a meeting of Birmingham students of this association, held at the Colonnade Hotel on December 11th, Mr. E. Pritchard, C.E., in the chair, Mr. H. J. Fereday read a paper upon the "Utilisation of the Powers of Nature to Produce Mechanical Effect." The principal object of the paper was to show how the vast consumption of fuel might be saved by applying the remaining sources, especially as means were fast increasing for storing power, making it quite possible to obtain a regular power from an irregular source. The paper was illustrated by diagrams. An interesting discussion followed, in which Messrs. Treglowne, Till, Hibbs, and E. Pritchard took part. A vote of thanks to Mr. Fereday terminated the proceedings.

Nicaragua Canal.—They are evidently in earnest about it, and the authorities connected with the undertaking now aver their belief that it can be completed before 1897. The purchase of six large dredgers has just been contracted for by the Nicaraguan Canal Company. They are to be used for improving Greytown harbour, in order to make possible the landing of steel rails and machinery for the canal works. The length of the transit from the Atlantic to the Pacific by the Nicaraguan Ship Canal will be 170 miles. But only 29 miles of canal will have to be excavated, the rest of the distance belonging to Lake Nicaragua and rivers on different sides of it. The distances between ports on different sides of the Nicaragua Canal would be about the same as by the Panama Canal.

Institute of Marine Engineers.—On Friday evening, December 6th, a conversazione was held in the Town Hall, Stratford, in connection with the above institute. There were various interesting exhibits by members, amongst which were several beautifully-finished models of Newall's high-speed engine, models of steamers, Joy's valve gear, and others too numerous to mention. The president, Mr. Beldam, referred to the great importance of engineering in developing the resources and advancing the trade of the world. Several interesting features in connection with the rise and progress of the institute were alluded to by the hon. sec., who said that the present condition of the institute was a most satisfactory one. A short address was given by Mr. H. E. Lester on the subject of honorary membership, and the proceedings shortly after terminated.

Mining and Mechanical Engineers.—A general meeting of the North of England Institute of Mining and Mechanical Engineers was held in the Wood Memorial Hall, Newcastle, on Saturday, December 14th, under the presidency of Mr. John Morley, when a paper by T. E. Forster and H. Ayton on "Improved Coal Screening and Cleaning" was read. This described at length the methods adopted at the Cowpen, Ashington, Beamish, Harton, and other collieries in the North of England, and the different processes of cleaning coal by mechanical means were dealt with under the following heads: Motive power, screens, belts, loading shoots, laying-out tubs, banking out, cost, &c. Some discussion on the merits of different systems followed the reading of the papers. A new mechanical device for the rapid fixing of survey instruments was exhibited and described by Mr. F. Colet-Larkin. The usual votes of thanks terminated the proceedings.

New Association of Foremen and Mechanical Draughtsmen.—The first meeting of the Birmingham and District Foremen Draughtsmen's Mechanical Association was held on Saturday evening, December 7, at the Midland Institute, for the purpose of hearing an inaugural address by the president (Mr. T. Meacock). Mr. Crockett presided, and there was a large gathering of interested persons. The association has been established to afford the means of promoting an acquaintanceship and mutual improvement amongst managers, foremen, and draughtsmen connected with the engineering and metal trades; and also by a small monthly subscription to form the nucleus of a fund to be applied for the benefit of its members as may be afterwards decided.—The President thought the selection of the place for holding their meetings was a most happy one, for the association had as it were taken root in a great centre of learning, scientific and otherwise. He then referred to the good work carried on by the Technical School, and went on to speak of the advantages of the association, which, he said, would be very great, inasmuch as men of theoretical and practical knowledge would be brought into close contact, with mutual benefit to each. It was very desirable that draughtsmen and foremen should have an opportunity of meeting together to mutually qualify themselves to cope successfully with the many difficulties and obstacles with which they had daily to contend by free interchange of thought. He trusted, also, that the employers of the district would speedily become honorary members, and it was with great pleasure that he heard the announcement that Mr. George Tangye had set the first example. It was hoped soon to form a library of useful works. Meetings would be held once a month, at which papers would be read and discussed. The steam engine would doubtless early form the subject of a paper, and would be a fitting one, considering its connection with Birmingham. The city was famous throughout the world for her manufactures, and it behoved those who, in different degrees and ways, were responsible for the quality of workmanship and material of those articles to maintain and build up that reputation.—We are asked to state that the secretary of the association is Mr. L. O'Brien, of 7, Highgate Crescent, Moseley Road, with whom persons desiring to join should communicate.

Manchester Civil Engineer Students.—A paper was read before the Association of Manchester Students of the Institution of Civil Engineers, on December 11th, on "Hydraulic Canal Lifts," by Mr. L. B. Wells, M.I.C.E. The author confined his remarks almost exclusively to the first one made, viz., the Anderton lift, constructed by Mr. E. Leader Williams, M.I.C.E., now engineer to the Ship Canal. This lift was devised to afford communication between the river Weaver Navigation and the Trent and Mersey Canal, which runs within 50 yards of the Weaver at Anderton, near Northwich, but is at a higher level by 50ft. 4in., and by this means to make a workable connection with a canal system to the Staffordshire Potteries, extending further to the Humber, and through Birmingham to the Thames and Severn. The ram had to be of such size and sufficient power to raise a tank or caisson, capable of taking two narrow boats, or one Duker,—*i.e.*, two boats with a cargo of 30 to 35 tons each or one boat carrying 70 tons. The caisson is 75ft. long, 15ft. 6in. wide, 4ft. 6in. deep, making a load of 240 tons. The lift is double. Thus by lowering the descending caisson with 5ft. depth of water in it, sufficient weight is provided to lift the lighter one to within 3ft. 6in. of the top. Meanwhile the engine raises an accumulator, which is then brought to bear and complete the operation. The accumulator has a ram 1ft. 9in. in diameter, 13ft. 6in. stroke. The main ram is a single one, 3ft. diameter, and cast iron, 1¾in. thick, cast in three lengths. The caissons are of wrought iron, the presses of cast iron, 3ft. 6½in. external, and 3ft. 1½in. internal diameter, and are sunk 65ft. below water level, on a concrete foundation. They are contained in cast-iron cylinders, 5ft. 6in. diameter, 1½in. thick. The press heads are cast iron, 3ft. 1½in. internal diameter, 2⅞in. thick, having a lower flange, 6ft. 1½in. diameter, which rests on the cylinders containing the press, the upper flange being 4ft. 1in. diameter. The slides are strengthened by eight stiffeners, 1½in. thick, extending from the upper to the lower flanges. The orifice through which the pressure is applied is 5in. diameter. The strain on a press was subsequently described, the presses used in warehouses of Manchester being mentioned. The paper was enthusiastically received, and was followed by an animated debate upon points emerging from the consideration of the subject under notice.

SELECTED PATENTS.

APPLICATIONS FOR LETTERS PATENT.

Where Complete Specification accompanies Application an asterisk is suffixed.

November 26th.

18929 Generating Steam, J. Hargreaves, Liverpool.
18930 Metallic Chains, E. J. Trevitt, Birmingham.
18945 Safety Lamps, W. H. Johnson and R. I. Moorhouse, Manchester.
18950 Steam Boilers, W. Fairweather, Glasgow. (The Babcock and Wilcox Company, United States.)*
18956 Rotary Engines, D. Williamson, Manchester.*
18957 Fasteners for Belts, F. Reddaway, Manchester.
18963 Valves, J. Shenton, London.
18978 Heating Stove, E. Laemerhirt, London.*
18985 Furnaces, C. A. Piat, London.
18994 Punching Machines, W. P. Thompson, Liverpool. (A. Beaudry, United States.)
18995 Purifying Feed Water, B. F. Field, London.*
18996 Steam Engines, N. H. Edgerton, Liverpool.*
19001 Furnaces, D. Clegg, London.*
19011 Dynamo-electric Machines, J. Hopkinson, London.
19016 Rolled Forgings, H. H. Lake, London. (Gould Rolling Machine Co., United States.)*
19018 Furnace Grate Bar, F. W. Barker, London. (R. Rose, G. T. Gearhart, and C. R. Allen, United States.)
19019 Gas Regulator, F. W. Barker, London. (W. C. Rossney, United States.)
19022 Packings, F. Metzeler, jun., and J. Pose, London.
19023 Locking Nuts, H. Löhnert, London.*

November 27th.

19032 Cargo Steamers, W. B. Thompson, Glasgow,
19034 Packings, J. J. Galloway, Glasgow.
19043 Joint for Tubes, R. Howorth, Wolverhampton.
19087 Tool-holder, J. Lilly, London.
19089 Bearings, G. F. Simonds, London.
19092 Boilers, W. S. Akerman, London.

November 28th.

19110 Rotary Engines, G. J. Clarkson, Stockton-on-Tees. (R. C. Fisher, Canada.)*
19124 Hot-air Motors, W. Schmidt, London.
19138 Type-writers, C. Spiro, London.*
19140 Cutting Fibrous Material, E. V. A. Mitchell, Bury.
19145 Furnaces, F. A. Herbertz, London.*
19151 Motors, C. Wells, London.
19164 Compound Fuels, A. Shippey, London.

November 29th.

19173 Valves, H. F. Hill, Nottingham.
19183 Furnaces, J. A. Yeadon and W. Adgie, Leeds.
19197 Pumping Engines, H. Davey, London.*

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